COASTAL ACTION PLAN

FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

TECHNICAL DOCUMENT

the Coastal Centre

THE LAKE HURON CENTRE FOR COASTAL CONSERVATION

www.lakehuron.ca

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Disclaimer:

The views, opinions, and recommendations expressed in this publication are those of the Lake Huron Centre for Coastal Conservation created using the best available scientific information regarding sustaining ecological integrity and resiliency. These views, opinions and recommendations are informed by advice and discussions from partner organizations, steering committee members and members of the review team. This Plan has no legal status. It is a compendium of stewardship practices and recommendations intended to inform behavioural change along Lake Huron's coastline. The recommendations are based on best available data. Stewardship is a human activity based on knowledge and valuing the coast. Therefore, only with an informed and engaged coastal community will the stewardship efforts and recommendations be successful.

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These investments support positive, measurable change in Ontario's coastal communities. Encouraging support for a healthy and sustainable environment, this initiative connects people with the environment, increases understanding of their impact on it, and has an impact on the lives of people in these communities.

The vision of a Coastal Action Plan was ignited by Geoff Peach, a founding member of the LHCCC. Geoff, whose creativity and foresight helped establish the Lake Huron Centre for Coastal Conservation in 1998, had been a significant voice in coastal management in Ontario for over 30 years. His wisdom, his wit, and his ability to effectively communicate complex scientific issues about Lake Huron, brought a deeper understanding to the coastal community. He was a respected educational resource to all members of the coastal community. This plan embodies Geoff's vision for a coastal corridor of healthy, eco-conscious citizens with a passion and love for Lake Huron, equipped with the knowledge and initiative to protect the fragile coastal ecosystems along the southeastern shores. The primary author of this document is Hannah Cann, M.Es , Coastal Stewardship Coordinator, guided and directed by Executive Director, Erinn Lawrie.

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Grey Sauble Conservation Authority (GSCA)
Saugeen Valley Conservation Authority (SVCA)
Maitland Valley Conservation Authority (MVCA)
Ausable Bayfield Conservation Authority (ABCA)
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CONTENTS:

Acronym List:

ABCA: Ausable Bayfield Conservation Authority

AUs: Assessment Units

BMP: Best Management Practice Guide

CA's: Conservation Authorities

CAP: Coastal Action Plan

ECCC: Environment and Climate Change Canada

GSCA: Grey Sauble Conservation Authority

Km: Kilometers

LHCCC: Lake Huron Centre for Coastal Conservation

M: Metres

MECP: Ministry of Environment, Conservation and Parks

MNRF: Ministry of Natural Resources and Forestry

MOECC: Ministry of Environment and Climate Change

MVCA: Maitland Valley Conservation Authority

Phragmites: *Phragmites australis subsp. Australis*

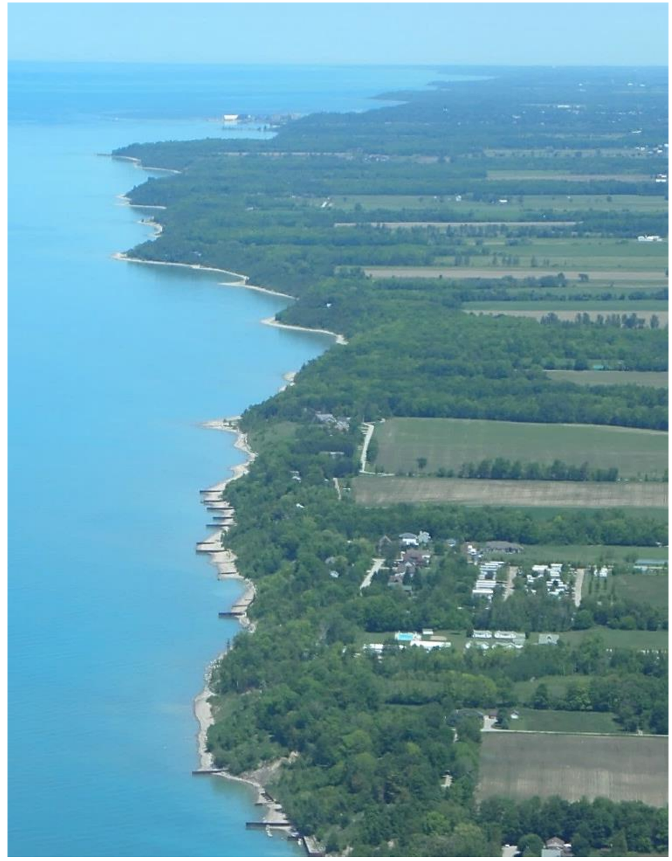
PNPS Pollution: Point and Non-Point Source Pollution

SCRCA: St. Chair Region Conservation Authority

SVCA: Saugeen Valley Conservation Authority

USEPA: United States Environmental Protection Agency

CHAPTER 1: INTRODUCTION



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, the Atlantic, Pacific, and Arctic Oceans are most commonly considered when thinking of the Nation's coasts. However, a large population lives on a 'fourth coast'. The Great Lakes are a system of five water bodies containing the largest source of surface freshwater 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 1800s, Lake Huron was called, "La Mer Douce", translated as "the freshwater sea". It built this reputation among colonists, as they could not fathom a lake its size made of freshwater. Appreciation and respect for this fragile resource were 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 50+ Indigenous communities on the Canada/U.S. borders (Figure 1). The deep-rooted culture and history of these nations are 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.

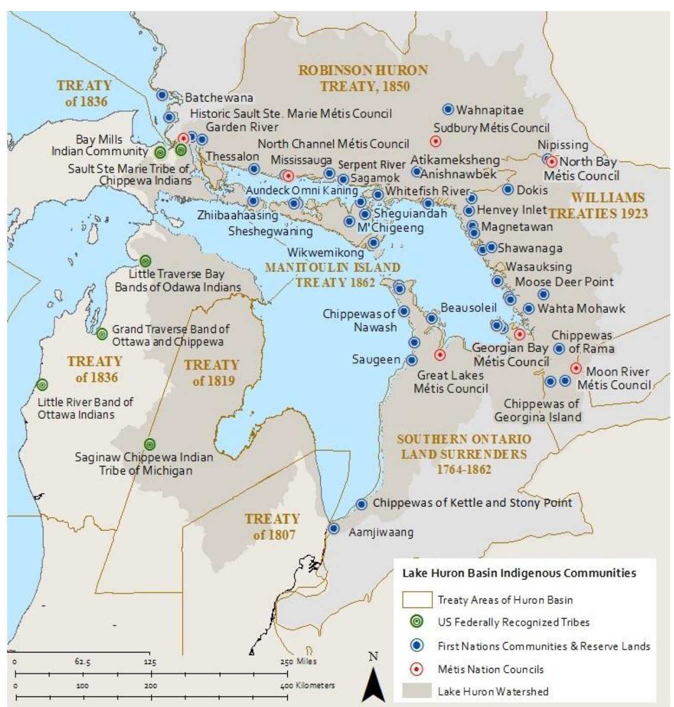


Figure 1 - First Nations and reserves on Lake Huron (Gov. Canada, 2011)

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 are "adversely affected by a lack of planning and coordination" when anthropogenic influences overlap sensitive areas (WCB, 1999). Establishment of Ontario's Conservation Authorities (CA's) in the 1940s 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 became apparent to reduce inefficiencies in existing projects and programs by improving communication and nurturing collaboration across the 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.

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, newly retired individuals, seasonal residents, and tourists. The diversity of people sharing one shoreline creates a stratification of influences on coastal management decisions.

1.1 PURPOSE OF THE COASTAL ACTION PLAN

Lake Huron's southeastern coastal corridor is home to thousands of permanent or seasonal residents and visitors interacting with the lake through fishing, swimming, boating, and other recreational activities. Coastal communities recognize Lake Huron is 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 coastal ecosystems providing valuable ecosystem services and supporting rare species in the coastal corridor. Maintaining ecosystem function, wildlife populations, adapting to climate change and maintaining water quality requires environmental restoration, protection, and enhancement. Significant regional threats to Lake Huron's biodiversity and water quality, including pollution, shoreline development and alteration, invasive species, and climate change create risks to the health of coastal ecosystems.

The Coastal Action Plan for the Southeastern Shoreline of Lake Huron (CAP) is a living document, with its conception creating a unified vision for conservation and stewardship efforts between Sarnia and Tobermory Ontario. This action plan encourages a collaborative approach to address common issues and set goals for environmental sustainability and resiliency between grass-roots, local, and regional stakeholders. The CAP intends to unite the shoreline's diverse portfolio of landowners, visitors, and land managers under a common strategy to ambitiously implement scientific-based recommendations to improve the well-being of Lake Huron's coastal ecosystems and waters for future generations. The CAP planning process has engaged local communities, First Nations, Métis, conservation organizations, and the various levels of government to encourage collaboration and awareness of conservation efforts existing, and needed along the coast. The recommendations put forth in the CAP outline actions needed to mitigate and remove the threats and stressors negatively influencing the ecological integrity of the coastal ecosystems. These recommendations may be a stark contradiction to current land-use practices, and may support existing programs, the goal of which is described best by the University of Kansas (2017b):

"an action plan is a 'heroic' act: it turns dreams into reality. An action plan is a way to make sure a vision is made concrete. It describes the way [the shoreline] will use strategies to meet objectives. An action plan consists of actions or changes to be brought about in communities".

The CAP recognizes that the coastal corridor is a popular area for residents and seasonal visitors, requiring a balance between ecological integrity, recreation, and economy. This balance is acknowledged by creating realistic recommendations that marry coastal communities to the ecosystems around them. This action plan, like many plans that have come before it attempts to determine:

- What actions are needed to ensure the southeastern shores is resilient to change and increased threats, and sustainably managed for future generations;
- Who will carry out these changes, e.g. 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 a priority, based on location and natural sensitivities affected;
- What resources are needed to complete projects or eradicate threats (Resources include money, time, partnership programs, and community engagement).

The CAP serves 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 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

'The ribbon of life' represented by the coastal corridor is the land and water margin running from Sarnia to Tobermory along the southeastern shores of Lake Huron. It is a living coast in terms of its distinct ecology and geology, and the ample opportunities for people to engage in active, healthy lifestyles with a vibrant economy. The coastal corridor links communities, building on the shared experience of coastal marine heritage. The CAP seeks to engage the coastal community to think in a holistic, broader ecosystem perspective while making stewardship decisions at the local or grass-roots level. This vision promotes adopting natural heritage policies into local Official Plans and zoning bylaws which, in turn, supports elements of this vision. This vision anticipates increased use and stress placed on coastal environments in the coming years and recognizes the value and importance of the coastal corridor to municipalities for the 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) allowing increased visitation without compromising ecological integrity.

The coastal corridor of Lake Huron includes the Huron Fringe; a narrow band of ecosystems bordering the shores of Lake Huron from Sarnia to Tobermory. 'Huron Fringe' refers to the physiographic region the lands and waters intersect, creating a band of coastal ecosystems. Coastal ecosystems provide numerous ecosystem services including climate mitigation, water purification, and habitat for many plant and animal species, forming an important migratory corridor. Rare coastal ecosystems like dunes, coastal wetlands, alvars, bluffs, and estuaries include environmentally significant areas such as 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 needs for healthy ecosystems with wants for anthropogenic development is the harmony sought by the CAP. The vision 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 effects of threats and stressors are not isolated to the ecology of ecosystems, encompassing social ramifications, historical significance, and economic prosperity of coastal communities. The CAP reviews the threats caused by stressors to recommend actions to reduce impacts on the ecosystems overlapped by communities. Grass-roots, local, and regional governance working in collaboration with open communication will allow effective coastal management and implementation of the CAP's recommendations.

Understanding how and why humans use the coastal corridor is imperative to effectively managing this area now and in the future. Mitigating a range of interests is challenging, especially within a fringe of water-and-land, with many 'players' vying for the same resources but different uses. Understanding how communities rely on the coastal corridor for their economy, identity, and values is vital to implementing the CAP's recommendations. The reasons why people value Lake Huron's coast, as well as their vision for the future of Lake Huron's coastal corridor were reviewed to prepare recommendations that would be realistic, optimistic, and customized to coastal communities across the shoreline. These recommendations provide a tangible set of goals and best management practices to ensure local stakeholders are encouraged to accomplish actions to improve the resiliency and ecological integrity of the coastal environments.

2.1 OBJECTIVES

Objectives of the Coastal Action Plan embrace three themes; Process ('improve the process'), Community-Based Action ('acting as a community'), and Behavioural Change ('elicit behavioral 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 Lake Huron's coastal corridor using a multi-discipline stakeholder engagement approach to address cross-jurisdictional environmental issues. Establishing and comparing baseline data to indicators and thresholds determines ecosystem health within the coastal corridor. This data can be used to improve the resiliency and sustainability of their jurisdictions. This objective provides the collaborative groundwork to implement positive strategies and actions.
COMMUNITY-BASED ACTION	Collaboration of grass-roots, local, and regional governance to work together towards the CAP's objectives. Nurturing knowledge and information sharing to increase awareness of ecosystems and threats within the coastal corridor. Citizens actively engaging in management and regulatory decisions, understanding the interdependence between ecosystem health, the economy, ecological services, and socio-cultural heritage of coastal communities.
BEHAVIOURAL CHANGE	Cooperation and collaboration encourage the adoption of best management practices. Recommendations made in this plan nurture grass-roots changes and 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 (CAP) aims to improve the awareness of threats and stressors affecting coastal environments and provide place-based recommendations for protection, restoration and enhancement actions to be implemented collaboratively. Approaching the analysis by ecosystem type allows communication between land managers and landowners who have a connection to respective ecosystem types, instead of segregation by a social or political jurisdiction. Outcomes include recommendations for action prioritized by impact, timeframe, and challenge.

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" (Annis et al., 2017). Geographic Information System (GIS) maps showing bio-physical and cultural information were reviewed to conduct a spatial analysis of the coast to better understand sensitive coastal environments, human use of the coast, and distribution of threats and stressors. Communicating this information to partners and the public increases awareness of how to actively embrace a coastal stewardship ethic to improve the environmental, economic and social well-being of Lake Huron's coastal corridor.

Figure 2 - CAP outcomes & expected products

Recommendations made through the CAP are built on a portfolio of studies 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 increases community uptake of the recommended actions made in the Plan. A review of the existing literature and studies done in the coastal corridor allowed for an understanding of the anticipated emerging issues and barriers to implementation. Three outcomes will come from the CAP:

OUTCOME 1:

Measurable improvements to the ecological integrity of Lake Huron's coastal corridor through a coordinated collaboration 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:

Increase public awareness and understanding of the coast of Lake Huron's dynamic nature, ecological significance and enable community members to be active stewards of coastal ecosystems.

- 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 improving ecological integrity, sustainability, and resiliency in the coastal corridor.

- Support existing environmental groups and initiatives, while encouraging local grass-roots 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 and expected products of the CAP is illustrated in Figure 2. Adaptively managing the CAP's recommended actions (Figure 2) and nurturing partnerships is key to successfully implementing the recommendations. The CAP is a living document, intended to consistently improve actions made towards coastal resiliency, sustainability and ecological integrity of coastal ecosystems. In future renditions of the CAP, examining what has been done to meet or exceed recommendations made, and how successful the recommendations are, will be done. Monitoring the progress after 3 to 5 years will allow adaptive management of the CAP and the recommendations made. These three questions will be referenced when completing the review or progress of the CAP:

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).

1.3.1 EXPECTED PRODUCTS

1. **Coastal Action Plan Technical Document:** Available online, intended for grass-roots, local, and regional governance.
2. **Coastal Action Plan Public Document:** A short, public-oriented document summarizing the CAP providing an overview of conservation and stewardship priorities. Available at no cost online, 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

Lake Huron's southeastern shore is a diverse corridor of ecological, economic, and cultural entities. This area is distinct, containing diverse ecological habitats, socio-economic value, and historical importance. The Coastal Action Plan focuses on this ribbon of life of nearshore waters and lands between Sarnia and Tobermory.

1.4.1. PHYSICAL SCOPE

The southeastern shoreline is 946 kms long, including islands. The physical scope follows the ecologically defined boundary of the Huron Fringe; a narrow band

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

of ecosystems bordering the shores of Lake Huron from Sarnia to Tobermory. ‘Huron Fringe’ refers to the physiographic region the lands and waters intersect, creating a band of coastal ecosystems, and is expanded to stretch from Sarnia to Tobermory Ontario. Ten ecosystem types exist in the coastal corridor including; sand beaches and dunes, bluffs, gullies, cobble beaches, wetlands, woodlands, river mouths, islands, nearshore, alvars and bedrock. Coastal ecosystems provide numerous ecosystem services including climate mitigation, water purification, and habitat for many plant and animal species, forming an important migratory corridor. 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. The coastal corridor provides extensive water purification services and habitat for rare plants and animals. 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.

Along with the nine terrestrial ecosystems, the CAP includes nearshore waters abutting the shoreline spanning offshore to a depth of 6 m derived using Provincial bathymetry layers. The area of shallow nearshore waters is at the highest risk for contamination and manipulation due to actions occurring onshore. Figure 3 shows a depiction of the coastal corridor including the nearshore waters, extending from Sarnia to Tobermory Ontario.

1.4.2 SOCIO-POLITICAL SCOPE

The landscape analysis will occur through areas called Assessment Units (AUs). Eleven AUs have been derived across the coastal corridor. AU boundaries were formed using littoral cell nodes determined in the Flood Damage Reduction Program (FDRP) mapping completed in the 1980s. These boundaries were cross-referenced with work being completed with Environment and Climate Change Canada on a Nearshore Framework for the Great Lakes, Lake Huron in particular. AUs ‘disregard’ political jurisdictions of municipalities, federal and provincial districts, and Conservation Authority (CA) boundaries; studying the coastal corridor using this ecologically-derived boundary. Using AUs for analysis instead of socio-political boundaries places the call for action on all stakeholders in each AU, encouraging communication, and collaborative action, fulfilling recommendations made in the CAP.

1.5 COLLABORATION, ENGAGEMENT AND OUTREACH

Land management in coastal environments is challenging and complex due to nature’s inability to adhere to political boundaries (NOAA, 2017). Lake Huron’s coastal corridor is a patchwork of political boundaries and jurisdictions. There are many types of land managers in the coastal corridor, ranging from individual landowners to the federal government. These land managers have been categorized into three groups; grass-roots, local governance, and regional governance. Managing a healthy shoreline ecosystem is a shared responsibility of all community members, as echoed in Huron County’s Official Plan (County of Huron, 2015a). Local governance within the coastal corridor includes 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 Figure 5 illustrates the amount of shoreline managed by the individual shoreline municipalities.

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 (Table 2).

Table 2 - Indigenous communities within the Coastal Action Plan project scope.		
Community	**Members**	**Description**
Aamjiwnaang First Nation	2,300	*“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	*“***Kettle Point** *is also known as* **Wiiwkwedong***, part of the* **Anishinabek Nation.** *Kettle Point is an unceded territory 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… 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 the harvest of resources, which remains important to our people. Fishing is of special importance, historically and today. 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) is 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… 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).

Recent reports about Great Lakes management specify collaboration and communication as paramount in the success of multi-jurisdictional projects. Coordination across jurisdictions, collaboration and working with other disciplines, coordinating funding, and planning across departments are all imperative to efficient coastal management (Allan, Callewaert & Olsen, 2018). Coordination and cooperation among different agencies and organizations are essential to complete ecosystem-based projects being recommended through the CAP. Some agencies engaged in the formation of the CAP intending to adopt recommendations include:

REGIONAL

- ECCC
- OMAFRA
- MECP
- MNRF
- Policy & Acts

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 1980s, "*the main obstacle to implementing 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 1980s 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, opportunities exists for collaboration at the local scale to harmonize initiatives across the coast.

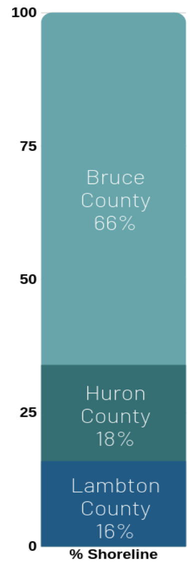


Figure 4 - County shorelines on

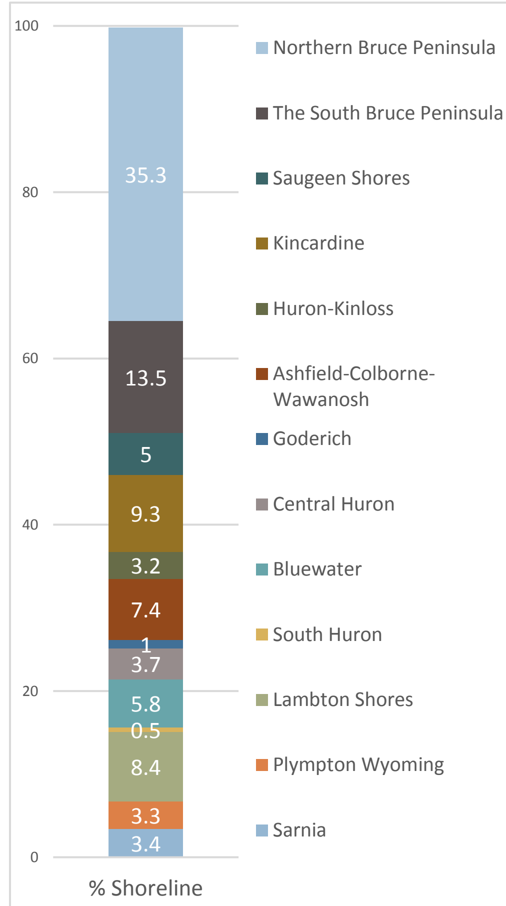


Figure 5 - % of shoreline managed by each municipality

The CAP is shaped by a 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 build on previous coastal planning work from 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

Landscape planning at a broad regional scale presents challenges. Lake Huron has considerable regional differences, ecologically, demographically, and economically, that can be masked by assessing the lake's biodiversity as a single entity. The most striking variation is observed across the north-south gradient. Northern sections of the coastal corridor have lower population density and are substantially forested, while southern sections have higher population densities in urban centers, dominated by agricultural and industrial activities. Intensified developed land-use types result in more ecological degradation and additional challenges

Identify baseline conditions of ecosystems and stressors

- Identify stressors and threats;
- Review GIS data and existing plans and studies;
- Analyse ecosystem quantity and quality;
- Define type, severity, prevalence and extent of impacts;

Determine best management practices and thresholds

- Engage public and partners to contribute values and desires;
- Set limits of acceptable change or thresholds;
- Identify collaborative management actions;

Implement recommendations

- Partnerships to implement actions to fulfill recommendations

Adaptive management

- Evaluate effectiveness;
- Adjust projects to fit community goals and realistic limitations.

Chart 1 - Methods of Assessment (CAP in blue, post-plan action is green) to natural resource management. The Coastal Action Plan for the Southeastern Shores of Lake Huron (CAP) recommends actions for the coastal corridor of Lake Huron.

Executing these recommendations as well as future recommendations will employ a combination of the Conservation Action Planning methodology developed by the Nature Conservancy (USA); and the Community-Based Participatory Action Research (CBPAR) method commonly used for specific geographic areas and communities. These methodologies are most appropriate owing to their flexibility to be used at different scales and across various ecosystems or geography. These, "*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 easily monitored. The CAP approach is collaborative and holistic, considering ecological, socio-economic and cultural factors*" (Carolinian Canada, 2018). A combination of these methods is most feasible for the coastal corridor (Chart 1).

Coastal action planning relies on understanding ecosystems, cultural elements, and stressors, to recommend action within the coastal corridor (Allan et al., 2012). The CAP uses adaptations of the Community Based Participatory Action Research (CBPAR) method, involving stakeholders to establish a research question, develop data, analyze findings, addresses practical concerns of the community, and recommend action from the findings (Advancement Project, 2011; Table 3).

Table 3 - Coastal Action Planning and CBPAR method

CBPAR Method	Lake Huron CAP	Steps needed
Establish research question	Improve ecological integrity, resiliency and sustainability in the coastal corridor.	– Conduct a literature review to determine the current 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.	– Using GIS, find land cover composition and shoreline ecosystem types, to determine areas with high concentrations of threats and stressors.
Address practical concerns	Identify inconsistencies and limitations to meeting targets.	– Bring together stakeholders consistently regulate, incentivize, or provide 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 the potential for future projects across the coastal corridor.

Adaptive management strategies are the most effective method to implement recommendations. To facilitate adaptive actions along the coast and nurture partnerships between organizations, concepts for Great Lakes integrated coastal ecosystem management are recommended utilized in the CAP (Table 4).

Table 4 – Coastal ecosystem management for the southeastern shores (Adapted from Lawrence, 1995)

CONCEPT (What is needed)	**ACTIONS** (How the CAP fulfills the concepts)
1. Political and public commitment.	Engaging public and partners in 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 the health of the coastal corridor.
5. Recognition of significant coastal ecosystems.	Analysing ten coastal ecosystems and indicators that determine their state.
6. Consider threats in a land-use and environmental context.	Analysing land-use types that 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.	Ensuring the most appropriate scientific-based indicators and thresholds are used to monitor ecosystem health.
10.	Provisions for education, public awareness, and communication.	Partner agencies collaborating to do community workshops, presentations, information sessions, social media engagement and education through scientific posts, videos, webinars, podcasts, newsletters, and blogs.

Using biological indicators to monitor the health of aquatic ecosystems has 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 indicators and thresholds as a scientific basis to determine the health and ecological integrity of coastal ecosystems along the southeastern shores. This framework creates a direction for CAP recommendations and actions. Table 3 illustrates CBPAR and CAP methodologies used.

1.6.1 PUBLIC AND PARTNER ENGAGEMENT

The 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). Engaging community members and regional stakeholders in the development and implementation of the CAP is critical. The process of engagement and collaboration is inclusive and collaborative, providing numerous opportunities for the public and stakeholders to participate in all phases of the project.

From 2016 to 2019, community involvement 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, +850 people interacted with or contributed CAP development and recommendations (Chapter 2).

1.6.2 GEOGRAPHIC ASSESSMENT AND DATA ACQUISITION

The coastal corridor's inland boundary uses biological and anthropogenic factors due to the diverse coastal ecosystems and communities. The physiographic regions of the Huron Fringe and Huron Slope [see the Great Lakes Conservation Blueprint for Terrestrial Biodiversity] have a narrow but appropriate inland stretch coinciding with the 2 km coastal zone threshold in most areas, but in other areas only extends a few hundred metres inland. Therefore, the easterly between Grand Bend and Kincardine is extended inland to trace Highway 21. This highway is a major transportation corridor and a definite separation feature along the coast. The northern extent of the Huron Fringe and Huron Slope stop short of the Bruce Peninsula. To include the Peninsula to capture the entire southeastern shores of Lake Huron, a method for determining inland reach north of Tiverton and south of Pinery Provincial Park was needed. Quaternary watershed boundaries were used to delineate inland boundary from Sarnia to Pinery Provincial Park, and from Tiverton to Tobermory. The inland reaches of the quaternary watershed boundaries penetrated up to 10 km inland, farther inland than the desired geographic scope. A consensual decision between the steering committee and project managers clipped the inland boundary to the northwestern side of Highway 21. Bathymetric datasets from NOAA were used to delineate the nearshore waters boundary, at the 6 m depth. Most impact from adjoining land base, as well as sediment and nutrient transport, occurs within the 6 m depth from the nearshore.

Reliance on external information sources for most of the GIS data required data sharing agreements with partner agencies including NHIC, CA's, municipalities, MNRF, and NGOs like Ontario Nature and NCC. Environment and Climate Change Canada provided datasets to aid in ecosystem analysis. Other citizen science programs including E-Bird and The Ontario Amphibian Atlas were referenced for information. GIS data varied in vintage, as well as detail and accuracy. Unfortunately, the best available data 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 stable (e.g. mature woodlands) (County of Huron, 2018).

CHAPTER 2: ENGAGEMENT

Engaging the general public, grass-roots groups, local, and regional governance is critical to the successful development and implementation of the Coastal Action Plan (CAP). The CAP unites organizations to address priority issues and expand public support for conservation and stewardship. The process has facilitated dialogue regarding regional ecosystem goals and provided opportunities to learn about aspects of Lake Huron's coastal corridor. The process has been inclusive and collaborative, encouraging contributions in the CAP's development.

Stakeholder Workshop

Twenty-two representatives from coastal partners attended a stakeholder workshop on April 27, 2017, at the University of Waterloo's Heritage Resources Centre, to gain support for the CAP, to determine what existing resources are available, creating a map highlighting threats and valuable areas across the corridor.

Community Workshops

Twelve (12) Coastal Community Workshops (CCWs) were held to involve the public and gather regionally-specific knowledge (Table 5). These evening events attracted residents and representatives from community groups, NGO's, and clubs, attending to learn from guest speakers and contribute their experience, concerns, and vision for Lake Huron. These workshops presented material relevant to local coastal ecosystems and stressors enabling individuals 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. 408 attendees participated in the CCWs contributing ideas for stewardship projects and action towards threats and habitat health in their community.

Table 5 – 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	

Municipal Forum

The Lake Huron Municipal Forum held from 2016 to 2019 engages local and regional governance during a one-day conference. This forum educates, raises awareness, and gathers input from Municipal, County, Conservation Authority, First Nation, and Métis representatives. Stakeholder and partner engagement identify regionally specific limitations, requirements, desires, and visions for the coastal corridor. Dialogue during these events focuses on encouraging sustainability and resiliency of the coastal corridor through collaborative efforts.

Attendees view 3 to 6 presentations discussing local conservation and restoration efforts, updates on shoreline conditions and lake health and participate in break-out groups to discuss how their area and organizations manage the shoreline. Over the four years of the meeting, 180 individuals attended this event.

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 distributed through Typeform (an online questionnaire software) from April 1, 2017, to October 31, 2017, provided respondents the opportunity to contribute their concerns for Lake Huron, describe their values, and vision for Lake Huron's future. 256 respondents provided input through the questionnaire. Refer to Appendix G for more details.

Presentations at Community Events

Presentations to individual groups, at community events, cottage association annual general meetings, and special interest group meetings were made throughout the CAPs development (2016 to 2019). These presentations would occur by invitation to partner events. Approximately 630 individuals attended the presentations and learned about the CAP, coastal ecosystems, and threats associated along the coastal corridor.

Social Media and Newsletters

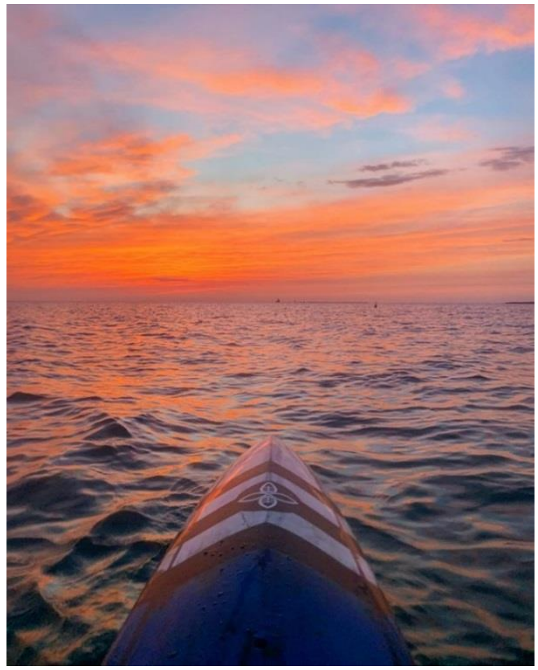
Engaging social media posts and newsletter articles were written to educate coastal citizens and raise awareness of threats and stressors. These articles conveyed thought-provoking information about ecological processes, ecosystems, threats and stressors, events, opportunities to get involved in the 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. An objective of the CAP is to increase awareness and educate individuals about the coastal corridor; this number represents the reach of social media and its ability to educate thousands of people every year with coastal information.

Interviews on radio and in newsprint were done to promote the CAP, educate about coastal issues and raise awareness of coastal ecosystems. One reporter estimates the reach of a media article to be between 2,000 to 8,000 people. Over the CAP's development, 71 radio, newspaper, online news, television interviews, and articles occurred, equating to a public reach of 142,000 to 568,000 readers and listeners.

Video Series

Short videos were requested in CCWs and the questionnaire to raise awareness among a diverse audience. An 8 episode, high-definition video series featuring imagery of the southeastern shores and coastal corridor was produced to raise awareness of coastal ecosystems and the threats they face. These videos premiered between October and November 2019, one released per week on YouTube and Facebook. These videos were viewed 160 – 1,200 times per video in their respective premiere week, with over 23,300 total views.

CHAPTER 3: VALUING THE COAST



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 Lake Huron's coastal corridor differently. Someone valuing aspects of their surroundings may emphasize an understanding or respect of the 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 the risk to the environment and actions needed to reduce threats to ecosystems (Dietz et al., 2005). Scientific and psychological literature clarifies that broadly viewing people's environmental values assists in studying human-nature relationships paralleling values of ecological services and ecosystem values (Schroeder, 2011). Values reflect culture, society, and knowledge base, and can be influenced in the short or long-term through reflection or new understandings are gained (Dietz et al., 2005). For example, individuals may have littered while driving, but upon learning hazards to wildlife posed by plastic litter, their actions change and the value of litter-free natural areas increases.

A binational poll conducted by the International Joint Commission's Water Quality Board in 2015 indicated that 85% of residents in the Great Lakes basin feel it is important to protect the Great Lakes (ELPC, 2019). This binational poll was repeated in 2018 (IJC, 2018), affirming that public support for protecting the Great Lakes remains high (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 (30%), but the majority were willing to be cognizant about what is dispose of down the drain (83%) and their water use (74%)" (ELPC, 2019).

During CAP development, 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; 64% valued the presence of natural shorelines; 61% valued the preservation of natural areas and; only 24% of respondents valued tourism (Chart 2). In regards to stressors, the IJC survey found that 73% of people considered climate change a negative impact, whereas 58% of respondents to the CAP questionnaire found climate change is of high importance (ELPC, 2019; Chart

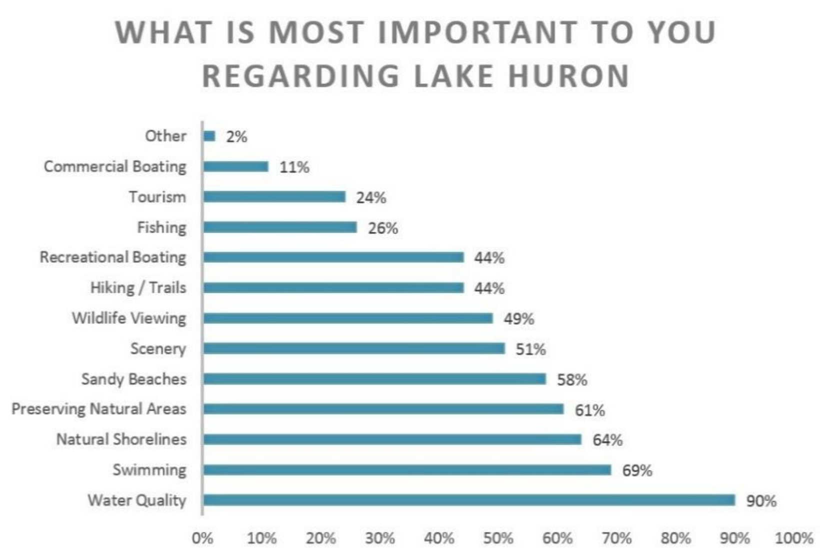


Chart 2 - Responses from 2017 CAP Questionnaire on Values

2). This example shows that values can vary in environmental topics. 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 will allow recommendations for coastal stewardship efforts to be realistic for the coastal community and identify gaps in awareness and value for ecosystem services and coastal environments.

3.1 ENVIRONMENTAL VALUES

DEFINITION: *"A person's attachment to the natural environment may involve a sense of respect and obligation motivating the person to care for and protect a place for its own sake… It must be understood 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 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 recognize environmental value as the value of habitat to species relying on these habitats, and the interaction and aesthetic value of having nature around us. Researchers are beginning to realize and quantify how people value nature, even if it serves them no financial gain or services (Schroeder, 2011). Five types of environmental values have been identified (Schroeder, 2011; Chart 3).

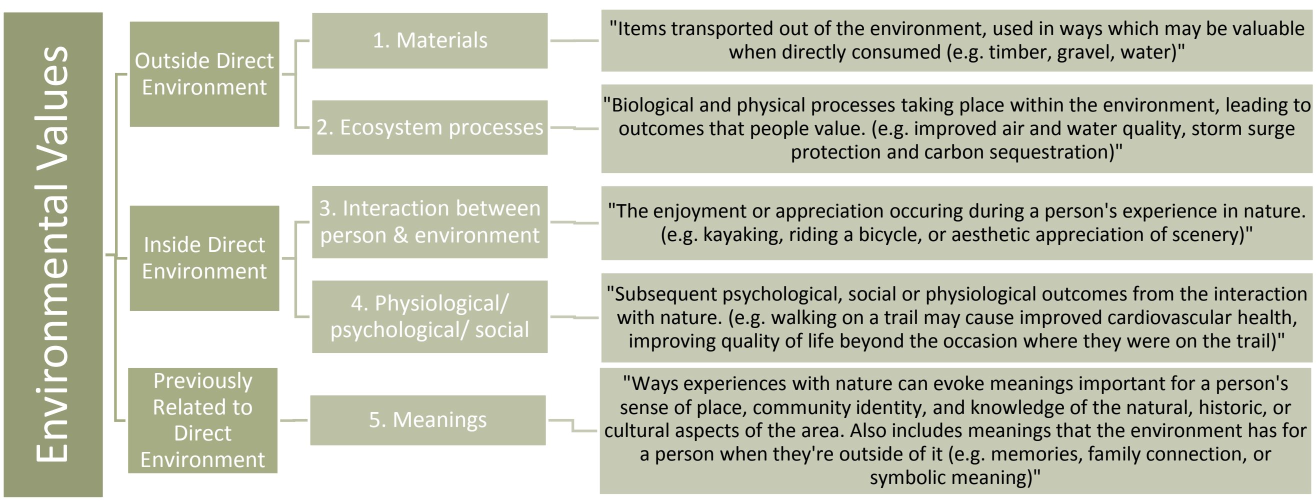


Chart 3 – Types of environmental values (Adapted from Schroeder, 2011).

Values represented by coastal First Nations are vast but some can be illustrated through the perspective of Wahkohtowin. First Nations Natural Law (*Wahkohtowin*) is the strong relationship and foundation identified by Ojibway, Anishinaabe, and Cree people across Canada. "*Our relationship with our Mother the Earth, the water, with different plants, medicine, the herbs, the animals, the birds, all four-legged beings. 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). Wahkohtowin provides an understanding of how First Nations and Métis value environments along Lake Huron. The Natural Law governs 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 is for elders to teach youth how to live in a way that respects the Earth, and one another. Members attending the CAP speaker's session at the Lake Huron

Centre for Coastal Conservation's 10th biennial conference in May 2018 were asked whether Wahkohtowin resonated with their values and sense of place of Lake Huron. In a diverse audience consisting of members from the public and communities across the shoreline, 83% of respondents felt that Wahkohtowin aligned with their values (Figure 6). Values commanding intrinsic respect for Lake Huron could be increasing because of the 'recent' resurgence in awareness of local culture, historic value, and traditional ecological knowledge as well as the insurgence of awareness of the reality of climate change.

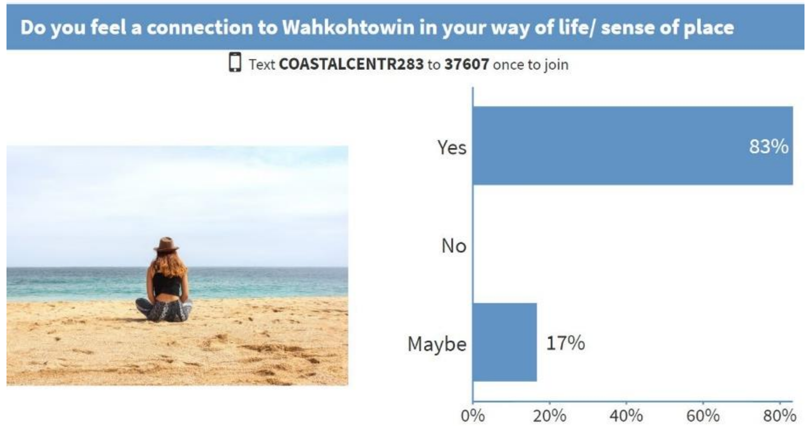


Figure 6 - CAP survey results when asked "Do you feel a connection to Wahkotowin through your way of life?" (2018).

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 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). Understanding 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. Attendees to the CAP speaker's session at the Lake Huron Centre for Coastal Conservation's 10th biennial conference in May 2018 were asked which of Schroeder's environmental value divisions they most closely aligned to. Figure 7 shows the responses obtained from a digital survey taken during the presentation, depicting the diversity of values, even within the group of individuals in attendance.

Conclusions drawn from the 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 (County of Huron, 2015a). No matter their reason, individuals value Lake Huron's coastal environments, with communities willing to protect and enhance habitats in the coastal corridor for ecological benefits, ecological services, and aesthetics.

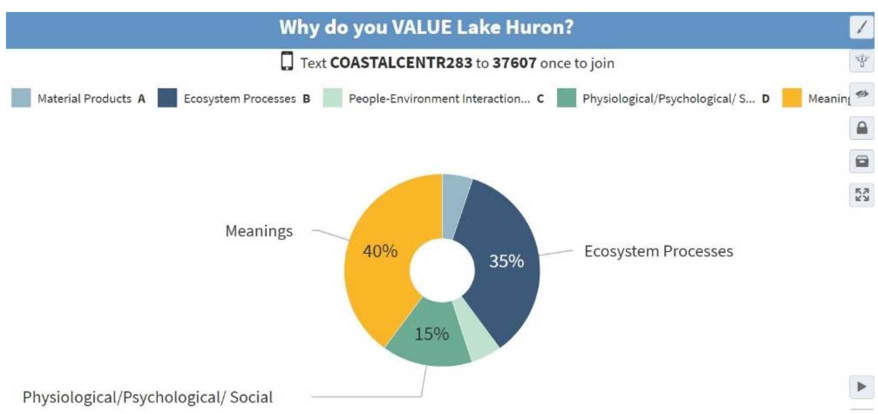


Figure 7 - Coastal Action Plan survey results when asked "Why do you value Lake Huron?" (2018).

3.1 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 (County of Huron, 2015; County of Lambton, 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 area's main industry. For example, in Bruce County, coastal communities rely on tourism, fishing, and agriculture for their economy. Other industries such as Bruce Power Nuclear Generating Station and Provincial Parks deliver economic value to the coastal corridor of Bruce County. In Huron County, agriculture is most prominent, with manufacturing, cottage community developments and major coastal communities serving as tourism hubs. Other industry such as the salt mine in Goderich and the major shipping port provide the heavy-industry base of this area. Lambton County's coastal corridor is dominated by residential development, agriculture, resource extraction, and heavy-industrial uses such as major city centres and transportation corridors. These regions rely on the coastal environment very differently for their economy with the north relying on 'wilderness' and 'natural beauty' for its sustenance in the tourism industry, and recreation sectors; whereas the south relies on the coastal environment for residential and industrial purposes with tourism scattered in.

3.2.1 ECOSYSTEM SERVICES

Ecosystem services are direct or indirect outcomes from natural processes. They can be provisional (e.g. food, fuel, freshwater), 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 are 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 areas requiring water purification for drinking water, and flood attenuation of wetlands reducing the reliance and overuse of stormwater drainage.

Ecosystem services reduce costs for the equivalent services of human-made infrastructure requiring investment from municipal, provincial, federal, or private landowners. Value of ecosystem services is now included in Canada's biodiversity goals and targets for 2020 (TD & NCC, 2017). For example, ecological services provided by forests include carbon sequestration, disease regulation, water filtration and purification, flood control, nutrient recycling, and soil erosion prevention (TD & NCC, 2017). Placing monetary value on ecosystem services in the coastal corridor assigns them higher value and, in some cases, may 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). 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 accept a tax increase of 5% to pay for manmade breakwaters to 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). Valuations 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 to have it in the future for visiting, using, extracting, etc. Or, the value placed on an ecosystem that can be passed on to the next generation (Annis et al., 2017).

- **Avoided Cost:** determining the value of added damage that would occur if the ecosystem did not exist. 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 occur 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 natural services with human-made alternatives (e.g. water treatment plant vs. wetland). Understanding what the natural service gives vs. how much the human-made equivalent would give. How much people are willing to pay for the equivalent human-made option determines how much the ecosystem service is worth (Annis et al., 2017).

The number of ecosystem services existing in the coastal corridor has not been quantified but there are opportunities to calculate the economic value of these resources to better respect and manage these ecosystem services. "By understanding the 'currencies' communities use to value coastal resources, allow new data to inform current and future conservation actions toward ecologically, economically and socially resilient futures" (Annis et al., 2017). Placing monetary value on ecosystem services will allow an 'apples-to-apples' comparison between natural infrastructure to the building, operating, and maintenance costs of human-built infrastructure. For example, mature dunes have been valued at $3,000 per linear metre for shore protection services alone (LHCCC, n.d. [1]). Increased awareness of ecosystem services translates to less destruction and land-use change favouring human-made alternatives. Partnerships between municipalities and the grass-roots and academic community to quantify and denote the monetary value of ecosystem services within management boundaries could be an efficient way to determine the value of natural infrastructure across the coastal corridor.

3.2.2 ECONOMY OF TOURISM

Interactions between humans and nature can glean economic value through the tourism industry and the businesses that work to support tourism. Many 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, Regional Tourism Organizations, RTO1, RTO4, and RTO7, use 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 infer that National Park visitation will increase by 5 to 14% in the 2020s and 7 to 31% in the 2050s, whereas Provincial Park visitation is expected to increase 11 to 27% in the 2020s and 15 to 56% in the 2050s (Scott, n.d.). The same reports estimate that beach season and swimming seasons are expected to increase into the shoulder seasons in the future (Table 6). Beach visits specifically are focused between April and September, with 94.4% of annual visits occurring during this time (Ontario, 2014).

These estimations suggest that tourism along the coastal corridor, especially in currently protected areas will increase in frequency and duration stimulating local economies, providing consistent visitation throughout the year. Increasing shoulder seasons and peak season times will ensure consistent economic inputs for local business.

Table 6 - 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
2020s: 161 – 182 days	2020s: 76-99 days	2020s: 202 – 218 days
2050s: 166 – 216 days	2050s: 83-135 days	2050s: 202 – 229 days

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), adding $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 economies and proper land management will preserve the ecological integrity of these areas.

3.3 SOCIAL AND CULTURAL VALUES

Lake Huron's freshwater coast draws visitors and residents to enjoy sandy beaches, blue waters, and diverse ecosystems. The sense of peace humans feel around water is what Wallace J. Nichols calls the "blue mind"—a chance to escape the hyper-connected, over-stimulated state of modern-day life, in favor of a rare moment of solitude. Humans are pulled toward Mother Nature's blue in part for its restorative benefits. For example, in the Victorian era, doctors prescribed 'sea air' as a cure for pulmonary complications to mental health conditions. A UK-based project called Blue Gym—have found that people who live near coasts are generally healthier and happier (White et al., 2016). Other studies find that when shown photographs of natural green spaces, respondents' stress levels drop, but more blue spaces in the photos are preferred by respondents. Real estate data suggests a water-view adds a 116.1% premium on a property, and real-world figures suggest a willingness to pay 10 to 20% more for the same room with a water view in a hotel. Although these studies have produced results specifying how humans value water within the environment, placing 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 use and enjoy Lake Huron for recreation, sustenance, and livelihood. The four First Nations along the southeastern shores are active in their roles as educators passing traditional ecological knowledge throughout their communities and to younger generations. Sustainably using Lake Huron is commonplace to these lasting cultures, with much to be learned from their traditional land-use management techniques of finite resources. First Nations and Métis relationship with Lake Huron's shores and waters permeates environmental values, cultural and historical significance, and 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, feathers, Sage, Sweetgrass, 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, where 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) has exclusive harvesting rights of 930 ha on the Bruce Peninsula, along with exclusive fishing reserves covering most of the waters around the Peninsula and the Oliphant Fishing Islands (Lowitt et al., 2018). Some species harvested by First Nations have exceptional significance to their culture, including Whitefish; *"Currently, SON operates the largest Indigenous commercial fishery in the Canadian Great Lakes, with approximately 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 to 60% of its TAC, due mainly to the wholesale price volatility for local fish arising from supply gluts"* (Lowitt et al., 2018). Members of the SON fishing industry say "changes in culture are considered closely tied to changes in the environment" (Lowitt et al., 2018). This is mirrored in communities that have changed from rural to urban, losing some of their historical identity and sense of place as expansion occurs.

A coastal community's cultural values are still distinguishable through historical infrastructure, including light stations. Many light stations pepper the southeastern shoreline, commemorating 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, built between 1855 and 1859, is one of 6 Imperial light stations built on Lake Huron, a design exclusive to this area (Parks Canada, 2018). Point Clark's lighthouse, once used for navigation, is now a museum operated by the Township of Huron-Kinloss, attracting tourists, bolstering the summer economy for local business (Parks Canada, 2018). Strategically installing light stations at these ports encouraged harbours to generate activity through recreation and shipping. Shipwrecks along the southeastern shores are an attraction for tourism and recreational diving, significantly contributing to local economies (Tobermory is the scuba diving capital of Canada). Communities using resources to maintain light stations exemplifies the importance of marine heritage and their contribution to the sense of place these coastal communities have. This effort made to value social and cultural histories is a visual depiction of the affectionate relationship between communities and Lake Huron.

3.4 SUMMARY: PROTECTING COASTAL VALUES

To revisit the questions of how Lake Huron's coast is valued, conclusions are drawn that show environmental value, economic value, and socio-cultural value are the main contributors to 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 e.g. 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 it's always been done");
- Economic gain or subsistence (a limited budget or need to manage it this way to make money or keep financial situations viable);
- Unfamiliar with management techniques or best practices that can positively contribute to coastal management
- Education and outreach highlight values of individuals using them as leverage to encourage change. This method evokes the adoption of recommendations.

3. **"What are impediments to people having a conservation-minded approach to shoreline value?"**

An impediment 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 occur). Another impediment is ensuring consistent and adequate education and awareness of community members, visitors, and local governance agencies. Inexperienced visitors and residents are often unaware of the area's cultural history or stressors and ecosystems 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 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 the environment and the resources contained here are subject to the 'Natural Law' and should be shared and respected by all- for all.

CHAPTER 4: COASTAL ECOSYSTEMS

Assessing the condition of Lake Huron's coastal ecosystems is important to determine the health, resiliency, and the sustainability of human influence. To determine health, threats and stressors that affect them are overlaid and examined using indicators and thresholds to determine priority actions and opportunities to improve 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. 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 occur by analysing indicators (ECCC & EPA, 2011). Indicators have been adapted from associated scientific study and international systems to determine the health of Lake Huron's coastal corridor.

Two initiatives underway by the Ministry of Natural Resources and Forestry (Province of Ontario), and by Environment and Climate Change Canada (ECCC, Government of Canada) are accurately mapping and monitoring existing conditions and habitat presence along Great Lakes coastal ecosystems (within 2 km of shoreline). These projects will provide baseline data for monitoring changes to species diversity, and ecological integrity of coastal ecosystems. 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 these partner agencies as extremely important to adequately monitoring Lake Huron's coastal ecosystems. These studies and monitoring work completed by partner agencies will be referred to when making recommendations in the CAP.

4.1 BACKGROUND

The coastal corridor of Lake Huron is an important area of community and livelihood. Human presence along the coast is dynamic in community identity, size and shape, and level of development. Métis and First Nations have lived along the shores of Lake Huron, and have Traditional Ecological Knowledge dating back over 9,000 years in the Lake Huron Basin. Over the past century, Lake Huron's shoreline has seen negative changes to coastal ecosystems from land-use change, hardening of shorelines for protection, channelizing streams and removing wetlands, decreasing nearshore water quality, and industrial sites. Positive changes along the shoreline have included the establishment of Provincial and National parks in the 1960s and 1970s, as well as private conservation and preservation efforts from various environmental groups. Now perceived 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 best management practices of sensitive coastal ecosystems. Protecting and sustainably managing shorelines, restoration efforts, and reducing stormwater runoff in coastal communities began around the 1980s and 1990s. Coastal communities are now beginning to experience the cumulative effects of decisions made in past decades, and are collectively working towards positive change to establish healthy, resilient coastal ecosystems.

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). Through the body of literature regarding ecosystem and community coexistence, understanding how indicators and thresholds monitor change is a crucial aspect of management. Chart 4 describes the drivers influencing ecosystem changes, pressures caused by drivers, states which can be monitored, the impacts that are felt due to these pressures, and responses to mitigate and repair damages.

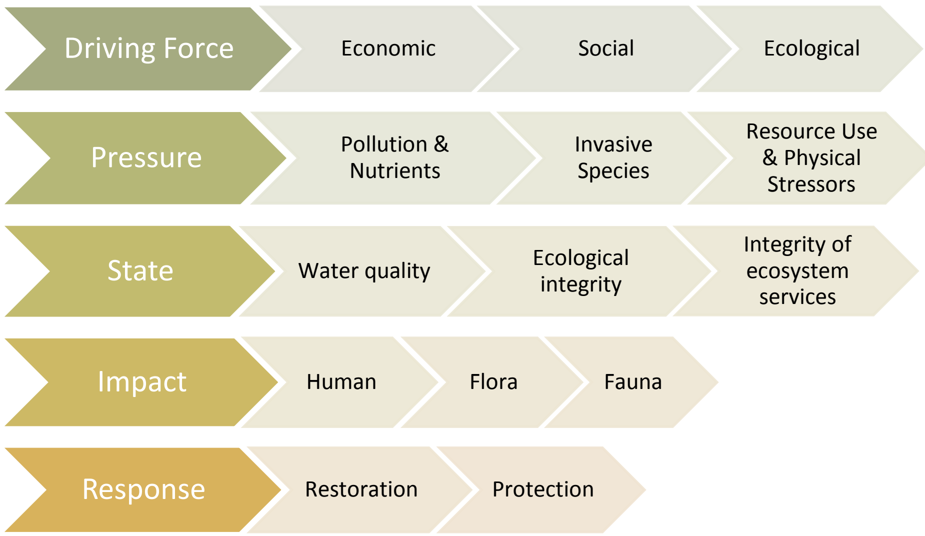


Chart 4 - SOLEC 2011 Reporting Categories

Collaboration among grass-roots, local and regional land managers to prioritise conservation action and formulate responses to negative environmental pressures in Lake Huron's coastal corridor has been established through groups like Healthy Lake Huron and specific projects across the shoreline (Annis et al., 2017). Organizations have vocalized the need for conservation actions to meet measurable ecological thresholds to sustain use without compromising ecological processes relied upon by coastal communities (Annis et al., 2017). A baseline assessment is needed to create measurable and attainable improvements in ecological integrity, and determine priority areas for conservation based on ecosystems, threats, and stressors. Local and regional groups have begun establishing long-term data sets of monitoring in an array of environmental facets such as stream water monitoring, crop rotation patterns, and forest cover improvements through tree planting programs. Support for long-term monitoring is essential to ensure scientifically derived indicators and thresholds for ecological integrity are not exceeded. Partnerships between federal, provincial and regional agencies to fund current and future monitoring programs through local and grass-roots organizations is imperative to ensure continuations of monitoring for long-term data sets.

Baseline assessments for the CAP were completed using data from partner sources with varying degrees of accuracy including Geographic Information System (GIS) data, and assessment of other projects. Some data from Federal and Provincial sources are broad-scale and less accurate at the level of analysis required. However, in areas where local authorities are lacking similar data, broad-scale data was the only record of certain ecosystems. Therefore, there are data limitations and variability in the spatial accuracy of the best available data across partner agencies. One coincidental outcome of this process of reviewing available data highlighted areas for future monitoring projects or data acquisition among partner agencies. For example, among the five CA's there are varying amounts of GIS data available and are therefore not the most effective to compare directly. However, data provided by most of the CA's at the scale of this analysis exceeded anything available through the Federal and Provincial government's digital data archives. Another coincidental outcome was the realization that open data sharing among partners is mutually beneficial 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 Chapter 3. A healthy shoreline is here defined using four factors; (1) presence and health of vegetation, (2) presence of natural material (detritus), (3) ability of the ecosystem to complete coastal processes, and (4) presence of wildlife. These factors must hold true at all analysis scales 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.

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 such as invasive species.

Presence of detritus: 'Detritus' includes driftwood, wrack (washed-up dead vegetation), fallen trees and limbs, and leaf litter. As detritus decomposes, it contributes nutrients and organic matter to the ecosystem, creating important breeding habitat and camouflaging opportunity for feeding birds, insects, and reptiles. Detritus provides habitat for small mammals (e.g. rabbits and mice) and small birds to seek shelter from predators (e.g. hawks and vultures) when approaching the shore for food or water. Whether washed up from the lake or fallen from nearby trees, detritus should be left in place. Some storms bring up massive quantities of detritus from the lake, covering entire beaches. In these cases, mass quantities of detritus can be thinned out and some removed to allow for recreation on the shoreline. Social stigma around detritus needs to change to view it as natural and important for coastal health; changing perceptions of what a 'healthy' shoreline looks like.

Ability to complete coastal processes: Coastal habitats rely on natural processes to function resiliently. For example, bluff and gully environments need to erode to supply sediment to sand beaches and dunes down drift. If rates of bluff erosion are altered, these associated habitats are affected. Most natural process interference 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 including sand transportation from eroding bluffs to sand beaches. 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).

Presence of wildlife: Wildlife presence within coastal ecosystems is an indicator of whether that habitat is providing all the amenities needed for feeding, breeding, and nesting. The old expression, 'the canary in a coal mine' metaphorically describes sensitive indicator species presence monitoring to determine the 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 can indicate whether the ecosystem is healthy enough to accommodate populations of diverse species. Diverse species compositions are important to ensure a functional food web. 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, land managers can back-track and attribute the loss of that species to an influence induced anthropogenically or naturally.

Throughout the CAP's analysis strategies identify if coastal environments are 'healthy' and whether current coastal management tactics address 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 kms 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.

The term ‘ecosystems’ is synonymous with ‘habitats’ in the CAP. Ecosystems are defined as natural areas containing homogeneous features including flora, fauna, and geology. Ten ecosystems were identified on Lake Huron’s southeastern shores: 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 5 illustrates their responses. Most respondents felt connections to, or valued sand beaches and dunes, coastal wetlands and bluffs above others. Although responses were received from individuals across the shoreline of Lake Huron, ecosystems spanning more physical area and shoreline than others had 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. The CAP examines these ecosystems and explain threats and stressors that affect these areas. Further analysis of ecosystems and stressors in Chapter 5.

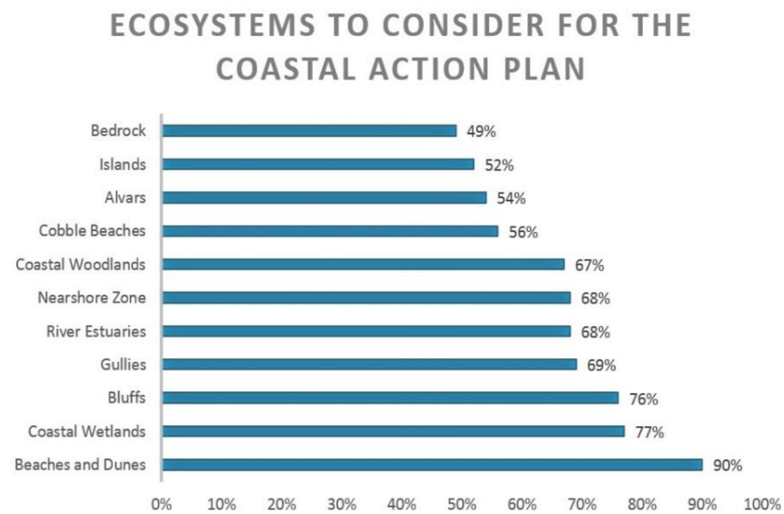


Chart 5 - Responses from the 2017 CAP Questionnaire on Ecosystems (256 Responses)

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 (County of Lambton, 2019, 8-12). Lambton County has an immense development footprint along the coastal corridor including almost continuous shoreline hardening and residential development, and is inundated with 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 as expansion occurs. Huron County’s recent Official Plan update has some similarities to that of Lambton County. They mention, “Lake Huron and its shoreline are important for their recreational, residential, ecological and tourism services” (County of Huron, 2015a, p.29), but fail 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 Official 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” (County of Huron, 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” (County of Huron, 2015a, p.29). The CAP recognizes the delicate balance between community and environmental protection needed across the coastal corridor. Dedication from coastal municipalities and counties to solidify an unwavering commitment to the protection of sensitive ecosystems within the coastal corridor, including establishing environmental protection and restoration on the same priority as development or land-use change for short-term economic gain. The ‘one-or-the-other’ approach done historically is no longer the reality of modern development. It is the synergy of nature within communities using Low Impact Development strategies that balance priorities. Bruce County's Official Plan mimics these two in many ways, but within a vastly different landscape context, as discussed in Chapters 5 and 6.

Multiple agencies review and approve projects so they may proceed safely without negatively impacting aquatic environments, water quality, endangered species or adjacent properties. Rules, regulations and permitting processes by municipalities and CA's intend to keep coastal communities safe and protect the environment. It is also recognized that First Nation and Métis have Indigenous or Treaty Rights protecting shoreline environments experiencing negative impacts by proposed shoreline alteration. These rights may vary depending on the community and the traditional lands and land-use practices of that community. Improved communication and collaboration techniques to effectively address these concerns are needed.

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 the most popular area for visitors and residents on Lake Huron's shoreline, providing ample opportunity for tourism and enjoyment. Sand beaches on Lake Huron are rare, fragile, dynamic environments, growing and shrinking depending on lake levels. This fluctuation is what makes living on sand beaches and dunes hazardous. The extreme rarity and ecological fragility of Great Lakes dune ecosystems are cause to consider them nationally significant (Municipality of Bluewater, 2013). 96 kms of sand beach and dune ecosystem, and 145 km of mixed sediment beaches cover the southeastern shores (946 km). Sand beaches make up 25% of the total shoreline *length* on the southeastern shores but only 2 to 3% of the total Lake Huron coastline. Ontario SOLRIS land-use data shows beaches (mixed sediment, sand, and cobble combined) make up 738.5 ha (0.8%) of the coastal corridor (85,838 ha). On the southeastern shores, mixed sediment beaches hold more sand than cobbles, therefore, mixed sediment beaches and sand beaches will be referred to synonymously as sand beaches. A cross-section of a Lake Huron sand beach and dune ecosystem is illustrated in Figure 8.

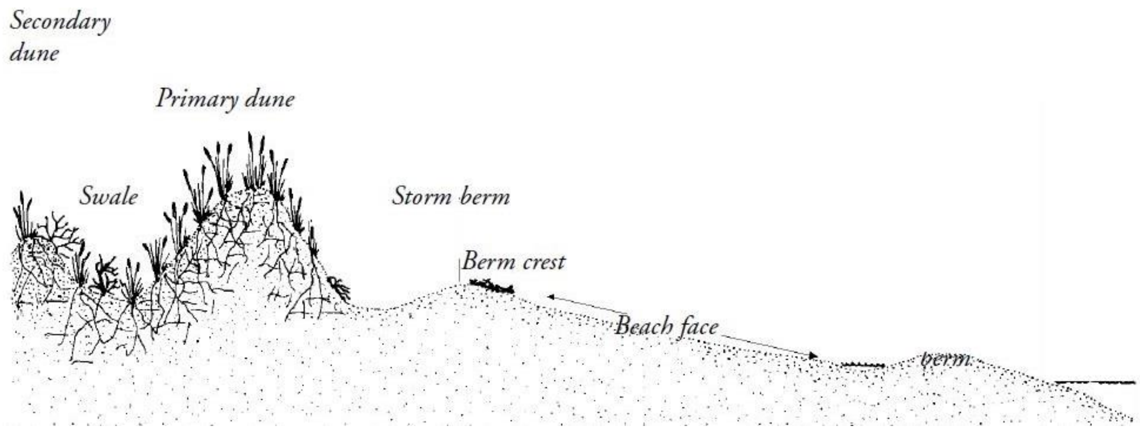


Figure 8 - Dune and beach profile (adapted from DFO, 1996a)

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. Lake Huron's dunes are active, moving back and forth parallel to the shoreline, growing and receding depending on lake levels, winds, and vegetation cover. Wind blown sand covers roads and buildings adjacent to the shore where vegetation is sparse, emphasising the need to give sand beach and dune ecosystems space to grow dune vegetation to catch blowing sand and area to expand and contract from year-to-year (DFO 1996a). Healthy, mature dunes provide ecosystem services such as shore erosion protection from storm surges (DFO, 1996a). Once a popular place to build cottages and homes, sand beach and dune environments are hazardous to develop upon; continued development is leading to habitat loss for endangered species. 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 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 40,000 m^3 and thus about 65,000 m^3 annually is deposited in 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 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 scarcer along Lake Huron and less 'healthy-looking' than high-energy beaches, these beaches provide habitat for many aquatic species and are less resilient to disturbance than high-energy counterparts. Low-energy beaches take a long time to recover from human manipulation since new sediment isn't deposited as quickly as high-energy beaches experience. An example of a low-energy beach is Singing Sands

(Dorcas Bay) on the Bruce Peninsula. Protection is the only viable long-term management option for low-energy beaches, as restoration presents challenges including manual sediment nourishment and re-introduction of rare plant populations that are often futile. Sand beach and dune environments can be preserved and enhanced using inexpensive, simple methods including (1) installing sand fencing parallel to the shoreline, and (2) planting dune vegetation such as Marram Grass (*Ammophila breviligulata*) (USACE, 2003). Avoiding compaction of soil will reduce the mortality of dune vegetation and increase resilience from storm surge erosion. Two examples of healthy dune and sand beach environments are found in Pinery Provincial Park and Kincardine's Station Beach.

THREATS AND STRESSORS

Sand beaches and dunes are mostly privately owned on the southeastern shores, spread sporadically 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 infiltrate beaches and dunes altering the composition of vegetation from dune to meadow species, "displacing native dune vegetation because of their ability to grow aggressively, smother native dune species, and compete for available nutrients" (LHCCC, 2008).

Removing invasive species with simple hand-pulling methods will preserve dune sediment from erosion, leaving native species such as Marram Grass in place. Figure 9 shows results from the removal of Sweet White Clover from a dune and swale, taking a few hours to complete. Vigilant prevention, monitoring, and removal are consistently required to combat invasive species on beach and dune environments. Landowners require education to identify invasive species, and knowledge of removal and treatment methods to adequately preserve the coastal ecosystem on their property. Information on invasive species can be found in Chapter 5.

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 11). 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, cottages and auxiliary structures were built as far forward as the fore-dune during the settlement and development of the coastal corridor in the 1960s (Figure 10).

Figure 10 – Structures on the dune within the Township of Huron Kinloss in 1986

Our current understanding of coastal processes and the sensitivity of beach and dune ecosystems requires raising awareness among private landowners about the natural fluctuations occurring to beach and dunes through lake level changes. Most of the shoreline is privately owned; therefore, proper stewardship and best management practices are placed in the hands of the landowner. Landowners residing adjacent to beach and dune ecosystems must manage their impacts, including inappropriate landscaping, nutrient management, vegetation protection, and proper setbacks. Some shoreline regulation by CA's and municipal bylaw protects dynamic beach area and shoreline zones for their quality or human hazard risk. Management and protection inconsistencies of beaches and dunes occurs across the southeastern shores strongly relies on the awareness and knowledge of landowners influenced simultaneously by the duration of experience on the coast by the landowner (e.g. property turnover).

Figure 11 - Shoreline development along sand 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 for their tendency to be highly dynamic. Shoreline hardening intended to be a way for landowners to protect their investments from fluctuating lake levels. However, modern study and analysis show these structures ripple negative effects across coastal ecosystems. Hardening structures include groynes, jetties, sea walls, armour stone, gabion baskets, and poured concrete walls. Regardless of size, hardening 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. *"To prevent erosion, humans* *harden the shoreline to stabilize and protect property in the immediate area… Unfortunately, this protection is often short-lived and often comes at the expense of beach health. Hardened structures cause erosion by preventing waves from accessing sandy reservoirs and by changing nearshore wave patterns" (UH, 2014).*

Figure 12 - Groynes along Lambton Shores

Many structures installed between 1960 and 1980 are reaching the end of their lifespan and have become a hazard to human and animal health and safety (Figures 13 and 14). 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 impacts 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 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). Heavy precipitation events bringing 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; Sutherland, 2019). Information on climate change is located in Chapter 5.

4.3.4 Point and non-point source pollution

Respondents to the 2017 CAP Online Questionnaire identified water quality as Lake Huron's biggest concern. Lake Huron's water quality has a diversity of stressors with inputs coming from inland landscapes, within the ecosystem itself, and from the atmosphere. 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. Other NPS pollution sources such as leaky septic systems, urban stormwater sources, and impermeable pavements contribute to nutrient loading and sedimentation in varying amounts depending on the land-use within each unique AU. Private shoreline properties impact the quality of sand beaches through inputs from household septic tanks and shoreline hardening causing reduced water quality. Plastic pollution and large litter items washing up from the Lake's nearshore zone, whether human-made or natural, end up accumulating on sand beaches and dunes, and unless regularly tidied become buried as sand dunes mature. During high lake levels, infrastructure, pollution, and litter are exposed as the lake erodes beaches and dunes away (Figure 15).

Figure 15 - Staircase exposed by bluff erosion (Photo by Ewa Wronka, 2019).

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) stating:

"Algae clean up shall be carried out on a limited basis 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 15 cm wide, 2.25 cm deep and 250 m long, no action will be taken… The harvester must be used within 4.9 m 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.

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 since 2013 (Huron County Health Report, 2015; ECCC & USEPA, 2018; Figure 16). County Health Units regularly monitor water quality on beaches and at key recreation nodes along the southeastern shores, publishing the results to inform visitors of safe or unsafe swimming conditions. The Environment, Law and Policy Centre found, *"a single beach closure due to a pathogen like Escherichia coli (E. coli) reduces recreational value by around $2 per trip or around 10%". Beaches 'posted' with a high bacteria count reduces trust visitors have in visiting the area, causing some tourists to choose different locations to visit –affecting the area's long-term economic stability"*. Public health and safety and the local economic impact of tourism are two of many reasons why water quality concerns are important to monitor on sand beaches. Understanding how water quality affects the social, economic, and ecological value of an area quantifies the impacts.

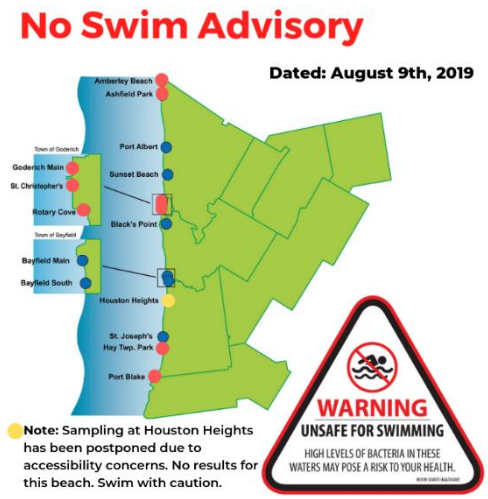


Figure 16 - Huron County Health Unit Facebook post (2019)

In areas with high visitation rates like sand beaches and dunes, plastic pollution is increased through littering, escape from garbage receptacles, and lack of awareness about 'pack-in, pack-out' methods. Plastic pollution enters beach areas from littering onshore, 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 wildlife entanglement, animal consumption of plastic waste, and potential human safety risks. Information on plastic pollution 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 are worth $15 to $25 per trip. [Others] estimate that beach recreation in the lower peninsula of Michigan is worth $32 to $39 per trip for day-trips, and around $50 per day for multiple day-trips," (ELPC, 2019). Therefore, balancing demands for tourism and preserving coastal ecosystems for the ecological functions are important to mediate threats and stressors of over-use.

Socially acceptable 'beach use practices' such as parking on beaches have changed as awareness of the damage these actions do grows. Publicly communicating the impacts to beach ecology and dune integrity caused by parking has almost stopped the trend all-together (Figure 17). There are still many impacts from current recreation and maintenance methods yet to be rectified.


Figure 17 - 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 simple, effective methods 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 7).

Table 7 - 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	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 threat prevalence is done using indicators, shoreline regulations and approvals. Scientific literature and coastal best management practices have determined 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. The Dune Vulnerability Index (DVI) determines vulnerability comparing the dune's ability to return to its original 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 8. Unfortunately, indicators in relevant literature don't pronounce gradients that would specify stable, minor, moderate, and severe conditions. Work is needed to formulate gradients for quantitative analysis and monitoring.

Table 8 - 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 8) is a comprehensive method of beach health analysis and can be employed by shoreline managers, private landowners, and interest groups to measure changes in this habitat. To broadly characterise biophysical vulnerability components of coastal dune systems, variables enunciating signs of degradation or regeneration of the system, and the type and necessity of managed response have been described in the Dune Vulnerabilities Checklist by the Lake Huron Centre for Coastal Conservation (Table 9).

Table 9 - 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.

The Dune Vulnerability Checklist is the broadest version of sand beach and dune health and resiliency monitoring, compared to the intricate details of the DVI. 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).

Combining the DVI and Dune Vulnerability Checklist to create a 'user friendly' standardized methodology to monitor dune and sand beach ecosystems on the southeastern shores would enable standardized monitoring of this ecosystem. A standardized approach of monitoring identifies areas that need conservation, rehabilitation, or restoration action. Table 10 lists threats and stressors affecting sand beach and dune ecosystems.

Table 10 – Beach and dune ecosystem indicators identified for the southeastern shores 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).
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.

CURRENT MANAGEMENT STRATEGIES

Sand beaches and dunes occur mainly AUs 1 to 4 and 6. Therefore, there it is mostly organizations in these regions that have specified mandates and management plans regarding sand beaches and dunes. See Appendix A for full analysis of hectares of sand beach and dune ecosystem per Assessment Unit.

REGULATORY TOOLS:

Municipal Official Plans

Lambton County (LC) includes in its 2017 Official Plan that sand beaches are primarily used 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 are 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" (County of Lambton, 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.

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 vegetation removal, vehicles on the beach, open fires, and animal waste 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.

CA Regulation, Management & Reports

The Province of Ontario, including the Ministry of Municipal Affairs and Housing defines 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 and sand beach and dune habitats, not all beaches across the southeastern shores are considered 'dynamic' or have regulation (e.g. in areas where no CA exists). Therefore, there are gaps within the regulation and the awareness of landowners on privately owned shoreline areas. Deciphering differences in beaches, or 'blanket' regulating beach areas in regulatory management documents will provide consistency in the long-term management of coastal wetlands 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 resilience 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 beach health (Huron-Kinloss, 2015).

Educational initiatives using interpretive signs (Figure 18), 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.

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).

Figure 18 - Dune ecosystem signage from LHCCC

RECOMMENDATIONS:

1. **Standardized beach and dune monitoring protocol:**

Examining indicators, thresholds, and monitoring techniques at different scales suggests a need for a standardized beach monitoring protocol to consistently monitor and management Lake Huron's beaches and dunes. No established, widely accepted methods are currently used to determine health of beach and dune ecosystems within the coastal corridor. A system like the *Ecological Land Classification Guide for Southwestern Ontario* could be derived to establish thresholds and indicators for ecological integrity. An example of established monitoring across jurisdictional boundaries is the Conservation Authority Watershed Report Cards published every 5 years with standardized descriptors and ratings for ecosystem health.

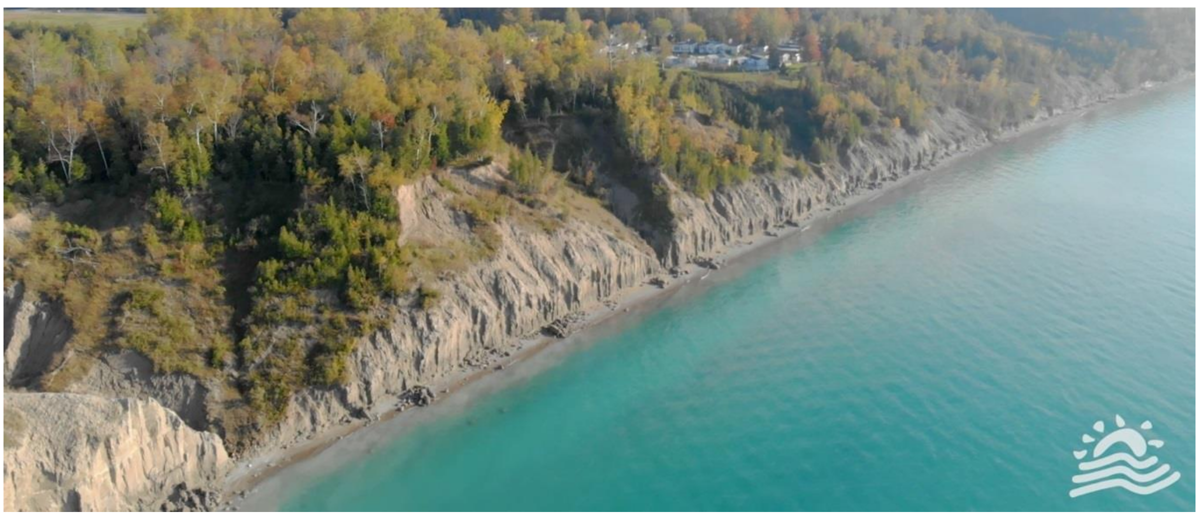
2. **Continuity of municipal bylaws:**

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 confuse shoreline residents residing in different municipalities and aren't aware of the specificities within their area. Recommended actions include a review of bylaws among municipalities to incorporate sand beach and dune best management practices and consistent regulation of activities on beach and dune ecosystems.

3. **Improved public awareness:**

Public education focusing on coastal ecosystem fragility will encourage improving the resiliency and sustainability of land-use practices in the coastal corridor. Many agencies contribute to public education through programs like Eco Mentors, public presentations, and speaker series events. Continuation of these efforts is needed to ensure a coastline of informed, educated lakeshore residents and visitors who protect sand beach and dune ecosystems. 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 combinations. Bluffs are prone to erosion due to their direct interaction with changing lake levels* (LHCCC, 2013).

ECOSYSTEM DESCRIPTION

Lake Huron's bluffs are erodible, sandy cliffs, non-erodible limestone dolomite, or bedrock cliffs. The bluffs on the southeastern shores exist between Grand Bend and Amberley Ontario consisting of St. Joseph till composed of 86% silt and clay, and 14% sand, gravel, and cobbles (Davidson-Arnott & Mulligan, 2016). The bluffs, also-known-as the Algonquin Bluff, "provide a distinct boundary between the Huron Slope and the Huron Fringe regions, due to a 10-30m near vertical drop" (HLH, 2012). In the southern third of the coastal corridor, bluffs up to 18 metres tall lie parallel to the shoreline, fronted by a narrow reach of beach (Davidson-Arnott & Mulligan, 2016). These erodible bluffs are a volatile environment covering 368.87 ha of the coastal corridor; equating to less than 1% of the total study area.

Figure 19 – Cohesive bluffs on Lake Huron

Bluffs are vulnerable to human destruction and alteration due to their location. Coastal bluffs and cliffs offer spectacular waterfront views and are visible from the water. The scenic beauty of this area attracts recreational boaters, contributing to local economies. Scenic views and waterfront locations inflate property values, making this area of coast highly desirable (Hubbard et al., n.d). From an ecological perspective, bluffs and gullies are valued for their ability to erode. Vertical cliffs comprised of glacial till provide habitat for local and migratory species, and supply sediment to beaches down-drift. 72% of the sediment feeding beaches on the southeastern shores originates from bluff and gully erosion (ABCA, 2019). Sand beaches on Lake Huron would be sediment-starved without the inputs of sediment from bluffs. Ecosystem services provided by bluffs include habitat, carbon sequestration, and water-retention.

Figure 20 - Development on Lake Huron bluff

Although erodible bluffs are volatile and ever-changing, natural stabilization methods including vegetated buffers, water-flow reduction across the landscape, and proper development setbacks are the easiest, cost-efficient methods to preserve slope stability of bluffs (MVCA, 2013a). Natural stabilization is attractive for landowners with buildings on erodible areas of shoreline.

THREATS AND STRESSORS

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

4.4.1 Development and site alteration

Development and site alterations include (1) homes, septic systems and municipal infrastructure like roads; (2) vegetation removal, non-native shallow rooting vegetation; (3) shoreline hardening structures. Bluffs on the southeastern shores have been developed by seasonal and permanent communities with infrastructure built 60+ years ago to present day. Development on the bluff head and within high-risk bluff erosion zones can cause mass wasting events from the added weight at the edge on unstable sediment layers. Shear stress failures caused by excess weight occur on steeper bluffs than those with gradual slopes. Vegetation removal on bluffs, including trees, shrubs, grasses, and downfall to 'improve' views has increased the potential for erosion and slumping. Although vegetation stabilizes sediment on healthy bluff slopes in the 3 to 1 slope (run-over-rise), no amount of vegetation can prevent shear stress failure. Limiting weight-loading on bluff slopes by restricting development and current loads by removing structures can reduce the potential for slope failure. 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" (USACE, 2003, p.16).*

Over 1,150 landowners with buildings in the 15 m high-risk areas due to volatile bluff structure are at risk for damage to structures due to bluff failure (Allan, Callewaert & Olsen, 2018; 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, snowmelt, 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 would not naturally be (e.g. septic tanks and weeping beds), bluff seeps could occur, 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).

Increasing vegetation on slopes to absorb groundwater or water in seeps, as well as protect against surface erosion from precipitation and stabilizing the slope with deep roots will reduce the threat of ecosystem loss and slope failure. It should be noted that a bluff barren of vegetation does not necessarily mean it is 'unhealthy' but that it experiences increased erosion potential. However, if a bluff is meant to be vegetated but vegetation has been removed, this will contribute to a moderate or severe ecosystem health condition of that bluff, expediting erosion. 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 is extremely important for the preservation of critical nesting, feeding, and breeding habitat. Understanding that niche species use non-vegetated slopes is important from an ecological management and development perspective. 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 the spread of these species when restoring bluff environments is extremely important in maintaining ecological integrity. Removing invasive species and immediately replacing them with native species reduces the 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 population density.

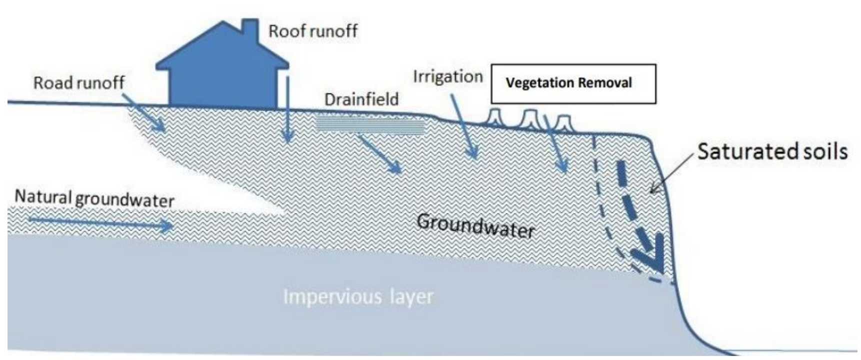


Figure 21 - Groundwater recharge along bluffs (Nichols & Brzozowski, 2014).

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 since the 1960s to 'protect' shorelines from erosion but are not ideal, as they are 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 causes unnecessary compromise to slope stability versus implementing natural protection measures.

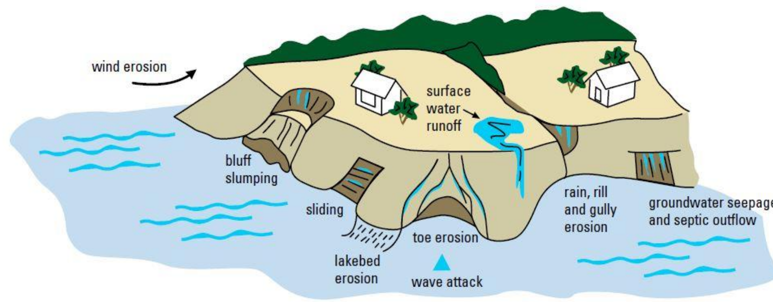


Figure 22 - Bluff erosion types (USACE, 2003)

4.4.2 Climate change

Climate change impacts bluffs along the southeastern shores of Lake Huron in two ways: (1) heavier precipitation, more storms, and extreme weather events; (2) sporadic and intense lake level changes. An increase in the average number and intensity of storms in the winter months will directly increase erosion of cohesive bluff shorelines and lead to increases in bluff recession rates on the Great Lakes. Lake levels are generally lower in the winter months, potentially limiting increases in short-term bluff toe erosion, simultaneously increasing erosion of the nearshore profile (underwater) leading to an increase in long-term recession rates (ELPC, 2019). "*Underwater erosion of the lakebed controls the rate of recession of adjacent cohesive shoreline slopes, allowing waves to reach the toe of the bluff increasing rates of recession… Measurements have shown rates of vertical erosion in the range of 1 to 15 centimetres per year. Typical erosion rates are 3 to 5 centimetres per year*" (USACE, 2003, p.10). Increases of storm intensity and frequency partnered with changes in lake levels will cause toe erosion rates to increase, leading to more frequent, serious slumping events (Figure 22).

Lake water levels fluctuate from low to high (approx. 2 m), highs occurring every 10 to 15 years (Figure 23). Erodible shoreline ecosystems like bluffs, are restructured during times of high lake level. Beaches at the toe of the slope protect bluffs by absorbing wave energy, preventing erosion caused by wave action (County of Huron, 2015). 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" (ABCA, 2019, p.15). However, during high lake levels, the toe-beach is under water, exposing the bluff-toe to wave energy, causing toe erosion (Figure 22).

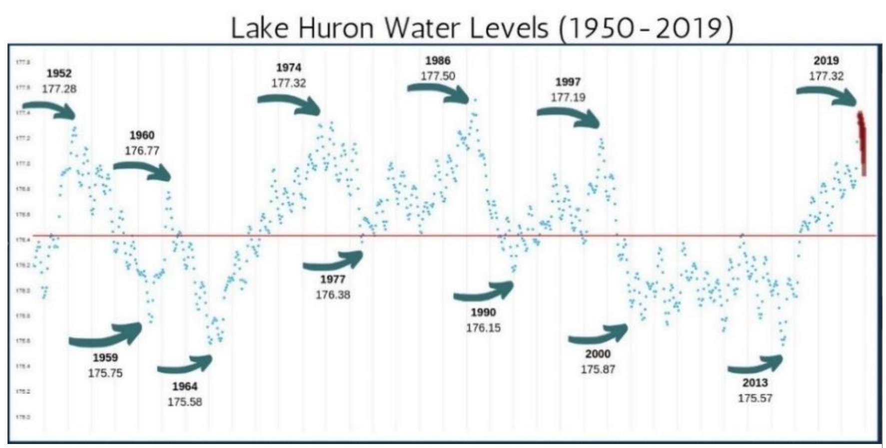


Figure 23 - Lake Levels on Lake Huron 1950-2019

> *"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 decreased lake level will result in reduced bluff recession rates for a period of several decades and dune progradation of sandy shores. Conversely, an increased lake levels will result in an increased rate of bluff recession for several decades and landward migration of the shoreline and foredune on sandy beaches"* (ELPC, 2019).

Lake levels will continue to fluctuate regardless of climate change or anthropogenic influences. Therefore, understanding that toe erosion 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, wave direction, and weather, but can be amplified by 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). Bluffs on the southeastern shores differ in erosion rate and associated risk to landowners. The bluff's slope face and the top of the bluff can erode in small quantities over time, or quickly in one mass-wasting failure event (Allan, Callewaert & Olsen, 2018). 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. "The effects of rainfall are reduced by the presence of continuous vegetation cover which shelters the soil from raindrop impact, slowing 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 and wave energy. Figures 24 & 25 show historical annual average bluff recession rates along sections of the shoreline. Estimated recession rates range from 0m/year to 0.98m/year (Davidson-Arnott & Mulligan, 2016; MVCA, 2013a). In the ABCA shoreline alone, they estimate that on their shoreline alone:

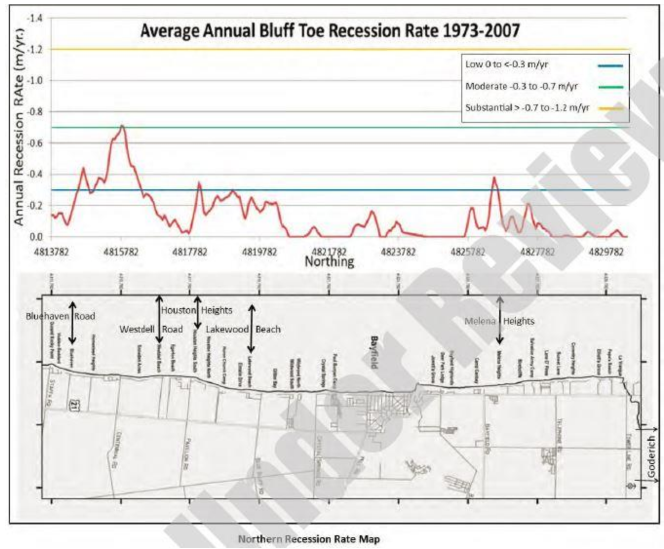


Figure 24 – Historical depiction of bluff recession rates (ABCA, 2019)

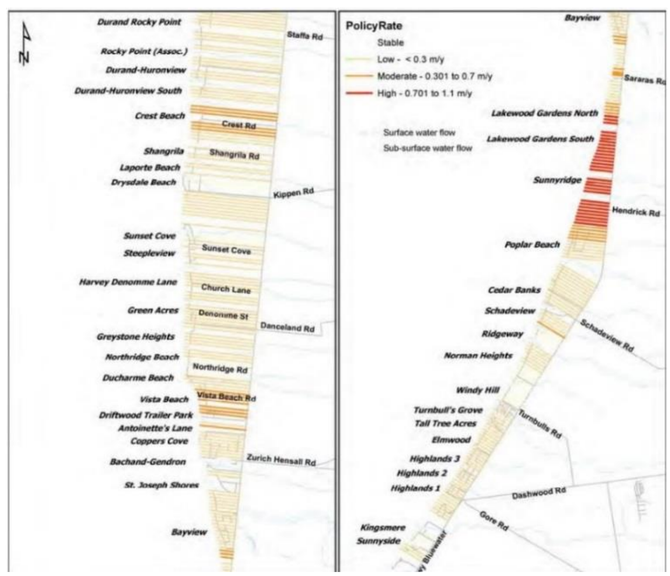


Figure 25 – Historical depiction of bluff recession rates (ABCA, 2019)

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

Most of Lake Huron's bluffs have low annual erosion rates, but threats and stressors can cause serious failure events of 1.5m to 15.25 m losses from the bluff head in one event (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. Figure 25 is an example of a historical bluff recession rate study completed on Lake Huron. Reiterating these zones of recession to landowners on a semi-annual to bi-annual basis to update for slumping events will assist in educating lakeshore landowners about the coastal environment they choose to reside upon. Creating a culture of environmentally aware and educated citizens is imperative to protect bluff ecosystems, the ecological integrity of these areas and public safety of those living on 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. Although suggested bluff hazard checklists exist, such as Table 11 adapted from Bhurji, 2014 by LHCCC, there are no established indicators and thresholds currently used along the southeastern shores to monitor ecological integrity and health of bluff environments.

Table 11 - 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 11 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 specific management recommendations based on the outcome score. Table 12 provides an overview of bluff indicators identified by the CAP Steering Committee that best fit bluffs on the southeastern shores.

Table 12 - Bluff ecosystem indicators identified for the southeastern shores 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 specificity into threshold quantification. Data collected across the shoreline using checklists such as Table 11 could establish a baseline assessment dataset, resiliency recommendations and thresholds for ecosystem integrity.

CURRENT MANAGEMENT STRATEGIES

Bluffs exist in a limited area of the southeastern shores, between Assessment Unit's 1 to 3. See Appendix A for full analysis of hectares of bluff ecosystem per Assessment Unit. 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.

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 international plans 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, the last resort and not recommended.

Development Guidelines – Shoreline Protection

	Bluff Areas
Shore Protection - new	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 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
Groynes -replacement or maintenance of existing	Permitted, but will be considered on a case by case basis.

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

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

REGULATORY TOOLS:

Erodible bluffs exist within Assessment Unit's 1 to 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 were 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. 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" (County of Lambton, 2019).

CA Regulation, Management & Reports

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 (ABCA, 2019). In Appendix F, there are clear development guidelines for bluff areas regarding development, building, alterations, and methods for structure relocation (ABCA, 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 26, is an example of shore protection regulation.

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

Regulatory tools such as this SMP, provide clear, decisive development guidelines for bluffs, helping landowners understand what is safe to do 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 the management of bluff environments. Figure 27 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).

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:

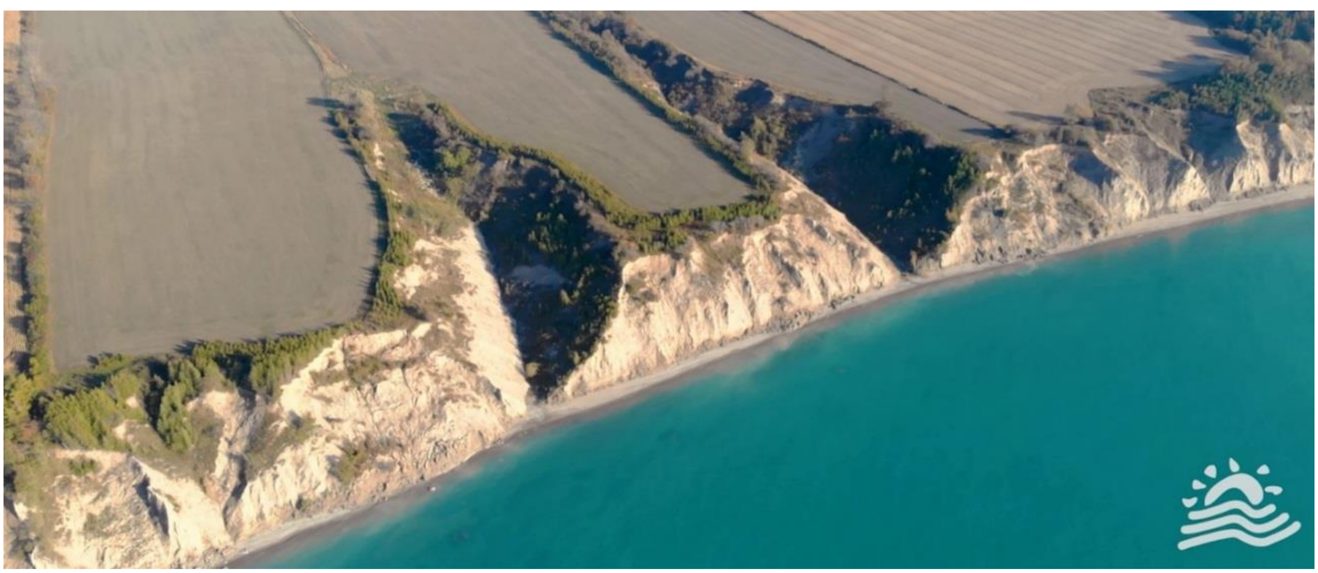
1. **Consistency in regulation, policy, and compliance:**

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 by 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. Standardization 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).

ECOSYSTEM DESCRIPTION

Approximately 200 gullies have formed along the southeastern shores of Lake Huron between Grand Bend and Port Elgin Ontario. These gullies are diverse in their conception, some occurring naturally, and others formed through anthropogenic influences and land-use change to moderate stormwater. Anthropogenically influenced gully development began in the 1800s with deforestation in southwestern Ontario for agriculture. Less vegetation increases water flow across the landscape accelerating soil erosion on 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 where erosion by small streams flow down the steep bluff slope. Gullies grow by extending inland producing unstable slopes on either side" (Davidson-Arnott & Mulligan, 2016, p.38). Once carved, gullies provide avenues for easy downslope movement of precipitation and snowmelt. Flowing water erodes soil from the gully sides and floor, making it wider and deeper. Landslides, slumps, and processes similar to bluffs contribute to the removal of slope sediments and vegetation. The gully entry point advances inland, enlarging the gully system. Gully erosion supplies nearshore waters and beaches down-drift with sediment. Approximately 10% of the sediment feeding beaches on the southeastern shores comes from gully erosion (ABCA, 2019).

Gullies are in most cases well-vegetated, vibrant wildlife corridors for mega-fauna including white-tail deer and migratory birds. Within Assessment Units 2 and 3, there are +100 streams, many which have formed gullies discharging into Lake Huron (MVCA, 2013a). Most gullies are relatively stable with little obvious erosion. However, drastic changes during precipitation events, snowmelt, and increased water flow rate events can cause significant erosion and even vegetation elimination on slopes (MVCA, 2013a). Entry (upland) and exit (lakeshore) points of these gullies experience the most erosion naturally due to water-inputs during the spring freshet and wave action during times of high lake levels with water inundating the mouth of the gully, pooling water (MVCA, 2013a). Lower lake levels provide wider beaches, sometimes cutting off the 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, and Google Earth 2018, orthorectification described gullies consuming 2% (1,830 ha) of the total coastal corridor (85,838 ha).

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 typically human-caused influences (e.g. pollution, vegetation removal). 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 variability in storm frequency. "*Heavy rainfall following periods of dryness are anticipated to be more common in coming decades, decreasing bluff stability. Bluffs destabilized by frequent cycling between freezing and thawing temperatures are expected to accompany warmer winters*" (Kemkes & Salmon-Tumas, 2019, p.76). Research by Maitland Valley Conservation Authority identified an increase in intense precipitation events throughout the watershed, in autumn, 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 potential erosion 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 (County of Huron, 2015). Areas of vegetated habitat within the 100 m buffer zones of gullies and valley lands are considered significant in most County planning documents (County of Huron, 2015).

4.5.3 Point and non-point source pollution

Inappropriate use 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 gullies adjacent to their communities were being used for yard waste and garbage disposal and cited 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 and agricultural runoff 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. These are 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 and reduced buffer zones around up-stream creeks and gullies contribute to increased nutrients entering the lake. Keeping gullies vegetated encourages nutrient absorption before entering the lake. More information can be found in Chapter 5.

INDICATORS AND THRESHOLDS

Coastal buffer zones are simple, effective ways 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) recommend natural forested buffer zones of 20 to 30 m from the watercourse's edge, a crop tillage buffer zone of 10 m from a watercourse's edge, and a 22.9 m setback distance for buildings and structures.

Bluffs and gullies are bundled into the same regulatory framework managed under an environmental hazard category by CA's and municipalities. Gullies are exit canals of streams, and are considered 'valley land'. SVCA specifies the need for vegetation along watercourses, especially those entering gullies:

"The health of watercourses is integral to the health of a watershed, providing key ecological and hydrologic functions such as habitat for fish and wildlife, sediment and nutrient transport and deposition, transfer media for energy and organisms, source of water supply and contributions to the hydrologic cycle… changes to

channel morphology reduces the watercourse's ability to process sediment causing erosion and changing the amount or size of bed load being moved. Loss of riparian vegetation results in more pollutants and run off being transferred from the land to the water, impacting water quality and flooding downstream" (SVCA, 2017).

Ensuring watercourses entering gullies have ecological integrity protects and improves the health of gullies along the southeastern shores. Indicators and thresholds rating the health and resiliency of gullies gathered through the official plans of municipalities, Province of Ontario, and CA planning regulations considering ecological integrity and human safety include;

Vegetation:

- A vegetated buffer at least 100 m wide from the top-of-slope to encourage vegetation regeneration and wildlife movement, "All-natural heritage patches within 100 m of a gully or valley land are considered significant" (County of Huron, 2015 p.18).
- "Amount of forest cover within 30 m of riparian zones 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, 30 m buffer zones are recommended around the top of a gully slope (County of Huron, 2015).
- "No development shall be permitted within 30 m of a cold-water stream bank or 15 m of a warm water stream. Landowners are encouraged to forest the area within 30 m of streams to maintain and improve fish habitat, ecological function of the stream and to increase natural connections" (County of Bruce, 2010).

CA's with gullies include an analysis of gully health in their 5 year Watershed Report Card, described in detail in the current management strategies section. Table 13 provides an overview of gully indicators adapted from relevant literature identified for gullies on the southeastern shores of Lake Huron.

Table 13 - Gully ecosystem indicators identified for the southeastern shores of Lake Huron.

GULLY INDICATORS IDENTIFIED	THREATS AND STRESSORS
% Vegetated buffer zone (30 m 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 unique features existing within Assessment Unit's 1 to 4 and 6 on the southeastern shores. See Appendix A for full analysis of hectares of gully ecosystem per Assessment Unit. Gully environments are known as 'hazard lands' to CA's and landowners but are not limited to that term. Many regulations exist for bluffs and gullies to protect human safety in the event of a failure, slump, or erosion event. From a CA perspective, gullies are often separated into two categories; 'significant valley lands' and regular gullies. CA's regulate significant valley lands and areas adjacent to river or stream valleys, great lakes shorelines, watercourses, hazardous lands and wetlands (SVCA, 2017). 'Significant valley lands' are managed on a case-by-case basis, in which development and alteration are rejected inside or adjacent to gullies (within 50 m) (County of Bruce, 2010). Unapproved development and site alterations are not policed frequently meaning 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 m of streams to maintain and improve fish habitat, the 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 there will be recognition of individuals who re-forest sensitive stream buffer zones. Clarity or reference to appropriate sub-plans is needed within County Official Plans to encourage funding applications subsidising restoration projects; increase landowner awareness through educational programming and outreach; and enforcement monitoring.

REGULATORY TOOLS:

CA Regulation, Management & Reports

Gullies have setback and development regulations through Conservation Authority jurisdictions. CA's, such as SVCA recommend in their Planning Policy Manual (2017) that existing valley lands be maintained in their natural state; to protect valley lands through the completion of an EIS or appropriate setbacks for planned subdivisions, preferring methods to dedicate valley lands to the municipality to ensure protection. Through this Manual, SVCA also does not recommend new development, site alteration, and lot creation on land adjacent to valley lands unless an EIS has been completed. SVCA also recommends that septic systems, storm sewers, and transportation corridors not be placed in valley lands or their buffer zones, unless approved through an Environmental Assessment process. Provincial regulations on gullies are determined depending on slope stability;

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

Depending on the gully's slope stability, different setbacks apply on a case-by-case basis. Educating landowners living beside or near gullies about how to properly manage this ecosystem may organically change actions and land-use adjacent to gullies if risk factors are known. Stewardship tools such as plans, fact sheets, and best management practice guides are recommended.

STEWARDSHIP TOOLS:

Bluff and Gully Stewardship Plans

Bluff and gully stewardship guides and plans on the southeastern shores were prepared by the Lake Huron Centre for Coastal Conservation (LHCCC). The LHCCC's website and resource library have information on gully stewardship. Some practical tips include:

1. Slow down water: too much water is artificially directed into gullies. Stormwater runoff from tiled farm fields, roads, driveways and downspouts, and impervious surfaces (concrete, asphalt) funnel water into the ravines in torrents when it rains, accelerating erosion. Professional consultation is needed to address serious drainage problems.
2. Don't throw yard waste into ravines: smothering 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 better than lawns that have shallow root systems and are prone to erosion.
4. Do not 'clean up' shoreline areas by removing vegetation: Erosion is magnified by indiscriminately removing shoreline vegetation increasing the speed of stormwater. Runoff can quickly create gullies and washouts, undermining landscaped areas and generally create more problems.

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

RECOMMENDATIONS:

1. **Raise awareness of buffer zones for ecological integrity and 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. Clarity regarding buffers for landowners would assist them in being sustainable land stewards. Recommended buffers in the literature include:

- 3 to 6 m buffer: Undisturbed land from the top-of-slope to reduce erosion (Cross et al., 2007);
- 10 m buffer: of natural land between edge of watercourse to crop production (Stewart et al., 2003);
- 30 m buffer: Development buffer from the top-of-slope to protect from load stress (County of Huron, 2015);
- 100 m buffer: Vegetated land to fortify sediment from erosion, provide a habitat corridor to support wildlife movement, and keep water in gully cool (County of Huron, 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 in 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 Network, or Healthy Lake Huron – Clean Water, Clean Beaches Partnership (Lake Huron Southeast Shores Initiative), may encourage individuals. Supporting and encouraging the public to clean up gullies would increase awareness of the threats of pollution, as well as create community stewards in these areas to keep up positive action.

3. **Re-naturalizing creeks entering gullies:**

Supporting existing programs and identifying gaps in restoration efforts to restore straightened creeks will slow down water entering gullies. Examples of these such projects exist in the work of MVCA, the Pine River Watershed Initiative Network, and private landowner efforts. Continuing these programs through advertising and financial contributions will improve water quality in the nearshore zone. Figure 28 illustrates the shape of channelized vs natural meandering stream.

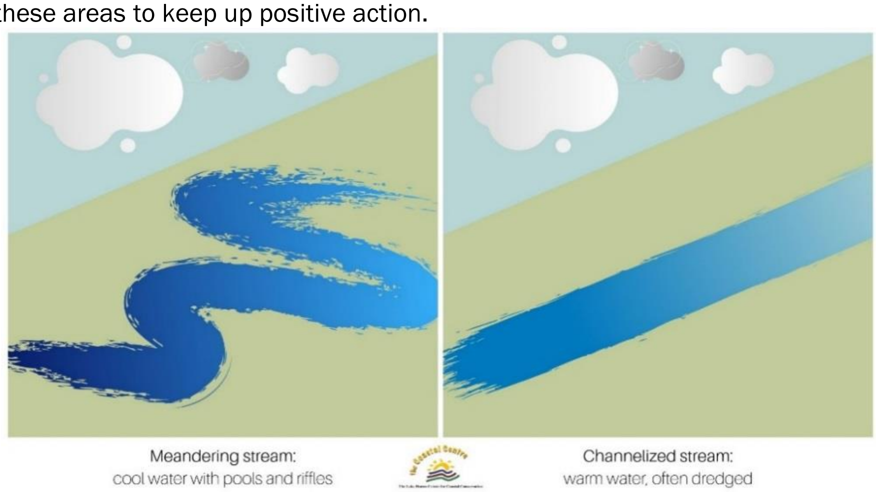


Figure 28 - Natural vs. channelized streams

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

Implementing buffers between the lake water mark and the gully exit will reduce bank erosion and ensure the toe of the slope is protected. Dune restoration and beach protection is discussed in Section 4.1

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

BMP guides distributed to landowners adjacent to gullies will raise awareness of proper land-use practices in these volatile zones. Supporting programs that overlap with BMPs e.g. septic inspection programs, replacement grants, and alternative products will enable positive uptake.

- 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 the local CA when making changes, repairs or upgrades. Avoid adding to groundwater where possible (green roof infrastructure, rain barrels, rain gardens).

4.6 COBBLE SHORELINES

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 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 to 256mm), pebbles (4 to 64mm) and granules (2 to 4mm) varying in size and diversity larger than sand (<1mm) (UH, 2014; Alden, 2017; DFO, 1996). Storm waves disturb beaches reconfiguring the stones and removing finer clay, silt, and sand from eroded glacial tills, resulting in leftover cobble layers with fine till material underneath. During the winter, shoreline ice freezes to the lake bottom plucking cobbles loose during storms. "*Other rocky shores composed of bedrock and large boulders do not experience this movement of rock… Cobble beaches are reflective, meaning that they reflect the wave energy that strikes them and are dominated by plunging breakers*" (DFO, 1996, p.5). Visitors to cobble beaches recognize the distinctive sound cobbles make as the powerful wave action moves them around, creating sounds like pins colliding at a bowling alley.

Cobble shores have a "wrack line", a distinguishable line of driftwood, algae, dead grasses and other items pushed onto the shore by waves (DFO, 1996). Wrack lines provide nutrients and habitat for insects, birds, and small rodents. Only highly adapted plants and animals can survive on cobble shores due to their ever-changing nature, making these areas sensitive to human and natural disturbance (DFO, 1996). The high energy nature of cobble shores and permeability of cobbles limits soil development and vegetation establishment, usually less than 5% vegetated (Kost et al., 2007; MSU [1], n.d). Limestone cobbles create calcium-rich environments favoured by species like Goldenrods, Rushes, Dogwood, and Poplar (Kost et al., 2007). Fauna living on cobble shores are small invertebrates like Crayfish, Mayfly and Stonefly species, and bird species like Ring-billed Gulls, Common and Caspian Terns, and Killdeer (Kost et al., 2007, DFO, 1996). Reptiles use cobble beaches for feeding, nesting, and basking with rare species including Blanding's Turtle and Eastern Massassauga Rattlesnake (within the 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 shores are seasonal spawning and migration areas for predator fish (e.g. Whitefish and Lake Trout) often located beside coastal fens, limestone bedrock shorelines, alvars, and forests on the southeastern shores (MSU [1], n.d). 47 kms of cobble shoreline exist on the southeastern shore (5% of total shoreline). An example of a terraced cobble beach exists at St. Christopher's Beach in Goderich Ontario.

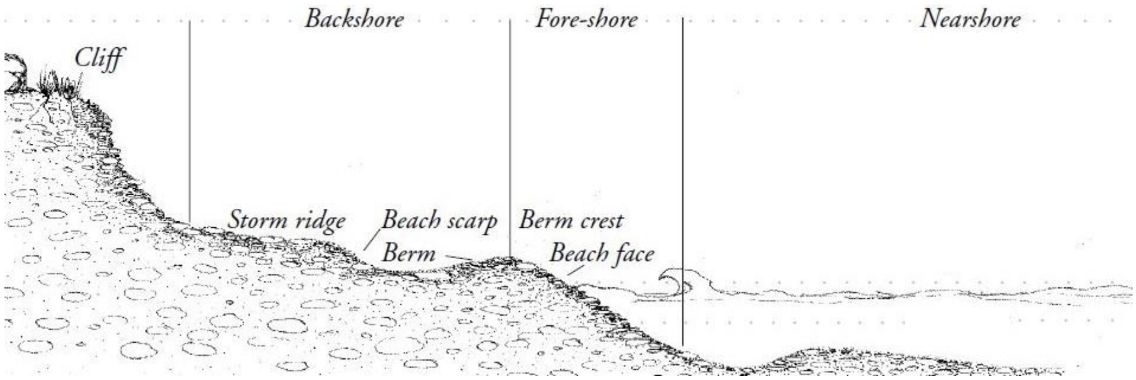


Figure 29 - Profile of a cobble beach (adapted from DFO, 1996)

Beach and shoreline profiles vary depending on lake levels, movement from lake ice, and storm surges. 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). High slopes adjacent to the water may deter some swimmers and beach-goers, but these slopes are more resilient to strong storm surges (McLean & Kirk, 1969).

THREATS AND STRESSORS

Disturbance to cobble shorelines most commonly occurs anthropogenically. Increased visitation and the physical removal of vegetation, wrack line debris, and cobbles to 'clean-up the beach' disturbs the ecology of the shore. Wash-ups of garbage and littering is another disturbance plaguing cobble beaches and most coastal shorelines on Lake Huron. Cobble shorelines are more permeable than other shoreline types, creating a dynamic water quality regime when combining inland runoff and impacts of heavy precipitation events (DFO, 1996). Permeable beaches 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 site-alteration.

4.6.1 Plastic pollution

Cobble shorelines are primarily used for recreation in the summer months. Visitation, combined with dynamic, high energy shorelines create multiple input streams of pollution. Water bottles, plastic twine, fishing line, nets, microplastics, and larger items like tires pose a threat to human health and safety. Plastic waste is commonly consumed by or entangle wildlife. Plastic pollution has a longer residence time on cobble shorelines is of concern due to photochemical degradation of the plastic. Solar radiation breaks-down plastic into smaller fragments making it challenging to clean up the longer it is there (Froklage et al., 2013). Plastic is a known carrier of chemicals latching onto the simple polymers. "Trace metal ions including chromium, zinc, cobalt, cadmium and lead" bind to plastic bioaccumulating in areas like cobble beaches where plastic litter gathers if not regularly cleaned up (Froklage et al., 2013). Many coastal bird species use cobble shorelines for feeding and nesting increases the probability of entanglement and consumption of small plastic fragments. There are reports of birds using plastic fibres and fragments to line their nests, increasing the probability for toxic bioaccumulation in the bird eggs and increasing consumption risk (Froklage et al., 2013).

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 vulnerable 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 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. With the limited nutrients available on cobble beaches and the constantly changing shoreline profile caused by wave energy and ice scour, cobble beaches are at higher risk to introductions of invasive species caused by existing vegetation getting outcompeted by invasives. 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. 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 shores and development protect landowners from hazards 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.

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

COBBLE SHORELINE INDICATORS IDENTIFIED	THREATS AND STRESSORS
% Hardened shoreline	– Cobble erosion (wind, wave, human alteration). – 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.).
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

Cobble shorelines exist in small clusters appearing in Assessment Unit's 1, 2, 4, 5, 6. See Appendix A for full analysis of hectares of cobble shoreline ecosystem per AU. There are no specific management actions attributed to cobble shorelines in the literature reviewed but there were references to dynamic beach areas that are regulated by CA's (see Section 4.3). Cohesive management strategies are needed across political boundaries to ensure consistent management across the coast.

STEWARDSHIP TOOLS:

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, material specifically focusing on this habitat could be created to further educate private landowners and municipalities on their value.

RECOMMENDATIONS:

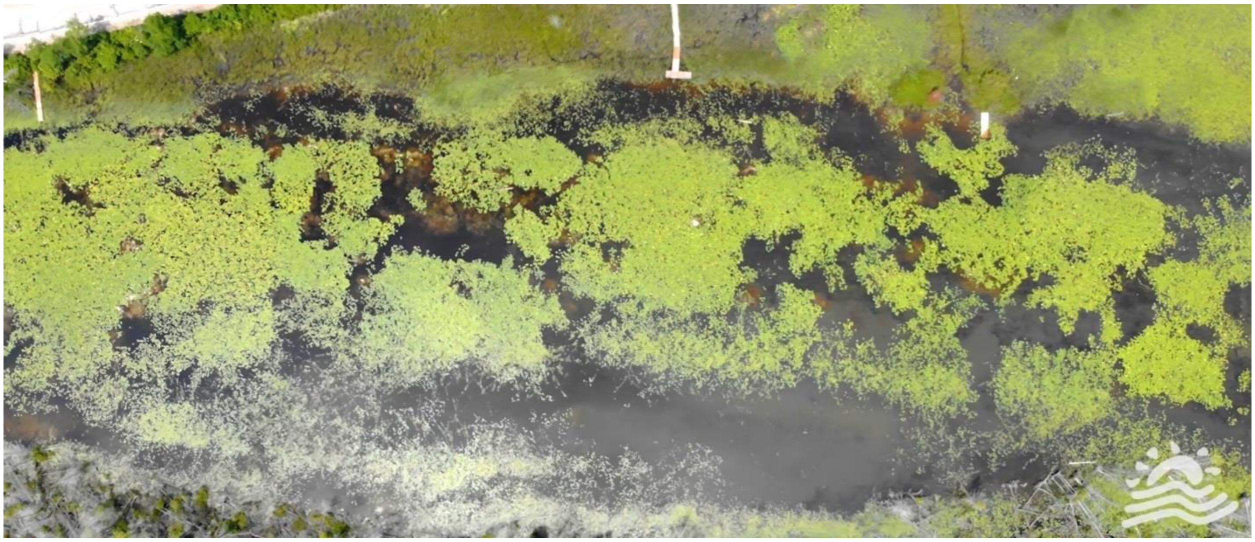
1. **Research and reports of threats to cobble shorelines:**

More monitoring specifically to cobble shorelines to outline the distribution of threats such as development/ hardened shorelines, erosion, and invasive species is needed.

2. **Educational material and guides for public and private use:**

Educating landowners and land managers about the sensitivities of cobble shorelines and the diversity of stressors that face them informs better future management decisions. 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 where the land is covered by shallow water" (Simon et al., 2007). Wetlands occur where there is natural protection from wave action and are strongly influenced by water level fluctuations making their hydrology and vegetation structure different from inland wetlands. Along the southeastern shore 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 Ontario Ministry of Natural Resources and Forestry (MNRF) as wetlands on the Great Lakes or a tributary to the Great Lakes lying either wholly or in part 2 km upstream of the 1:100year flood line (plus wave run-up) of the connected waterbody. Wetlands found within 2 km of the shoreline are considered coastal wetlands and are significant (County of Huron, 2018). The daily seiche, storm event, and interannual water level fluctuations have a 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 an embayment where shoreline geomorphology or bathymetric features (e.g. sand bars) reduce wave energy allowing rooted plants to thrive (Albert et al., 2005). These wetlands 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 to a depth of 2 m, 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 cycle and store carbon because of their high productivity. Ecosystem services provided by coastal wetlands include storm protection, nutrient transformation, removal and storage, non-consumptive recreation, fishing and hunting, and commercial fisheries (Simon et al., 2007).

The southeastern shores of Lake Huron are made up 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 of which is a palustrine marsh near the Chippewas of Kettle and Stony Point Area First Nation. Most coastal wetlands are found on the northern southeastern shoreline. The largest coastal wetland (measured by km of shoreline) is the Oliphant Fen, designated a provincially significant wetland. Refer to Chapter 6 for detailed assessments of coastal wetlands along the southeastern shoreline. Another assessment method involves analysing land-use within the coastal corridor. The coastal corridor includes 11,306.37 ha of wetland habitat.

Six coastal swamps occur in the coastal corridor (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 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).

Table 15 - Species reliant on wetlands in Lake Huron's Coastal Corridor (Adapted from ECCC, 2003).

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 Massassauga.*
Lepidopteran	*Mulberry Wing and Two-spotted Skipper*
Mammals	*Mink, Beaver, River Otter, Raccoon, Red Fox, Muskrat, White-tailed deer*

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 reptiles and 1 PS amphibian; as well as 1 PS lepidopteran species (ECCC, 2003). Table 15 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).

Figure 30 – Ecosystem services provided by coastal wetlands (MNRF Wetland Conservation Strategy).

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 No.28 northwards along the Lake Huron shoreline to just south of Red Bay (Tupman, 2004). The fen varies in width from 20 to 500 m. Therefore, the Oliphant Fen is the largest fen complex on the Great Lakes. The pH values typically range from 7.3 to 8.1, the alkalinity coming from bicarbonate ions (HCO_3^-) present in the groundwater nourishing the wetland. This bicarbonate is produced from dissolutions of dolostone and limestone bedrock yielding dissolved calcium and magnesium. The Oliphant Fen distinguishes itself because it does not contain peat (Tupman, 2004).

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 the 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 take a foothold in locations formerly occupied by meadow marsh and emergent communities. Invasive species, such as *Phragmites australis* will flourish in wetland ecosystems 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 serve as protective cover for young fish and other wildlife when the water rises again. 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 will not recolonize when water levels drop. Studies show that fish and invertebrates respond directly to the presence or absence of aquatic vegetation, serving 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). 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 range of wetland characteristics from water chemistry to plant community composition. Most often vegetation is the first wetland component to be affected. 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 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).

THREATS AND STRESSORS

Coastal wetlands experience threats and stressors from adjacent ecosystems resulting in increased vulnerability requiring frequent monitoring and protection to ensure ecological integrity. Like many coastal ecosystems, coastal wetlands are predominantly threatened by invasive species, land-use change, point and NPS pollution, and climate change. Cumulative long-term impacts also exist but are difficult to assess (e.g. road salting, fertilizer run off, leaking fuels, wildlife predation from domestic animals, recreation over-use) (ECO, 2018). Due to their regulated status, most coastal wetlands have been monitored or restored previously. 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. Historical wetland coverage has been estimated, but no comprehensive estimates of coastal wetland loss are available for the Canadian shore of Lake Huron. Regional losses of coastal wetland habitat are unknown because most of the shoreline is sparsely populated and remote. Most wetland loss is concentrated around small urban centres spread across the coastal corridor. Incremental and site-specific loss of wetland area from expansion of cultivated land and cottage development has occurred in the last 15 years. An example of the extirpation of coastal wetlands along Lake Huron is shown in the Pine River Watershed south of Kincardine Ontario. "160 years ago, wetlands covered >50% of the Pine River watershed. 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 loss and restore area and function. However, conservation remains an uphill battle as losses continue (ECCC, 2002).

Development adjacent to coastal wetlands has long-term negative consequences on the ecological integrity and resiliency of the habitat. Land-use changes within and adjacent to wetlands can take many forms such as roads, structural developments, and agricultural expansion. Human-induced disturbance is associated with increased nutrient and sediment loading from land conversion to agricultural and urban landscapes (Simon, et al., 2007). *"Stressors are 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, habitat fragmentation has commonly occurred. Throughout the Great Lakes region, areas of coastal marsh have been drained for agriculture and urbanization while boat launches and navigational channels cut through remaining marshes (Cooper et al., 2012). Although areas of wetland once developed could be restored, the ecosystem cannot return to its original state, and natural coastal processes may never recover. Once properly restored, coastal wetlands may still provide valuable ecosystem services. Negative repercussions of land-use change and development have the fastest irreversible impact on coastal wetlands. The pertinence of ensuring regulation and policy around development and land-use change in, and adjacent to ecosystems is paramount to their preservation.

4.7.2 Climate change

Coastal wetlands are among the most vulnerable ecosystems due to threats from climate change, including increased storm frequency and intensity, changing water levels, and higher water temperatures (ELPC, 2019). These stressors affect wetland hydrology, impact wetland type flooding them to become 'permanently' inundated, or drying them up entirely (Kemkes & Salmon-Tumas, 2019). Increased evapotranspiration caused by a lack of lake ice and higher temperatures during the growing season 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 nearshore water quality (Kemkes & Salmon-Tumas, 2019). 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 affect the 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. Existence of invasive species within these features could transport easily through the higher water levels infecting a new wetland area damaging the ecological integrity and plant composition.

Increasing water temperatures will reduce the dissolved Oxygen content in the stagnant waters of some coastal wetlands, reducing water quality and ability for certain species of fish to successfully rear eggs and fry. Coastal wetlands show influential changes to the composition of flora and fauna caused by lake level and temperature changes than by changes to land-use in 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 will need to be diligent at maintaining the wellbeing and ability of coastal wetlands 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. 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 (County of Huron, 2018). The value of a wetland is enhanced when they are close in proximity allowing wildlife movement to find favourable habitat, food and mates (County of Huron, 2018). Wetlands situated within 100 m 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 m) 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), wetlands located within 1 km of another wetland, regardless of hydrological connectivity, are functionally connected to that wetland from a biological and social context (County of Huron, 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

Buffer zones are a simple, effective way of reducing impacts to coastal wetlands (Stewart et al., 2003). As described in ECCC's document, *How Much Habitat is Enough*, buffer zones for wetlands are separated into two categories, Critical Function Zones and Protection Zones (ECCC, 2013). In their work, they determine different critical function zone data for wetland species, including zones for turtles, frogs, salamanders, nesting waterfowl, and dragonflies, that rely on wetlands for aspects of their lifecycle (ECCC, 2013). These zones range from 10 to 900 m depending on the species at risk. This document also provides recommended protection zones (buffers) for stressors including sedimentation, herbicide drift, residential stormwater, and human disturbance, most of which do not exceed the recommended 120 m buffer from PSW's but exceed the non-significant wetland buffer of 30 m outlined in the Conservation Authorities Act and Provincial Policy Statement. These two detailed charts from ECCC 2013 are available in Appendix F.

Although different in geographic location, the Department of Fisheries and Oceans Canada has developed minimum buffer widths for development and natural buffers around coastal wetlands on Prince Edward Island. These buffer zones can be used when applying setback distances on Lake Huron's southeastern shores. Stewart et al., (2003) recommend a natural buffer zone of 18.3 m measured from the high water mark or edge of the wetland; a forested buffer zone of 20 to 30 m from the edge of a wetland; a 10 m crop production buffer zone from the edge of a wetland; and a 22.9 m 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 and Climate Change Canada recommends a minimum wetland cover of 6% of every sub-watershed and 10% of every major watershed (Liipere, 2014). Table 16 provides a summary of indicators identified for the assessment of coastal wetlands along the southeastern shores. Indicators chosen provide a baseline inventory and assessment of wetland health in the CAP.

Table 16 - Wetland ecosystem indicators identified for the southeastern shores 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

Wetlands are common across the southeastern shores and coastal corridor, existing in all eleven AUs. See Appendix A for full analysis of hectares of coastal wetland ecosystem per AU.

CA Regulation, Management & Reports

Some CA's refer to wetlands in four categories: Provincially Significant, Locally Significant, Evaluated, and Unevaluated. Depending on the significance category they fall within, differing levels of protection are awarded. Provincially significant wetlands receive a 120 m setback allowance for development, while other wetlands receive a 30 m setback, as discussed in the Conservation Authorities Act, (*R.S.O. 1990)* and Provincial Policy Statement (2014) (Table 17).

Monitoring wetland cover occurs through GIS orthorectification of SWOOP data layers (South Western Ontario Orthophotography Project) acquired on a 4 year basis through the MNRF. Changes to wetland cover are reported through CA planning and regulations departments when a request for development occurs, and through visual changes to land-use identified in orthophotography analysis. CA's in the coastal corridor produce watershed report cards which report the status and health of wetland cover in their greater watersheds. As of 2018, coastal CA's reported wetlands to be in poor condition. These reports specify a need for increases in the number and quality of wetlands to ensure healthy ecosystems upstream and in the nearshore zone.

Table 17 - Reported coastal wetland condition and health as per CA Watershed Report Cards (2018)		
CA	**Rating**	**Comments**
GSCA	No Data	Did not analyse the Lake Huron shoreline (ABCA, 2018).
SVCA	Lake Fringe (Excellent), Penetangore River (Poor), and Pine River (Poor).	"more wetlands are needed in strategic locations, [and] commitment to conserving wetlands is needed across the SVCA jurisdiction" (SVCA, 2018).
MVCA	Eighteen Mile (Poor), North Shore (Poor), Mid-Shore (Poor), South Shore (Poor) (MVCA, 2018).	"remaining wetlands need to be protected because of their important ecological functions" (MVCA, 2018).
ABCA	No Data	Did not give ratings specific to the shoreline watersheds' wetland composition (GSCA, 2018).
SCRCA	Sarnia (Very Poor), Cow and Perch Creeks (Very Poor), Plympton Shoreline Tributaries (Very Poor), and the Lambton Shores Tributaries (Poor).	"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).

Table 17 describes the rating of each coastal sub-watershed, as well as overarching comments made regarding the presence and status of wetlands in the watershed managed by the CA. 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

County Official Plans (OP's) describe the importance of protecting, rehabilitating, and connecting wetland communities. Lambton County's (LC) Official Plan hopes to "maintain, restore, and improve existing wetlands and to increase the overall wetland coverage in the County" (County of Lambton, 2019, 8-8). There is no further detail as to how this goal will be accomplished. 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' principle, which somewhat contradicts maintaining, restoring, and improving existing wetlands (County of Lambton, 2019). Bruce County's (BC) OP (2013) specifies that development proposals within 120 m of a wetland need site-specific environmental impact statements if the development plan meets the policy requirements. BC's OP 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 OP. Huron County's (HC) OP states that there will be no development permitted in coastal wetlands (County of Huron, 2015a). HC's OP 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*" (County of Huron, 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. County OP's address the presence and necessity of wetlands, but need to have clearly worded protections and goals above and beyond current classification as hazardous lands (ECO, 2018). Official Plan cycles are 10 years, during which existing wetlands can be lost in legal loopholes or destroyed through a lack of awareness on the part of the landowner. OP's reviewed clearly state that development plans will be reviewed and utilize environmental assessment protocol but do not specify the prevention of development outright for the preservation of ecosystems.

Regional initiatives

The Environmental Commissioner of Ontario suggests the Province require 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 comprehensive 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 PPS 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 groundwater features" (OMMAH, 2014).*

The Ministry of Natural Resources and Forestry (MNRF) adopted the Wetland Conservation Strategy in 2017. This framework describes a series of actions the Ontario government will undertake including improving Ontario's wetland inventory and mapping, developing polices and tools to prevent the further loss, and improving evaluation of Provincially Significant Wetlands. MNRF administers an incentive program called the Conservation Land Tax Incentive Program (CLTIP), a voluntary program encouraging 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 ensure their protection and enhancement whether privately or publicly managed.

STEWARDSHIP TOOLS:

Some stewardship tools exist 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:**

   Grass-roots groups are taking action against invasive species on the Lake Huron shoreline, but many individuals are still unaware of invasive species. Educating coastal communities near coastal wetlands about the threats and skills to remove invasive species, collaborating to fund larger projects, and supporting early detection will prevent outbreaks of invasive species in coastal wetlands. This method has proven successful in coastal wetlands that have experienced inundations of *Phragmites australis* including 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 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, and mild protection through regulations for non-significant wetlands. Strict, specific regulation is needed to prevent development outright, with loopholes in the language removed. Re-evaluation of the proposed updates to the Provincial Policy Statement, Aggregate Resources Act and the Endangered Species Act by the Province of Ontario are needed to ensure wetlands cannot be developed on or mined for resources. Coastal wetlands are the 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 the monetary value of these ecosystem services should be continued so land managers may better find value in protecting these sensitive ecosystems.

4.8 COASTAL WOODLANDS

DEFINITION: *An area of treed vegetation with canopy cover exceeding 60%. Woodlands are coniferous, deciduous or mixed. Coastal woodlands exist 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 pre-European settlement which covered approximately 90% of the landscape in southwestern Ontario. Between 2000 and 2019, Canada lost 40.7 million ha of tree cover (9.7% total cover lost) (Climate Transparency, 2019). Today, coastal woodlands in the southern two-thirds of the coastal corridor have mostly been reduced to small patches, with contiguous forest swaths to the north. In the northern assessment units, tracts of second-growth forests date from the early 1900s and in some areas the forest stands are approaching older growth, undisturbed conditions (Liipere, 2014). The southeastern coastal corridor of Lake Huron consists of 32,618 ha of 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-drained soils in the south (Figure 31). Coastal woodlands range in structure from naturalized, older growth stands to plantation plots. Plantations are woodlots which were traditionally planted with one species at one time and intensively managed, usually planted and harvested for lumber. Although unnatural, “plantations are 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 improve biodiversity by increasing the presence of species in adjacent woodlands and in the local landscape” (County of Huron, 2018). The wide diversity in woodland vegetation communities and the species that inhabit these areas, challenge assigning a stable definition of a woodland. Woodlands have been defined in Official Plans and bylaws as being at least 1+ hectare in area with trees +6 m in height with a canopy cover of at least 35 to 40% containing:

- 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);
- Not including cultivated fruit or nut orchards or Christmas tree plantations (County of Lambton, 2012; County of Huron, 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, >5 cm DBH, per 0.2 hectares;
iii. 100 trees, >12 cm DBH, per 0.2 hectare;
iv. 50 trees, >20 cm DBH, per 0.2 hectare (County of Huron, 2013)

Woodlands and woodlots will be considered "woodlands" for the sake of this document. GIS orthophoto rectification and partner land-use layers including SOLRIS 2011 were used to derive the percent cover of woodlands per AU.

Ecosystem Services

Coastal woodlands provide shade during the summer, wind break from the intense winds off the lake during storms, Oxygen production, and aesthetic value. It has been proven that living near a forest has positive effects on the stress-processing areas of the human brain. Researchers found that city dwellers living close to a forest are more likely to have healthy brain structure than those without 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). Fundamentally, woodlands provide many ecosystem services including water filtration, air purification, and carbon sequestration. Woodlands are 'living filters' intercepting and storing sediment from inland sources absorbing excess pollutants carried in runoff from adjacent lands. Increased hindrance caused to process functionality deteriorates nearshore water quality (Liipere, 2014). Healthy woodlands are balanced ecosystems home to variety of species, soil, and microbes that contribute to the greater health of coastal ecosystems.

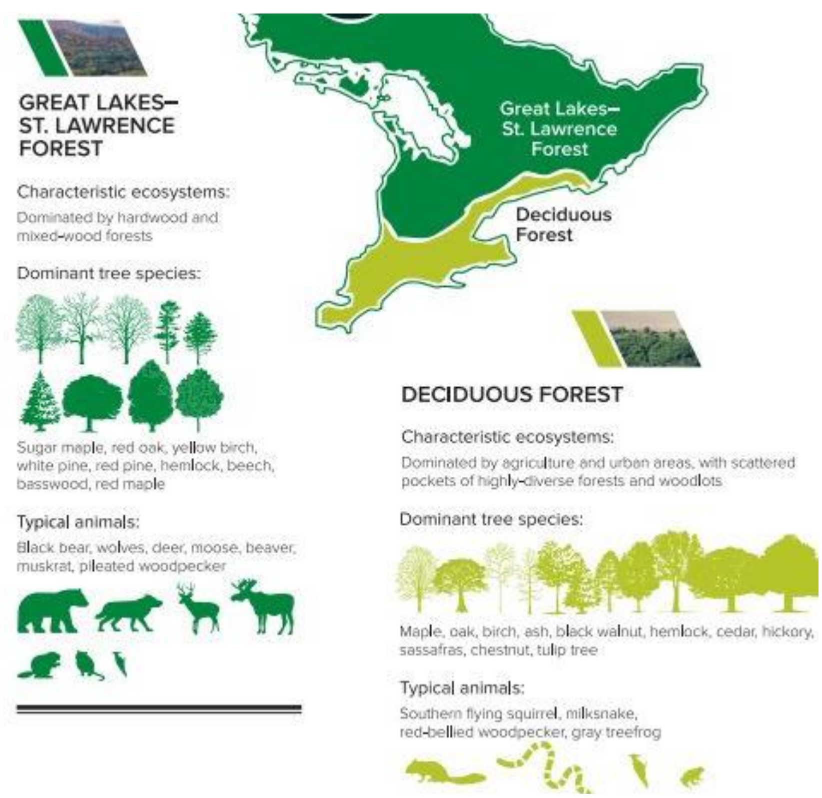


Figure 31 - Southern Ontario's forest regions (MNRF, 2016)

Lake Huron's Coastal woodlands are notorious for hosting rare plant species. 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 >20 sub-species of ferns, accounting for the most diverse fern populations in the coastal corridor (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 another 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 interior woodland loss affects species richness, species adapted to open or successional habitats, as well as those tolerant to human-induced disturbances in general can persist, and in some cases thrive (ECCC, 2013). Ensuring coastal woodland habitats are preserved, protected, and enhanced for the many ecosystem services they provide and the globally rare species they host will support the ecological integrity of Lake Huron.

THREATS AND STRESSORS

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 hold the largest area of continuous forest along the southeastern coastal corridor. In the 1800s, settlers were required to clear land and build one or two structures on their property to establish a claim to that land. Settlers cleared the land of trees to attempt agricultural practices before realizing the shallow soils on solid bedrock were not conducive for traditional tilling practices. Clearing of 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 'tinder', causing large-scale forest fires during the late 1800s. 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 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 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 and prone to disease and pests, reducing the habitats ability to complete ecological processes.

Forest interior is the area of a forest >100 m 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 closer to other woodlands or natural features have more potential for restoring connectivity.

4.8.2 Connectivity and fragmentation

Fragmentation of woodlands, and reduced 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 devoid of woodland patches. The upper third of the shoreline is well forested despite shoreline development (Figure 32).

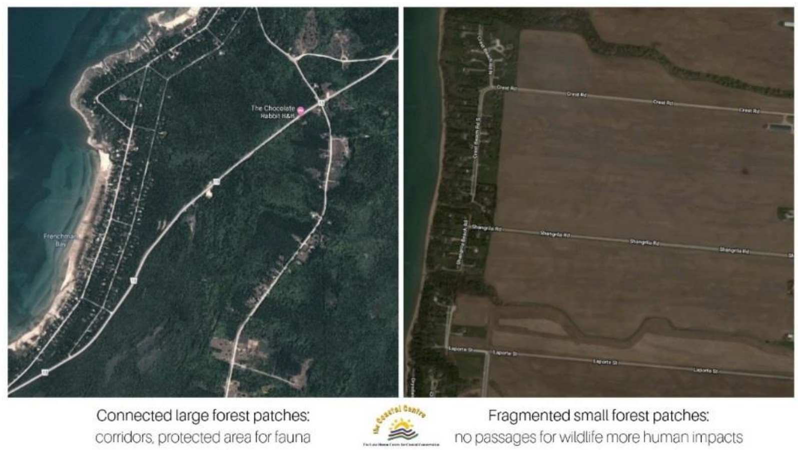


Figure 32 - Forest fragmentation comparison

When woodlands become isolated, the movement of plants and animals is inhibited. This restricts breeding and gene flow resulting in long-term population declines. Woodlands host many species, including Black Bears (*Ursus americanus*) on the Bruce Peninsula. It is important to protect woodlands to maintain habitat for large species with dynamic ranges and distinct territory areas. Although not a rare species, Black Bears embody 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.

4.8.3 Invasive species

The introduction of invasive species into forest ecosystems occurs through recreational impacts, transportation corridors, or natural movement of species. Introduced plant and animal species can alter natural functions in forests by removing the canopy, destroying the understory, or preventing natural regeneration. Woodlands 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

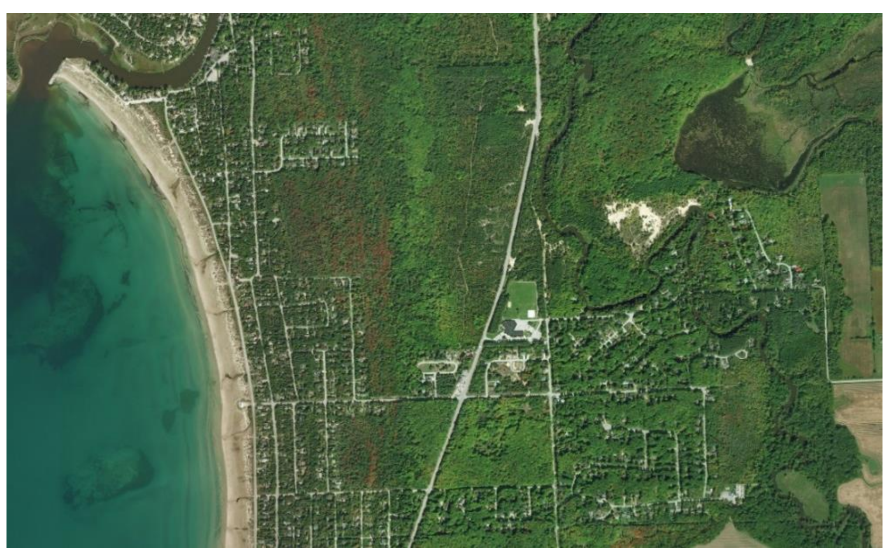


Figure 33 - Roads fragmenting woodland landscape

Ontario, 2016). 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 border.

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 decimating native Ash trees populations which previously dominated 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).

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 (County of Lambton, 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 (County of Lambton, 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).

4.8.4 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 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 to 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 18 shows how these indicators interact with known threats and stressors to coastal woodlands.

Table 18: 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), notes that woodland edge characteristics usually extend 100 m inward from the outermost trees (OMNR, 2010). The NHRM and other supporting documentation recommend woodlands to be considered significant if the have at least 2 ha of continuous interior habitat where woodlands cover is between 15% and 30% of the landscape and are located within 30 m of another natural heritage feature. 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 19 - Natural Heritage Reference Manual for Forest Cover on a watershed scale.

NHRM, 2005 Criteria	% of land cover	Significant Size
Woodlands	<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

The document, *How Much Habitat is Enough*, described in detail forest habitat parameters to follow to ensure woodlands with high ecological integrity. Described in this document, percent forest cover at the watershed scale has ratings to compare existing woodland cover to high-risk, medium-risk, and low-risk approaches to land management:

- "*30% forest cover at the watershed scale is the minimum forest cover threshold. This equates to a high-risk approach that may only support less than one half of the potential species richness, and marginally healthy aquatic systems;*
- *40% forest cover at the watershed scale equates to a medium-risk approach likely to support more than one half of the potential species richness, and moderately healthy aquatic systems;*
- *>50% forest cover at the watershed scale equates to a low-risk approach that is likely to support most of the potential species, and healthy aquatic systems*" (ECCC, 2013).

Contained in ECCC's 2013 Guide are other indicators and thresholds for woodlands, including area of largest forest patch, forest shape, proximity to other forest patches, fragmented landscapes and corridors, and forest quality. Table 20 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 20 - Guidelines for woodland ecological integrity on a watershed scale.

Rating	% Cover	Average size	Large Forest Patches**	Connectivity	
Stable, Low-risk	>50	Should be circular or square in shape*	>5, 200ha forests	Corridors present connecting all woodlands; at least 50m – 100m in width	Forest patches should be within 2km of one another
Moderate, Medium Risk	40-49		2 to 5, 200ha forests	Corridors present connecting most woodlands	Woodlands within 100m of another are significant (County of Huron)
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	

* "*Forest shape determines the amount of core habitat – avoid narrow, linear shapes for maximum core habitat*".
** *Large forest patches should have 200ha of interior forest, with additional hectares of edge forest.*

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 to 100 m wide. 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 100 m of another natural feature as significant. These metrics are used to analyse current woodland cover in the Assessment Unit analysis in Chapter 6.

CURRENT MANAGEMENT STRATEGIES

Woodlots are commonly found throughout the coastal corridor, with a diversity in density and cover occurring across Assessment Units 1 to 11. See Appendix A for full analysis of hectares of coastal woodland ecosystem per Assessment Unit. 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 >1 ha 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 ha in size. These surpass recommended policies in the Provincial Natural Heritage Reference Manual (NHRM). Municipalities of Huron East and South Huron exceed NHRM guidelines by protecting areas of natural environment and areas ≥2 ha. The Township of Howick does not have a significance criterion, but states that woodlot significance will be determined in conjunction with the local CA and County of Huron (County of Huron, 2018).

COUNTY	Development Restrictions	Adjacent Lands	Significant Woodlands	
Huron	EIS required within or adjacent to natural heritage features. Development and site alteration are not permitted in significant woodlands, excluding islands; including significant wildlife habitat (County of Huron, 2018a). "Huron County Forest Conservation Bylaw 38-2013 regulates all woodlots >0.2 hectares (0.5 acres) and woodlands >1 hectare (2.47 acres)" (County of Huron, 2018a).	120m from natural heritage feature (County of Huron, 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 subsequent convictions, to a fine of not more than $25,000.00 or $2,500.00 per tree injured or destroyed, whichever is greater" (County of Huron, 2013)
Bruce	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 (County of Bruce, 2010, p.10).		Townships <30% forest cover, woodlands ≥ 40 ha are considered significant (County of Bruce, 2010, p.10).	

Lambton	EIS Required	≥2 ha; has interior woodland habitat (100 m 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 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 (County of Lambton, 2017, 8-9, 8-10)	Protect 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 (County of Lambton, 2017, 8-9). - Woodlots are recognized as a renewable resource that needs to be improved and maintained through proper forest management (County of Lambton, 2017, 8-10). Fines for tree removal include maximum $100,000 or $10,000/tree, whichever is greater (County of Lambton, 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. This act ensured 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" (County of Huron, 2018). For the time, this Bylaw was quite modern, however, it 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" (County of Huron, 2018). Bruce County has similar bylaws, including the Forest Conservation Bylaw and Eastern White Cedar Cut Permits (County of Bruce, 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.

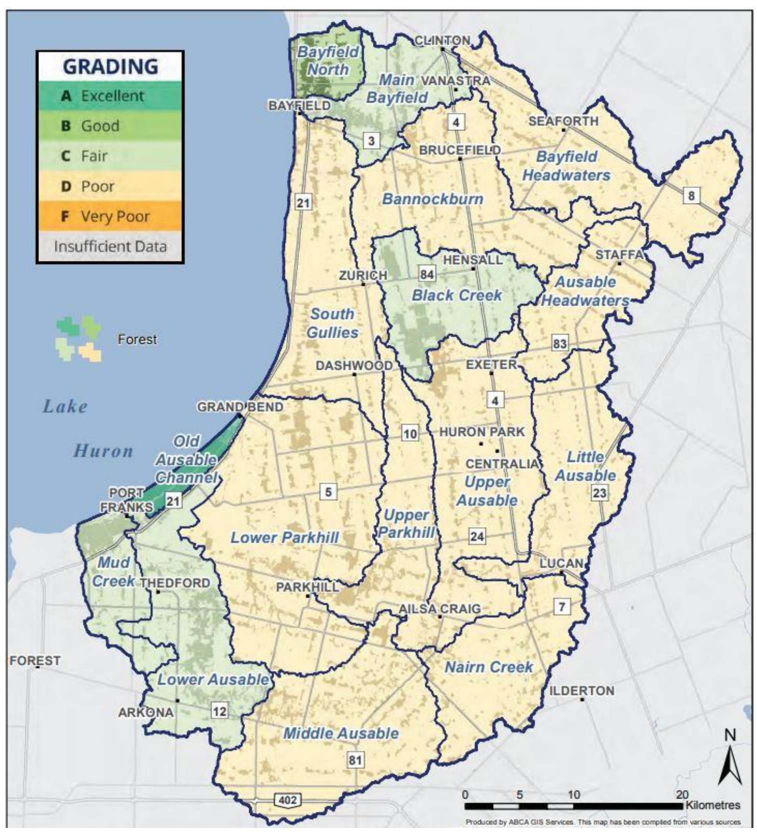


Figure 34 - Forest condition in the ABCA Watershed (2018).

Establishment and enforcement of forest conservation bylaws is crucial to control forest cover loss. There is no provincial requirement for municipalities to enact forestry bylaws. Since 2006, Ontario's Municipal Act has enabled municipalities to pass bylaws protecting trees on private and public property from removal or damage but such bylaws are not mandatory, and 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).

CA Regulation, Management & Reports

Conservation Authorities do not have specific regulations for tree cutting or woodlot preservation like those of municipalities and counties. However, CA's monitor tree cover across their jurisdictions and grade the level of cover on a scale from Excellent to Very Poor (Figure 34). The most recent watershed report cards (2018) have graded the woodland cover in the coastal corridor sub-watersheds as shown in Table 21). CA watershed report cards allow an analysis of forest cover over time, leading to conclusions about improvements or degradation occurring and what work is still needed to meet set thresholds for forest cover.

Table 21 - CA ratings of forest conditions as per the 2018 Watershed Report Cards

CA	Grading	Comments
GSCA	No Data	Do not analyse the Lake Huron shoreline… monitoring gap in this area (GSCA, 2018).
SVCA	Lake Fringe (Good), Penetangore River (Poor), and Pine River (Poor).	The SVCA in total has 27.5% forest cover (SVCA, 2018).
MVCA	Eighteen Mile (Poor), North Shore (Poor), Mid Shore (Poor), South Shore (Poor) (MVCA, 2018).	"Forest cover is low across the 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).
ABCA	Bayfield North (Good), South Gullies (Poor), Lower Parkhill (Poor), Old Ausable Channel (Old Ausable Channel), and Mud Creek (Fair)	"to value and protect existing forests, as there is high agricultural productivity and demand for much of the land meaning forest cover may remain limited" (ABCA, 2018).
SCRCA	Sarnia (poor), Cow and Perch Creeks (Very Poor), Plympton Shoreline Tributaries (Poor), Lambton Shores Tributaries (Fair) (SCRCA, 2018).	"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).

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

Communities in Bloom has been a long-standing NGO that holds tree sales in rural and urban communities within 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 partner tree planting programs have been obtained. Ausable Bayfield Conservation Authority have had overwhelming success with their tree planting program with the past 10 planting seasons exceeding 155,000 trees planted in their watershed. 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. 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 impacts by adopting stewardship measures that reduce impacts to woodlands.
- Preserve trees on property and keep properties as 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 neighbours and the cottage association to adopting conservation stewardship practices that will benefit the whole community.
- Encourage the 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 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:**

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 Official Plans should be improved to support the outright protection of coastal woodlands instead of “where possible”. 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 connection where large rivers enter Lake Huron is the river's mouth. Large rivers provide sediment, vegetation refuse and freshwater from inland sources to feed the lake and shorelines down-drift.*

ECOSYSTEM DESCRIPTION

Natural rivers are dynamic, continuously adjusting to natural and anthropogenic forces. Changes can be seen seasonally and annually as the river, surrounding landscape, and lake levels change. River water is warmer and less dense than lake water causes mixing of the two freshwater systems creating unique ecological conditions changing the water chemistry and energy of the area (Donnelly, 2013). River flows pick 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 have high rates of sediment deposition forming deltas in the nearshore causing sediment plumes (Donnelly, 2013; Figure 36). Lake depths, river mouth shape, and wind direction determine the timing and extent of sediment plumes influencing nearshore waters (Donnelly, 2013).

Orthophoto analysis identified approximately 70 large rivers entering Lake Huron between Sarnia and Tobermory 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. River mouths along the coastal corridor range in size and shape, from large, flowing rivers to small river entry points. Rivers and creeks

Figure 35 - Small river mouth on the southeastern shores

tend to be mature and longer in length providing less sediment to the lake, per length of watercourse. As described in Reinders (1989):

> *"Great Lakes river basins 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"* (p.13).

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. The most important features of a natural alluvial stream are pools, riffles, point bars, the flood plan and bank vegetation. 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 consistent flow of surface water whereas gullies have sporadic surface water flow sometimes only occurring after heavy rainfall and snowmelt.

Figure 36 - Sedimentation in nearshore from river mouth

Although areas of high turnover and change, river mouths on Lake Huron have historically attracted settlers, most communities still present today. Lake Huron river mouth ecosystems have long-supported the creation and sustenance 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 communities within the southeastern shores of Lake Huron include Sarnia, Grand Bend, Bayfield, Goderich, Kincardine, Southampton, and Sauble Falls.

Smaller rivers, streams and creeks cause stress to those living near by, as they fluctuate in flow and shape more than large rivers. Figure 37 illustrates how a small river mouth changes through hydrologic influence. 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.

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, over-fishing, drainage and filling of wetlands, eutrophication due to excessive nutrients from sewage and animals' wastes, pollution and damming for flood control or water diversion.

4.9.1 Land-use changes and hardening

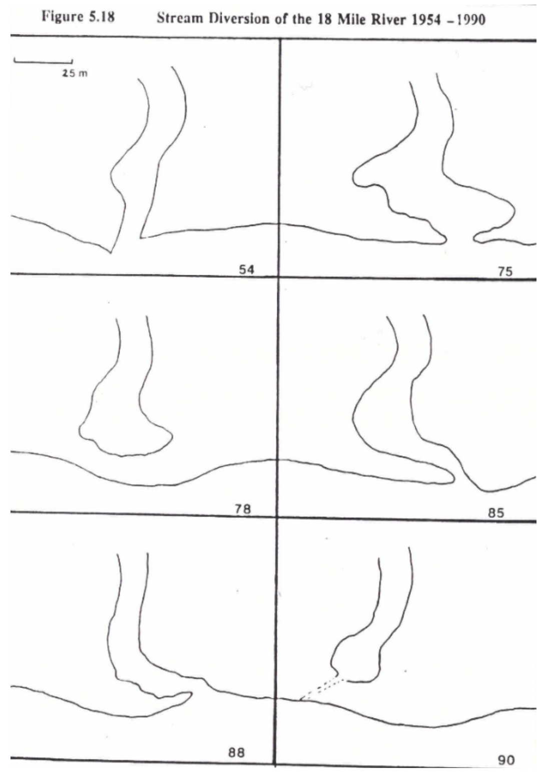


Figure 37 - 18 Mile River mouth changes from 1954-1990

Development of river mouth's and downstream channels has led to creation of harbours, dredging for boat traffic or shipping, hardening of shoreline, and habitat loss. The subsidiary impacts of harbours include dredging, shoreline hardening, and potential for chemical contamination creating an abundance of threats.

Some of the most dramatic reconfigurations of river mouth systems are linked to recreational boating marinas. Marinas have the potential to modify environmental conditions through their influence on hydrodynamics, sediment resuspension, coastal process interference and concentrations of contaminants (Rivero et al, 2013). These recreational areas are commonly found in sheltered mouths of waterways; if sheltered locations are not readily available, engineered structures such as break walls are constructed for these purposes.

The water near recreational boating marinas contains 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). The way marinas change natural systems requires thorough investigation on a site-by-site basis for the successful conservation of local biodiversity.

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, reforestation, changes in agricultural practices, building construction, urbanization, mining activity, agricultural drainage (e.g. field tile), and stormwater sewage systems will 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).


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

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. River mouths can attract invasive aquatic and terrestrial species more 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 subsp. Australis*, Water Soldier, and Water Hyacinth 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, damaging sensitive banks, pulling sediment, nutrients, and vegetation from these areas, carrying them further upstream or out into the nearshore waters spreading contaminants and stressors from river mouth areas widely across the shoreline, making the control of invasive species in these areas crucial.

INDICATORS AND THRESHOLDS

Rivers and watercourses are very well monitored by Conservation Authorities, who manage long-term monitoring projects and data sets associated with water quality in these rivers. The ongoing monitoring programs such as surface water quality, benthic invertebrate communities, fish community sampling and partnerships with Provincial Water Quality Monitoring programs with MECP are just a few of the successful initiatives managed by CA's tracking water quality in rivers. However, a specific niche research gap exists surrounding the ecological health indicators of 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 monitor health of river mouths on the southeastern shores. Most indicators reference quality of water of the nearshore zone, and runoff from adjacent land.

Table 22 describes recommended indicators for river mouths on the southeastern shores as well as their associated threats and stressors derived through an evaluation of this ecosystem. Monitoring how these indicators and threats intertwine to create specific thresholds to protect and restore river mouth ecosystems on Lake Huron is needed.

Table 22 – River mouth ecosystem indicators identified for the southeastern shores 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

River mouths occur across most of the southeastern shores, coinciding with gullies and large tributaries in Assessment Units 1 to 6 and 8. See Appendix A for full analysis of hectares of river mouth ecosystem per Assessment Unit. CA's in the coastal corridor have regulations protecting 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 across shoreline areas. In this regulation, "no person shall straighten, change, divert or interfere 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 is an opportunity for partner organizations to create toolkits of best management practices to use to best manage river mouths.

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 river mouths on the southeastern shore 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.

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 should inform management decisions on 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 approximately 32,000 islands, the largest, most diverse collection of freshwater islands in the world (Northland College, 2019). Lake Huron is home to approximately 25,000 of these islands (78%) 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 is dynamic and dependent on lake-levels. Predominant ecosystems types on islands include bedrock outcrops, sand plain deciduous forests, and wetlands, with cobble shores, mixed beaches and depositional sand beaches common shorelines on islands. Due to their isolated nature, some islands host rare species while others provide critical temporary rest-stops for migratory wildlife. Many of these islands have provided safe refuge for generations of flora and fauna, fostering adaptations that cannot be found elsewhere.

Lake levels, limited migration, and colonial water birds (e.g. Double Crested Cormorants) are some documented disturbances (Franks Taylor et al, 2010). 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. 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 also been documented– Lakeside Daisy, Pitcher's Thistle, Houghton's Goldenrod, Dwarf Lake Iris and Lake Huron Locust (Henson et al., 2010). Rare plant species observations include Sand Reed Grass- a Great Lakes endemic species, and American Beachgrass, a Great Lakes distinct species (Henson et al., 2010).

Islands adjacent to Lake Huron`s southeastern shores make up 122 km (12.6%) of the total 965 km of shoreline included in this plan. Islands on the southeastern shore occur within the northern section of the coastline, spanning Assessment Units 6 to 11. The southeastern shores have three island clusters: (1) Oliphant Fishing Islands, (2) Chantry Island, (3) Stokes Bay Islands. Islands have different physical and biological features depending on where they are located on the lake. These islands range from 6 ha to less than one hectare. Many of the islands in this region are less than one hectare in size.

Figure 39 - Populated Island

Figure 40 - Chantry Island

The Oliphant Fishing Islands (OFI) are a chain of islands off the shores of Oliphant, ON. Seventy limestone dolomite islands ranging from large, inhabited islands to small relic reef and shoal exposures. Cranberry Island is the largest island in this small archipelago, (40 ha) consisting of cottages which require boat access.

"The OFI were named after the abundant fish that once populated the waters and provided industries of the day with plentiful bounty. Many of the islands bear the names of historical events and places including those people who lived and worked the area for its resources. For example, Smoke House Island is where the First Nation people once smoked the fish caught in the shallow waters, and Main Station Island is the island where Captain Alexander Mac Gregor set up a fish canary. The area is also home to a few shipwrecks, which traveled these shallow shores and met their demise while running aground here" (OVAT, 2019).

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. These islands and the mainland, are traditionally significant for First Nations and Métis, which had portage routes between Oliphant and Wiarton, using this area of islands as a safe place to begin a canoe voyage on the southeastern shores (McGuire, J, pers. comm.).

Chantry Island (19 ha), located about 1 km off the coast of the Southampton 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 m offshore from the high-water mark of the island, which makes the MBS 63 ha 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 approximately 3 m high and is separated from the water by a 7 m 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 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.* 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, and Double-crested Cormorant. Chantry Island is the only island on the southeastern shores with protected status.

Previous studies 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). However, they remain an important part of the southeastern shores. According to Victorian Coastal Strategy (2014); small offshore islands play a critical role in supporting bird species by providing rookeries; and their developed microclimates imperative to some species. Small pockets of woodlands grown on the exposed bedrock provides niche habitat required by some species. Food resources are available in surrounding nearshore waters and the isolation of islands from the mainland provides nesting birds refuge from predators.

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. Lake Huron's islands (excluding Georgian Bay), have little or no documented threats associated with them. Although threats have not been specifically documented, they can be extrapolated from mainland ecosystems to the shorelines of these islands.

4.10.1 Development

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 have agricultural cropland e.g. Chantry Island (Henson et al, 2010). Due to their isolation, islands tend to be free of invasive species. However, human interaction from cottage development, tourism and recreation (e.g. ATVs), increases the risk of invasive species spreading from the mainland. The only other group of islands that contain physical diversity are the islands of Stokes Bay; remaining unprotected but with a much lower threat level. Chantry Island is the only island within the study that has protected status; considered to have one of the higher threat levels on islands across 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 storms and reduced ice cover altering the landscape and vegetation on island communities.

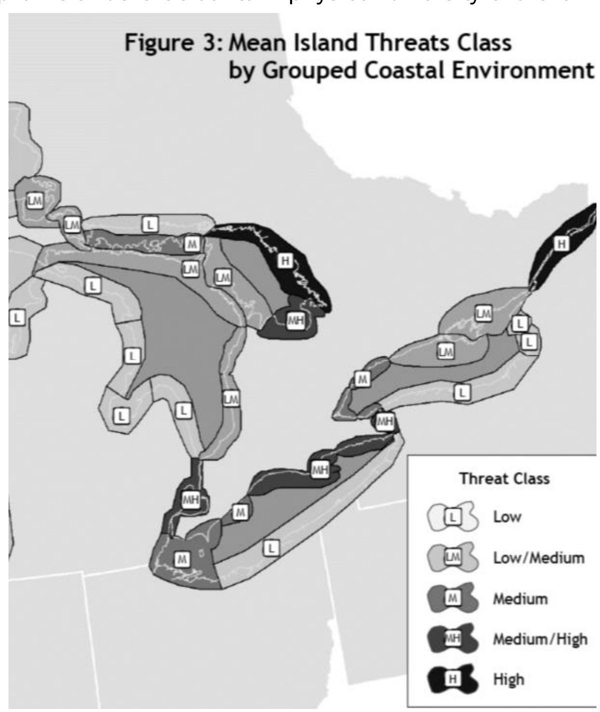


Figure 41 - Summary of island threats (adapted from Nature Conservancy of Canada).

The Nature Conservancy of Canada (NCC) and the Ontario Ministry of Natural Resources and Forestry (MNRF) conducted a high-level study in 2010 for the Great Lakes to assess threat levels for major coastlines and islands of Lake Huron. Figure 41 shows the southeastern shores classified as Low-Medium threat level; an indication of the size and density of these islands being smaller than other island communities throughout Lake Huron.

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", limiting 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 delineates shoreline ecosystems through Provincial and Federal data mapping.

The presence and abundance of invasive species is an indicator because of 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).

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 23 provides a summary of the indicators identified by the CAP Steering Committee and associated threats and stressors.

Table 23 - Island ecosystem indicators identified for the southeastern shores 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 for homes and cottages. – Transportation to island and vehicle storage.
Invasive species	– Presence and abundance (e.g. Phragmites australis, Purple Loosestrife etc.).
Building densities	– Development, recreational activities.

CURRENT MANAGEMENT STRATEGIES

The islands off the southeastern shores of Lake Huron exist in only a few Assessment Units. See Appendix A for full analysis of hectares of island ecosystem per Assessment Unit. 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). 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 the academic community:**

Fostering new and improving existing 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 WATERS

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

ECOSYSTEM DESCRIPTION

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 approximately 2.4 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.

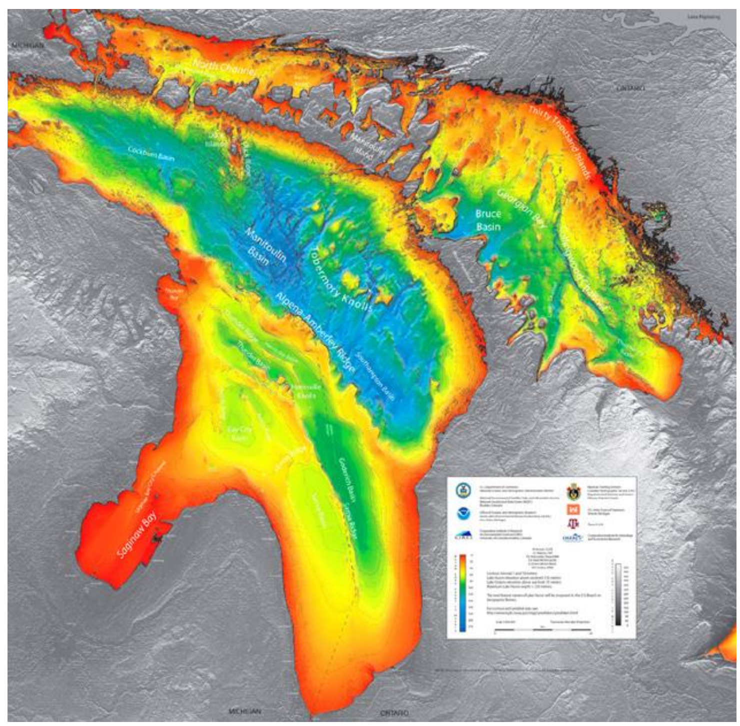


Figure 42 - Bathymetry of Lake Huron

The nearshore zone of Lake Huron where the shoreline meets the water extending to a depth of 6 m 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. 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 6m-depth of the nearshore in Assessment Unit 11 occurs closer to the mainland than in Assessment Unit 1 which has a shallower bathymetric retreat reaching out farther offshore (Figure 42).

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 geomorphology is inherited from previous interglacial period coastal processes (Davidson-Arnott, 2010).

The most significant ecological process associated with the nearshore is wave action approaching the shore from open water offshore, shoaling and breaking as waves move across the lake bottom, inducing wave generated currents transporting sediment from the shoreline offshore and alongshore (Liipere, 2014). Wave energy and deposition rates are important indicators of nearshore profiles (Lawrence, 1991). They impact depths, drop offs, sand bars, and shoreline erosion. Lawrence (1991) study matched low wave energy with gentle nearshore profiles and high energy monitoring stations with atypical concave cohesive shore profiles. Wave energy and increases in precipitation modify the water quality in the nearshore zone. Sediment inputs from rivers, eroding bluffs, and the nearshore bed can be transported along-shore, depositing in protected bays, allowing aquatic vegetation to establish (Liipere, 2014).

BIOLOGICAL DIVERSITY

The structure and function of the nearshore zone influences several other ecosystem types such as coastal wetlands, woodlands, and river mouths. There are many biological components occurring in the nearshore zone, including a complex food web. The nearshore zone includes a variety of substrate types providing habitat to diverse communities of submerged and emergent aquatic vegetation. 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). Biological productivity in the nearshore highly attributed to associations with coastal wetlands and river mouths (Liipere, 2014).

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. Nearshore waters support 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.

Populations of prey-fish and benthic invertebrates using the nearshore for breeding and feeding significantly influence populations of predator-fish residing in off-shore waters of Lake Huron. 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 and fish community indicators to determine water quality in watercourses, however, these agencies do not monitor benthic populations in nearshore waters. The area of the nearshore is within Provincial jurisdiction and is monitored through the agencies of MNRF and MECP during certain project initiatives, but does not occur on a regular basis, consistently across the southeastern shores. This is defined as a research gap for current, consistent monitoring data for nearshore water quality using these parameters.

In shallow nearshore waters there is a high diversity of small fishes (>60 species), the majority of which are native to Lake Huron (ECCC & USEPA, 2018). 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 mature fish feeding area (NRHM, 2005). Most nursery habitat can be generally defined as nearshore water depths of 2 m 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 is directly influenced by ecosystems adjacent to the shoreline and cumulative impacts from further inland, as well as holistic influences. The nearshore zone experiences an amalgamation of stressors from adjacent shoreline ecosystems and land-uses, with ecosystem stress highest in nearshore habitats (Allan et al., 2012). According to Allan et al (2012), the nearshore zone generally experiences 12 to 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 (Allan et al., 2012). The southeastern shores face cumulative impacts due to higher population densities, intensified development and land-use, limited protection of natural features, along with effects of activities happening up-drift due to littoral transport along the coastline.

4.11.1 Shoreline hardening and alteration

A significant concern for the health of nearshore waters is shoreline alteration, including groynes, dredging, and sea walls. Structures built on the lakebed or adjacent to nearshore waters affect the littoral flow, coastal processes, and water quality of the nearshore, drastically tampering with terrestrial abutting ecosystems. Section 5.2.1 provides an in-depth analysis on the threats posed by shoreline hardening and alteration.

4.11.2 Nutrient and sediment loading

Nutrient and sediment loading 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 to stream and nearshore water quality and influences aquatic habitat through NPS pollution from dense agriculture and urbanization in lake-adjacent watersheds (ECCC & USEPA, 2018). Ecological integrity of nearshore zone habitat is affected by stressors to adjacent habitats such as increased nutrient inputs in runoff, sediment discharge, groundwater recharge areas, and increased impermeable surface area (OMNR, 2005). Nutrient contributions from urbanized areas of watersheds and lakeshore development for residential, recreational and other uses impact water quality (e.g. phosphorus and nitrogen). Higher levels of phosphorus increase lake productivity producing vegetative matter, leading to exponential algae growth. 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.

4.11.3 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% /year yield decline in the fishing industry across the Great Lakes (Brenden et al., 2012; ELPC, 2019).

4.11.4 Invasive species

Abundance and distribution of aquatic invasive species infer how much native community has been impacted. Gathering up-to-date GIS data of aquatic invasive species is challenging as it changes every year. Continued spread of *Phragmites australis* northward, is another threat as it changes the chemical composition of the nearshore water, reduces fish spawning and feeding grounds, and habitat for other reptiles and amphibians. Nearshore invasives are mostly fauna including Zebra Mussel, Round Goby, and the Spiny Water Flea. These organisms impact the Lake Huron food web. Assessing species diversity and abundance of aquatic invasive species communities is needed to determine ecological integrity and quality of water in the nearshore zone (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).

Threats and stressors caused by 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 remedied inland, nearshore water quality and feedback to terrestrial ecosystems will improve.

INDICATORS AND THRESHOLDS

Indicators and thresholds for the nearshore zone were 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 reduction of natural land cover within coastal ecosystems (e.g. woodlands) has significant impacts on the nearshore zone, coastal aquatic habitat and water quality (Franks Taylor et al, 2010). Assessment of the nearshore zone is based on 3 to 4 indicators using best available data for the respective Assessment Units. 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 regularly occur in the northern reaches of the coastal corridor where the substrate is mainly non-erodible bedrock. Therefore, this indicator will not be applicable to Assessment Units where the nearshore zone is predominantly bedrock. Table 24 provides a summary of indicators identified by the Coastal Action Plan (CAP) Steering Committee.

Shoreline hardening is an important indicator and is 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 with hardened structures (e.g. armour stone, rip rap etc.). Consequences of shoreline hardening are felt locally among neighbouring properties, disrupting the deposition and accumulation of sediment further along the littoral zone, along with the explicit loss of habitat. 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.

Table 24 – Nearshore zone ecosystem indicators identified for the southeastern shores of Lake Huron.

NEARSHORE WATERS INDICATORS IDENTIFIED	THREATS AND STRESSORS
Land-use change and development	– % natural land cover within 2 km of shoreline. – 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.

Deposition rates influence the nearshore profile, and quality of water. Reinders (1989) provides an examination of recession rates for Assessment Units 1 to 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.

CURRENT MANAGEMENT STRATEGIES

Ontario has legislation, regulations, policies and programs in pace to protect nearshore water quality. The regulatory power from the Ministry of Natural Resources and Forestry (the Public Lands Act) and Department of Fisheries and Oceans (Fisheries Act) are some relevant Acts, with others including the *Provincial Policy Statement, the Conservation Authorities Act 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 regulate development and alteration permitted in the nearshore zone. Other documents including CA Shoreline Management Plans set requirements for development on nearshore adjacent ecosystems and around watercourses entering Lake Huron. 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" (County of Huron, 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 will be employed by adjacent land managers on the southeastern shores of Lake Huron.

RECOMMENDATIONS:

1. **Regulatory consistency:**

The nearshore zone is an area of importance for 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. Consistency in regulation and enforcement will make managing this ecosystem clearer and easier to understand.

2. **Education and outreach:**

Raising awareness of nearshore environments by providing education and signage in higher risk areas, such as wetlands, beaches, and bluffs will popularise stewardship initiatives. Incentivizing positive stewardship actions, as well as regulating and limiting vehicle access and land-use changes of buffer zones will encourage a coast of eco-conscious citizens. Although nearshore environments change in substrate and size, best management practices to protect water quality are relative.

3. **Supporting monitoring programs:**

Continuing diligent surface water quality monitoring, such as Health Unit water sampling at beaches, and stream water monitoring done by CA's, will enable land managers to accurately track changes to water quality across the landscape. Monitoring nearshore water quality through CA's or LHCCC's Coast Watcher program will be beneficial to study existing and emerging threats to nearshore water quality (e.g. microplastic and microfibre sampling). 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 system maintenance and replacements, beach and dune restoration, reforestation of shorelines, and shoreline pollution clean-ups will directly support nearshore water quality improvement and protection. Supporting and expanding existing programs such as a mandatory septic system inspection program would improve the mitigation of nutrients entering Lake Huron's nearshore waters.

4.12 ALVARS AND BEDROCK

DEFINITION: *"Alvar, a Swedish word, applies to naturally open ecosystems found on shallow soils over relatively flat, glaciated limestone 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. Alvar ecosystems are distinctive habitats with extreme conditions such as shallow, impermeable sediment profiles between 0-20 cm deep, and weather conditions with extreme temperature and precipitation schemes, fostering distinctive species of flora and fauna. Alvars were formed when glacial ice, wind, and water scraped away the landscape, existing now as sparely vegetated rock barrens on flat bedrock with shallow soils (Reschke et al, 1999). Species endemic to alvars, including plants, molluscs and invertebrates are rare elsewhere in the Great Lakes basin making alvars unique geological features. Almost all alvar communities are considered globally imperiled or threatened (Reschke et al., 1999).

Alvar bedrock pavements, grasslands and savannas have a blend of boreal, southern, and prairie species – relics of the post-glacial environment. Many species that occur in alvars are disjuncts, far from their normal range but able to survive in shallow soils under harsh conditions. Alvar ecosystems can look quite different from one another, but have key characteristics identifying them, classified by the percentage of established vegetation:

- **Alvar pavement:** exposed bedrock (>50%) with <2cm of soil, and<25% tree and shrub cover;
- **Alvar shrublands:** <25% shrub cover and <25% tree cover appearing stunted;
- **Alvar savannahs:** 10 to 25% scattered tree cover, the most uncommon alvar type, provides a range of habitat for wildlife, including birds and mammals compared to other alvar types;
- **Grassland alvars:** 1 to 10cm soil depth and <25% tree and shrub cover. Supports grasses and sedges, with continuous meadow type vegetation, in the wettest, seasonally flooded areas (Reschke et al., 1999);
- **Wooded alvars:** >25% tree cover, often adjacent to other alvar types and tend to be the oldest with the highest succession rates (Goodban et al., 1999; Liipere, 2014).

Alvar communities are highly influenced by periodic flooding and severe drought. Alvar ecosystems transition by season; during 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). The underlying bedrock limits drainage after rainfall, which causes frequent and rapid flooding.

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). Within the southeastern coastal corridor of Lake Huron there are approximately 179 identified alvar sites, eight of which occur on islands off the Bruce Peninsula (Liipere, 2014).

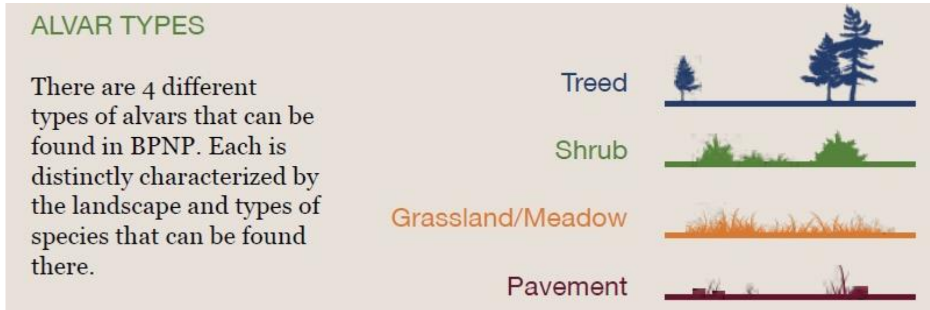


Figure 43 - Alvar types (BPNP, 2019)

Figure 44: 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).

Most of Lake Huron's alvars occur on shallow, easily eroded limestone or 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 like cracks and crevices in the topography. For example, dissolution of limestone by mildly acidic water has created features such as small circular holes (pitting), in sections of the Lake Huron shoreline (Parks Canada, 2017). Limestone bedrock is somewhat soft, weathering quickly when exposed, changing 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 coastal ecosystems are highly influenced and shaped by changes in lake levels and wind action.

The harsh geological conditions of alkaline, low nutrient limestone substrate combined with a limited growing season characterized by flooding and intense sunlight allow only highly adapted plants to thrive. These factors, in addition to local climatic conditions, contribute to the unique vegetation communities found on alvars (Reschke et al., 1999). 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 population of threatened or endangered 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). In addition to vascular plants, alvars support at least 62 algae species, 58 moss species, and 52 lichen species on the Bruce Peninsula (Liipere, 2014).

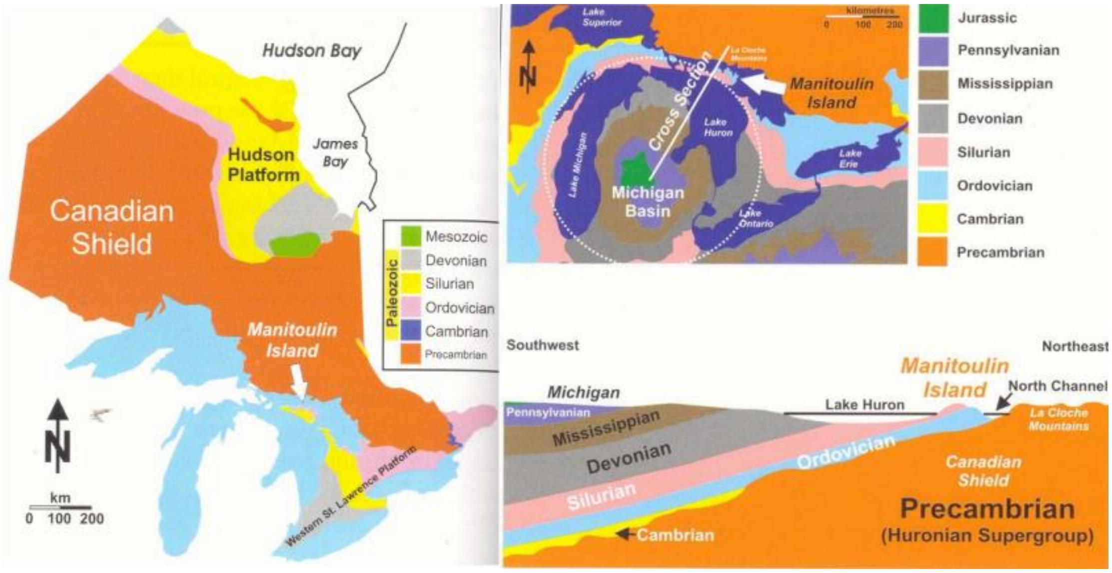


Figure 45: Geology of Ontario map (Fyon, 2009).

Rare animals found in alvars include Eastern Massassauga Rattlesnake, Eastern Fox Snake, Mottled Duskywing and several endemic land snails (Henson et al., 2010). 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 cracks 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. 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 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.).

Over-grazing from pastured animals has been identified as posing the biggest threat to alvars through removal of vegetation from the shallow soil overlay (County of Huron, 2006). 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. Over-grazing or over-browsing, that can occur by livestock and wildlife, including deer, can impact alvar species and composition (MSU [2], n.d.). Over-grazing does not occur widely across the coastal corridor, but is focused on inland alvars and the density of cattle farming on 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 increased '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 in 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

Mapping alvars along the southeastern shores of Lake Huron provides a baseline for future research. The Alvar Recovery Team (2010) accentuates the importance of maintaining total extent of alvar types across their range, allowing land managers to assess short and long-term changes. 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 including 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. 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 25 summarizes the indicators identified through literature research and guidance of the CAP Steering Committee.

Table 25 - Alvar ecosystem indicators identified for the southeastern shores of Lake Huron.

ALVAR & BEDROCK 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 lands. – Stewardship requirements.

CURRENT MANAGEMENT STRATEGIES

Alvars and bedrock are unique to the northern reaches of the southeastern shores between Assessment Unit's 6 to 11. See Appendix A for full analysis of hectares of alvar and bedrock ecosystem per Assessment Unit. The majority of alvars in the coastal corridor are on privately owned land and 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. 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) supported this initiative. 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. Increasing the awareness of the importance of alvars is needed to improve their 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 over-grazing preventing ATV use, and by minimizing other disturbances such as invasive species removal.

3. **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.

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: THREATS AND STRESSORS

A threat or stressor is an action, item, individual, or group of things straining or damaging ecosystems. Stressors and threats are caused naturally or anthropogenically across aquatic and terrestrial zones of the Lake Huron coastal corridor. Lake-wide Action Management Plans (LAMPs), include threats such as 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). Effective coastal management considers aspects that contribute to ecosystem threats e.g. temporal (time), spatial (space), quantitative (amount of people), and qualitative (type of activity). A simple adjustment to one of these categories can rectify some management complications (Williams & Micallef, 2009). For example, re-distributing tourists temporally and spatially around the area will reduce high-intensity visitation during the summer months.

Determining where and which threats are greatest (e.g. where they overlay sensitive areas or species, or those which cause the most irreversible damage), allows land managers to plan restoration or mitigation efforts to protect natural features and ecosystem services in that area. The 2017 CAP Questionnaire asked 256 respondents which threats and stressors were of concern (Chart 6). Respondents were general public, lifetime shoreline residents, land managers, and academia. The results reflect a collective opinion of the greatest threats to the southeastern shores, including invasive species, point and NPS pollution, new development, and shoreline hardening. Previous Great Lakes studies regarding stressors and threats align 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 in 7 categories: aquatic habitat alterations, climate change, coastal development, fisheries management, invasive species, NPS pollution and toxic chemical pollution (ECCC & USEPA, 2018). This stress index uses % artificial shorelines, road density, building density, % natural land cover on the coast, and natural land cover in the watershed as indicators and thresholds (ECCC & USEPA, 2018). Other literature

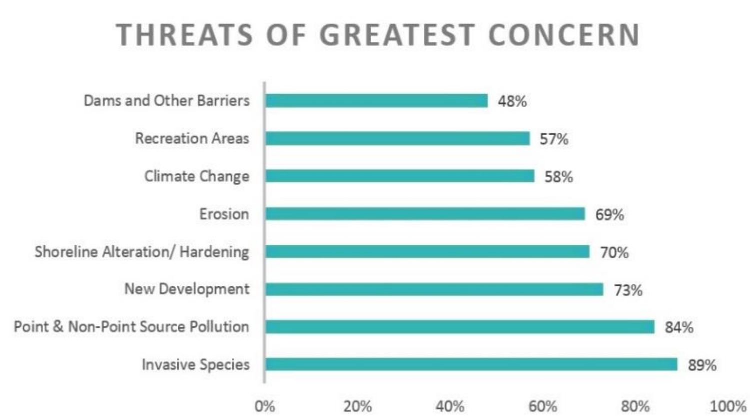


Chart 6 - Responses from 2017 CAP questionnaire on threats of concern examining indicators and thresholds include Bruce County's new tourism strategy defining impacts from tourism to coastal environments: unmanaged tourism growth, development of low-cost free attractions, increased negative impacts of visitation (traffic, litter, water quality), changing visitor characteristics and needs, and degradation of assets and reputation (Twenty31, 2017). Combining indicators from social and ecological realms will holistically represent the threats and stressors affecting coastal ecosystems.

Canada and the United States federal environmental agencies have developed Lake-wide Action Management Plans (LAMPs) for the 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 methodology contains a rating criterion used to assess the scope, severity, and irreversibility of coastal threats and stressors (ECCC & USEPA, 2018). LAMP's are consistent among the Great Lakes per the scope of the Canada-United States Collaboration for Great Lakes Water Quality. The CAP utilizes the threat rating criteria developed in the LAMP to be consistent in methodology. Rating criteria are separated into three groups; scope, severity, and irreversibility, with ratings of very high, high, medium and low threat levels. 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 to100% of its occurrence.
  - High: Threat is widespread, affecting the ecosystem across 31 to 70% of its occurrence.
  - Medium: Threat is restricted, affecting the ecosystem across 11 to 30% of its occurrence.
  - Low: Threat is narrow, affecting the ecosystem across 1 to 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 to 100%.
  - High: Threat is likely to seriously degrade/reduce the ecosystem by 31 to 70%.
  - Medium: Threat is likely to moderately degrade/reduce the ecosystem by 11 to 30%.
  - Low: Threat is likely to slightly degrade/reduce the ecosystem by 1 to 10%
- Irreversibility: The degree of whether a threat can be reversed and the habitat restored:
  - 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 to 100 years to achieve pre-threat conditions.
  - Medium: Effects of threats can be reversed and restored with a reasonable commitment of resources, taking 6 to 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 to 5 years to achieve pre-threat conditions.

Threats and stressors affecting coastal ecosystems on the southeastern shores are analysed using this threshold rating criteria to determine threat level and importance for action.

5.1 HABITAT LOSS AND DEGRADATION

Habitat loss and degradation seriously threatens ecosystems across southern Ontario. Through natural processes, Great Lakes shorelines retreat at various rates, but land-use change and anthropogenic (human) influences such as development expedite habitat loss and degradation (USACE, 2003). Years with high lake levels cause erosion, and reduce the area of terrestrial coastal environments, prompting added concern from landowners and land managers. Habitat loss and degradation caused by anthropogenic influences of land-use change and development, habitat fragmentation, and natural stressors such as invasive species contribute to the threat.

5.1.1 HABITAT FRAGMENTATION

Ecologists attribute the most pervasive threat to biological diversity to habitat fragmentation, the primary cause of extinctions in North America (USDA, 1999). Habitat fragmentation occurs when cohesive ecosystem areas are broken into smaller isolated patches of habitat, caused by development and land-use change (USDA, 1999). Fragmentation threatens coastal ecosystems by reducing interior habitat and increasing edge habitat, isolating less-mobile species, increasing potential for invasive species, and eliminating corridors for species movement. Fragmentation is caused by agricultural expansion, urban and industrial development, and transportation corridors on the southeastern shores. The southern half of the coastal corridor is fragmented by expanding urban-style development, whereas the northern coastal corridor is fragmented by transportation corridors, industrial development, and development of areas used by the tourism industry.

5.1.1.1 Edge and interior habitat

Defined as the area within 100 m from the edge of an ecosystem, edge habitat supports a different range of species owing to the different structure and function to that of interior habitat (Liipere, 2014; County of Huron, 2018). Edge habitat mainly supports generalist species and is not suitable habitat for specialist species requiring interior habitats for breeding and nesting (County of Huron, 2018). Reductions of interior habitat caused by habitat fragmentation contributes to a loss of critical habitat for specialist species. The patch-work' nature of shoreline ecosystems has contributed to increases in edge habitat, and reductions of interior habitat. Fragmented coastal ecosystems are small habitat patches dominated by edge habitat, in some cases consuming the entire habitat patch (Figure 46). Local governance has made efforts to monitor interior habitat of woodlands and wetlands. For example, ABCA has determined that 2% of the forests in the south gullies' region watershed is forest interior, however no threshold or minimum forest interior is defined. Although contiguous patches are preferable, smaller patches of natural habitat in close proximity can serve as 'stepping stones' for species movement (County of Huron, 2018). In areas where connecting ecosystems do not exist, clusters of diverse natural areas located close together support a diversity of ecological processes. Lack of interior habitat is a concern across the coast in wetlands, woodlands, and alvars.

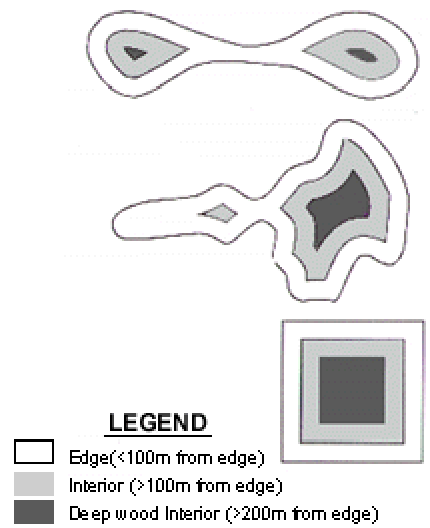


Figure 46 - Edge effects in ecosystems

5.1.1.2 Species mobility & habitat corridors

Fragmentation isolates species into smaller communities. This 'island effect' causes genetic diversity between patches, and reduced genetic diversity within each habitat fragment, causing higher vulnerability to threats (USDA, 1999). Reduction of species immigration between habitat fragments is most common in small species with limited movement zones, and vegetation species with smaller seed dispersal zones. Many plant seeds can travel by wind up to 100 m, but the distance between habitat fragments often greatly exceeds this distance.

The ability of species to move between patches without corridors decreases as the distances between patches increase. Decreased species immigration among fragments causes higher rates of inbreeding, increased vulnerability to catastrophic disturbance (e.g. invasive species), and reduces species diversity within habitat fragments (USDA, 1999). Megafauna species such as Black Bears (*Ursus americanus)* and White-tailed Deer *(Odocoileus virginianus)* require contiguous patches of sheltered habitat to have adequate territory for mating and threat protection (e.g. hunting). Fragmented habitats reduce the critical habitat required by megafauna negatively impacting population numbers. Habitat fragments with road crossings have an elevated risk of vehicle/animal interactions, reducing human safety and decreasing wildlife populations. Therefore, maintaining and establishing natural corridors between habitat patches is necessary to protect wildlife populations, reduce the potential for vehicle/animal accidents, and improve the genetic flow between habitat fragments.

Ecosystem corridors are ‘highways’ for flora and fauna to move between habitat fragments, performing important ecological functions including habitat, filters and sinks for pollution, nutrients, and water, and climate-modifying services (USDA, 1999). Plant community structure within corridors can be simple or complex. A complex vegetation structure has a range of species with a full canopy, sub canopy and ground layer (e.g. a gully with forest cover or a coastal wetland swamp). A simple vegetation structure has less species diversity such as a thin windbreak. Corridors created after fragmentation has occurred may not be as successful at fulfilling ecosystem processes as corridors retained around original ecosystem fragments. Both types of corridor provide services to species moving between fragments including 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.

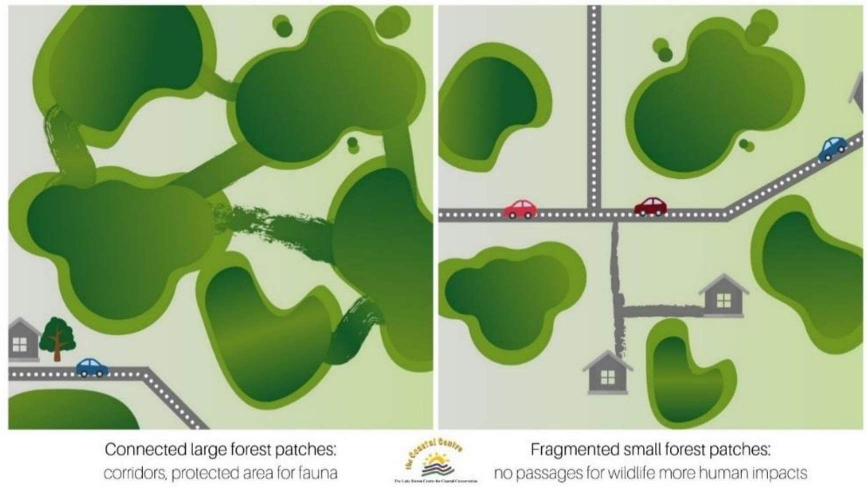


Figure 47 - Habitat fragmentation and corridors

5.1.1.3 Potential for invasive species

Increased edge habitat and penetration of interior habitat by roads and pathways increase potential for invasive species introduction. Invasive species thrive on disturbed land, fragmenting habitats that are susceptible to invasive species introduction (OISAP, 2019). As discussed in Section 5.1.2, invasive species move through the landscape quickly in runoff water movement, on tires of vehicles, through wood and equipment transportation, trail use, and horticulture. The Emerald Ash Borer, and Asian Long-horned Beetle were introduced to Ontario through transportation of firewood and wooden shipping pallets (OISAP, 2019).

5.1.2 INVASIVE SPECIES

Aquatic and terrestrial invasive species existing in the coastal corridor are typically generalist, meaning they thrive in many different ecosystems. Luckily, many of these species are monitored and treatment with population control occurs by multiple levels of government, communities, and individuals. Some grass-roots community groups have formed to eradicate invasive species colonizing areas of the Lake Huron coast, including the Lambton Shores Phragmites Community Group out of Port Franks, Ontario. Municipalities and CA’s are initiating invasive species treatment and removal programs such as *Phragmites australis* removal along roadsides by applying chemical controls to reduce the spread of the species and improve diminished visibility. Digital tools for reporting invasive species, such as Ontario’s Invading Species Awareness Program, exist to monitor existing populations and identify new areas where they have been spotted. The most prevalent invasive species within the coastal corridor are *Phragmites australis*, Sweet White Clover, Spotted Knapweed, Emerald Ash Borer, Zebra and Quagga Mussels, and Round Goby. These invasive species permeate forest patches, sand dunes, nearshore waters and coastal wetlands alike. Forests Ontario (2016) illustrates the management cycle of invasive species management (Figure 48).

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 patches are small and a seed bank has not yet formed. This requires training landowners 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).

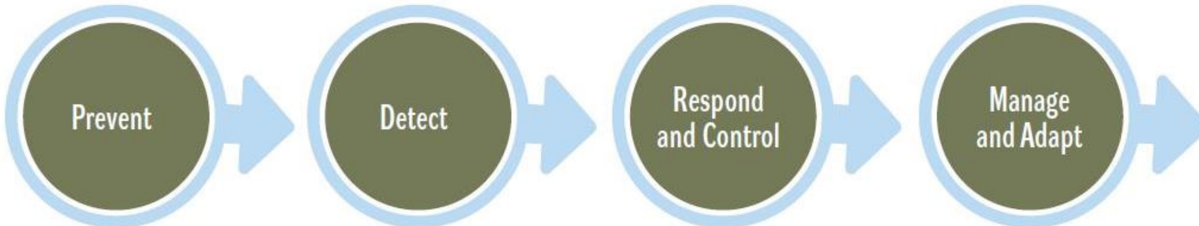


Figure 48 - Invasive species management cycle (Forests Ontario, 2016)

Typically, invasive species management and 'touch-ups 'are required for 5 to 10 years after the initial 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 prevent 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 long-term.

Terrestrial and aquatic invasive species in the coastal corridor are typically treated using mechanical and physical removal, and chemical controls. Table 26 provides an estimate of removal costs of *Phragmites australis* based on best available GIS data of Phragmites populations using The Nature Conservancy's estimate of a three-year Phragmites treatment program being $500/acre (Annis et al., 2017). Three-year treatment of Phragmites is required to ensure new growth is removed. Based on recently completed restoration projects, accurate removal costs are upwards of 4x the cost per acre than Annis et al., (2017) suggests (Table 26). 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

Table 26 - *Phragmites australis* 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

and typically, rural and remote patches don't receive as much monitoring or treatment as urban patches do.

Some grass-roots community groups are taking initiative to raise money to remove Phragmites in their communities. The Oliphant Fishing Islands Phragmites Community Group has fundraised over $16,000 in 2 years (2017 to 2018) and spent over 1,000 volunteer hours removing Phragmites from the shorelines of the fishing islands. Following Ontario Invasive Plant Council's Best Management Practices for Invasive Phragmites, this group has worked collaboratively with Bruce Peninsula Biosphere Association (BPBA) and Grey Sauble Conservation Authority to act against this invasive species on their shoreline (BPBA, 2019b). NGO grass-roots groups like BPBA work in partnership with regional governance groups like Parks Canada and the Nature Conservancy of Canada to map, control and monitor over 1,300 plots of Phragmites from Tobermory to Sauble Beach, using experts, amphibious cutting machines, and volunteers to remove thousands of kilograms of Phragmites biomass every year (BPBA, 2019b). These two examples of grass-roots groups using collaboration and pooling resources to complete restoration projects are examples of the importance of communication and partnership to tackle threats and stressors on the southeastern shores.

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).

Table 27 - Severity of threats caused by habitat loss and degradation

Threat	Rating
Interior and edge habitat	**Scope:** HIGH – threat of reducing interior habitat is widespread, affecting ecosystems across 31 to 70% of the coastal corridor.
	Severity: MEDIUM – the threat of increased edge habitat is likely to moderately degrade/reduce coastal ecosystems by 11 to 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 to 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 to 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 to 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 to 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 to 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 to 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).

RECOMMENDATIONS:

1. **Reduce habitat fragmentation using corridors:**

Each Assessment Unit has a different composition of coastal ecosystems, so each AU will have to focus on linking their specific ecosystems which have the most fragmentation. For example, coastal woodlands in AUs 1 to 3 have the most habitat fragmentation, therefore, focus on increasing connection between these habitats include planting forest links, reducing deforestation which occurs during the expansion of development, tillage, and land-use practices that abut woodlands, and supporting tree planting programs and incentives run through CA's and community programs. Reaching thresholds for low-risk woodland, wetland, and stream cover, among others, will be supported through increased connectivity.

2. **Accurately map invasive species population extents for treatment strategies:**

Regional invasive species reporting programs exist where observations of invasive species can be uploaded to a Mobile App, along with images, population size, and dates reported (Ontario's Invading Species Awareness Program [OISAP]). This data could be shared with or used by local governance and invasive species grass roots groups to map population extents of the most aggressive invasive species in each AU. Partnering with OISAP would utilize existing technology for reporting, allowing citizen science to keep up with new observations of invaders efficiently using budgets and staff to target and remove patches of invasive species.

3. **Increase and regulate vegetated buffer zones and setbacks:**

Indicators and recommended setbacks for development and vegetated buffer zones around coastal ecosystems exist and are proposed by Federal, Provincial, and Regional agencies. Increased awareness is needed about the importance, incentives provided for establishing and maintaining setbacks (e.g. tree planting, cattle fencing, grassland planting), and regulations enforced when these setbacks are ignored or developed upon. Raising awareness to landowners about the importance of these setbacks for overall water quality of Lake Huron will increase acceptance and application of these recommended setback distances for development, tillage, and vegetation buffer. Supporting incentive programs through grass-roots organizations and local agencies, such as cattle fencing, will also enable landowners to have the resources and expertise to install barriers and setbacks along hazard areas and sensitive coastal ecosystems.

4. **Encourage sustainable trails, roads corridors, and development abutting or within sensitive coastal ecosystem zones.**

Many trails, roads, and developments lie within sensitive coastal ecosystems such as wetlands, alvars, and river mouth banks. Sustainable trail design standards and policies exist through programs put on by International Mountain Biking Association (IMBA), and academic communities like Fleming College. The recommendations put forth through these programs specify how to build, maintenance and restore trails to follow management principals focusing on ecological integrity while maintaining and increasing levels of use. Land managers tasked at maintaining this type of infrastructure in public use areas can access free online resources through IMBA, or become a certified in sustainable trail design by taking courses through Fleming College (IMBA Canada, 2019). These tools and resource guides are easy to follow, and provide steps for completing trail assessments, and provide options for many types of trails depending on the type of use (e.g.

hikers, accessible trails and boardwalks, equine trails, ATV trails, mountain biking and pleasure biking trails, etc.).

The Ministry of Transportation Ontario (MTO) have developed a sustainability report titled *Sustainability InSight*, in which they describe the prediction for population growth in Ontario in the next 20 years, and acknowledge transportation as a major contributor to greenhouse gas emissions, deteriorating air and water quality, and loss of natural resources (MTO, n.d.). One of the main goals of the MTO's sustainability report is to ensure that transportation corridors are integrated into land-use planning in a way that balances the needs for mobility and access to report regions of the province while managing and reducing sprawl and protecting, natural and agricultural lands and promoting green alternative methods of transportation (e.g. biking, electric vehicles, car pooling, and public transportation methods). With municipalities and the MTO working in symphony to complete Community Value Plans (CVPs) when transportation corridors are being updated, maintained or approved, will ensure the infrastructure provides efficient and safe mobility while keeping within the scenic, aesthetic, historic values of the community and protecting environmental resources in these locations (MTO, n.d.).

Coastal communities can apply Low Impact Development (LID) design strategies to reduce impacts caused by point and NPS pollution. These strategies include rainwater catchment, night lighting reduction, permeable pavements, nutrient management, and thermal pollution dispersal. New developments can continue to be vetted by CA and municipal planning processes, with enhanced vocabulary in Official Plans to protect sensitive coastal ecosystems using a no-net-loss principal or a development footprint restriction. Ensuring clear wording in guiding documents to dictate where and what development is acceptable within the coastal corridor is imperative to reducing stressors on sensitive ecosystems.

5.2 COASTAL COMMUNITIES AND DEVELOPMENT

Many of Lake Huron's coastal ecosystems are in ecological decline as a result of urban development pressures, poor beach management practices, invasive species, careless property management, 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 coastal management restricted by jurisdictional boundaries and mandates, resulting in intermittent ecosystem and habitat preservation and restoration. Communities along the coastal corridor have changed land-use on the shoreline over decades, and as these communities grow, urban sprawl and intensification continue to reshape 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 coastal habitats are already degraded and development and public area currently exists. The baby boomer generation moves 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 need to be incorporated to preserve ecosystem services and reduce impacts on shoreline environments. Growing awareness of the impacts of shoreline hardening is creating a shift to restoring dunes and slowing erosion by managing water on the landscape through recognition of the services natural systems provide (SCER, 2004). Planning decisions made to support the growth and maintenance of these communities such as beach grooming, road networks, marinas and recreational boating, hardened shorelines and tourism, influence health of adjacent coastal environments.

5.2.1 COASTAL COMMUNITIES

Lake Huron's shores provide opportunity for vacation getaways, permanent residents, and seasonal cottages. Sections of the southeastern shores developed into cottage communities beginning in the late 1800s. "When cottage development first started taking place along Lake Huron, information wasn't readily available to help people locate their building safely" (LHCCC, 2018). With no regulation in place, many small cottages were built directly on the dunes and bluffs, now recognized as hazardous environments for development. "Several 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 ownership of coastal properties change hands through family members or newcomers, community developments grow and become dense creating cottage sub-divisions and closely-knit cottage association groups. Willingness to pay an increased price for shoreline property is shown through continual coastal community developments. 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). 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 (Liipere, 2014). Other estimates from the County of Bruce have suggested an 8.2% increase in permanent residents between 2001 and 2021, predicting this population growth will occur mainly in Kincardine and Saugeen Shores due to expansion in workforce at Bruce Power, tourism industries, and influx of retirees (County of Bruce, 2010).

Figure 49 - Stately home built on the shoreline of Lake Huron

Development and intensification of cottages communities and town centres in the coastal corridor is expanding, with infrastructure on shoreline properties being rebuilt and retrofitted into year-round homes (Figure 49). 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.

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 caused by this type of land-use and the infrastructure associated, including:

- Small cottages converted into million-dollar, year-round homes with enhanced septic systems, impervious pavements, and expanded building footprints (Davidson-Arnott & Mulligan, 2016).
- Landowner turn-over brings uninformed people to the shoreline without knowledge of sustainable land-use practices or coastal processes (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 false sense of entitlement or ownership in some circumstances (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 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 the Online Questionnaire (2017), and the twelve Coastal Community Workshops held between 2017 to 2019. Two such guides have already been completed to service two municipalities in 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 50).

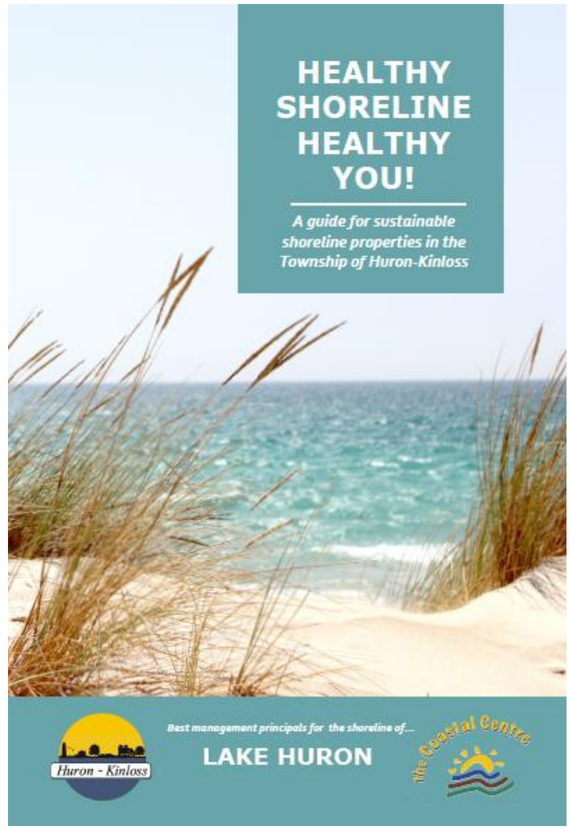


Figure 50 - BMP Guide for the Township of Huron Kinloss

The CAP questionnaire and community workshops shared a popular request from respondents and attendees, for short videos available online to show different coastal habitats, threats, and best management practices. An 8 episode video series released in October 2019 featured 10 coastal ecosystems on the southeastern shores met this request, and is available on social media, YouTube and LHCCC's website.

New developments along the shoreline creep closer to the lake, sometimes clearing the vegetation between cottage and water's edge to get an unobscured view. Development and removal of dunes cause 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" (County of Huron, 2006). Research shows that development and structures too close to the shoreline have experienced abuse from coastal processes, and reduction in 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, development setbacks are necessary for protection against natural hazards and to buffer stressors coming from inland sources entering the lake (County of Lambton, 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 are some of the most significant stressors to coastal ecosystems (Liipere, 2014). Therefore, development regulations and consistent setbacks for human safety and ecological integrity is necessary for sustainable, resilient coastal communities. Planning for the future of the coast as a place where the environment, and communities co-exist in a healthy balance is required on Lake Huron.

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 supporting community collaboration for resiliency and sustainability of 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.

5.2.1.2 IMPERMEABLE PAVEMENTS

Table 28 - 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

Urbanization and development reduce pervious surfaces which absorb precipitation and runoff from precipitation events. As the percentage of impervious surfaces increases, runoff is increased exponentially (Table 28). As discussed in the bluff ecosystem section, increased permeable substrates is not always recommended in erodible environments. However, most urbanized environments established for decades see increases in permeability cause a reduction in the reliance on stormwater systems, allowing filtration of runoff and stormwater through substrates, recharging groundwater sources, and reducing sedimentation entering nearshore waters. If permeability cannot be improved, Low Impact Design (LID) features such as rain gardens merged into landscapes and neighbourhoods encourage water retention during storms. Detailed stewardship guides are available to landowners and land managers to aid in awareness of LID principals. *Greening Your Grounds: A Homeowners Guide to Stormwater Landscaping Projects*, distributed by Ausable Bayfield Conservation Authority provides 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 awareness of the impacts caused by hardened surfaces, uncontrolled rainwater runoff, and development, describing projects that can be undertaken between 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 vegetation, and flattening beach and dune areas. Although both methods have negative impacts to beach ecosystems (other than plastic and litter removal), mechanical beach grooming is more damaging to beach and dune habitats than hand raking. Coastal communities rely on tourism to sustain their economy (Section 5.2.2). 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 51) are now over-used, in some cases used multiple times per week, expediting stressors to beaches through the disruption of fine top-sand and flattening of dunes.

Figure 51 - A Barber Surf Rake beach groomer (HBarber.com)

“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 can amount to substantial quantities of permanent sand loss. The value of beach-dune

systems simply as shore protection has been estimated at about $3,000 per linear metre. Beyond this, dunes provide a buffer for water filtration, reducing maintenance costs by preventing sand drifting" (LHCCC, n.d[1]).

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 heavily-groomed beaches become 'wet' (Figure 52).

Figure 52 - A wet beach caused by mechanical 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]).

Table 29 - 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 to 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%)

Recommended changes to beach grooming practices include ceasing surf-rake and algae harvester operation and instead employing seasonal staff like 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 supports human health and safety by removing hazardous materials, 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 29). Table 29 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 7 - Results from Butt Free Beach Survey (2016-2017) in Goderich, Ipperwash, Bayfield, Kincardine, Sarnia, Sauble Beach, Grand Bend

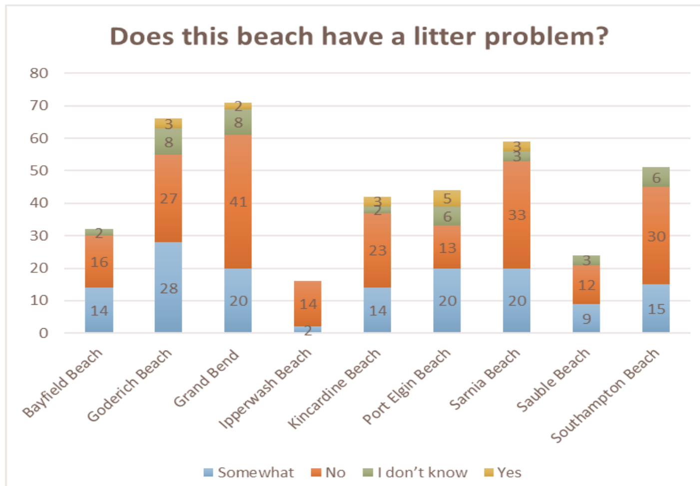


Chart 8 - Beach Litter Problem Results (Butt Free Beach)

Charts 7 and 8 describe how the 403 respondents viewed 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 29, 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 litter prevention campaigns or are busier during peak season.

Figure 53 - Recent grooming at the Grand Bend Main 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 realistic expectations of visitors coming to the beach.

Sincere photographs and information in advertising material with photographs depicting a natural Lake Huron beach environment will allow tourists and visitors to 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.

5.2.1.4 ROAD NETWORKS

The Province of Ontario is vast, with many locations and communities existing remotely from large urban centres. It is for this reason that Ontario has a higher density of roads than other regions in Canada with all areas of the landscape existing within 1.5 km of a road, creating highly fragmented ecosystems (OBC, 2015; OREG, 2010). High road density, travel trends, and shipping frequency have caused transportation in Canada to be the largest source (30%) of federal CO_2 emissions (Climate Transparency, 2019).

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 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).

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 54).

Figure 54 - Road densities along Lake Huron's 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 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 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 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, 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:

- >14 m per hectare of land (1,400 m to 1 km^2) wetlands will show signs of degradation (Liipere, 2014);
- 2 to 3 km of road per 1 km^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 to 1999m/km^2; High Density: >2000m/km^2 (GBC, n.d).

Land managers can use these metrics to determine if road density in their jurisdiction exceeds recommended levels, and by how much. Exceeded recommended road density may indicate that natural infrastructure and stormwater management devices such as bioswales need to be installed to combat stressors caused by roads.

Invasive species management in transportation corridors specifically is needed in the coastal corridor and further inland. Roads are known to spread Phragmites australis, Spotted Knapweed and other aggressive invasives by increasing the level of exposure to non-natives in uninvaded habitats. Vehicles on roads can carry seeds, pests, and disease through their structures or loads within trailers, while construction and maintenance of roads can increase probability for introduction through disturbed soil and introduced fill (GLPC, 2019).

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 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 detail in Table 30.

Table 30 - Marinas on Lake Huron's Southeastern Shores

Location	Marina Name	Notes
Sarnia	Lake Huron Yachts Marina	60 to 80 Seasonal slips Slip season cost: $2,340.00 (30 ft boat)[2]
Cedar Point Line	n.d.	n.d.
Kettle Point	R & R Marina	63 slips (8 transient), with dock depth of 10 to 12 ft[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	276 permanent slips, 14 transient slips. "maximum length of 50 ft, maximum draft of 7 ft. Extensive dredging as needed"
	Harbour Lights Marina Bayfield	
Goderich	Maitland Valley Marina	250 slips. Slip costs: $76 - $81/ ft "Accommodates boats up to 100 ft 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: 10 ft, Max Length: 150 ft"
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.cam; [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, formed in 1930, holds a 125 person membership (Sarnia Yacht Club, 2018); and the Kincardine Yacht Club, formed in 1977, holds a 155 person membership (Kincardine Yacht Club, 2018). A passionate group of individuals, boaters and 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
- hardened shorelines and habitat modification
- Wastewater, stormwater & parking lot runoff
- Nutrient inputs, pollutant loading
- Light pollution in dark sky areas
- Shoreline erosion, sedimentation and turbidity
- Disruption of wildlife
- 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.

Dredging

Marinas use dredging to improve access to the open lake during low lake levels. Dredging occurs in many recreational marinas, and in small private communities (Figure 55 & 56). Dredging is a regulated activity requiring permits from MNRF (Public Lands Act) and Federal agencies (e.g. Department of Fisheries and Oceans). *"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). 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. 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, affecting the quality of the lake bed significantly by unsettling sediment.

Figure 55 - Dredged Boat Channel

Figure 56 - 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.

Criteria for Blue Flag status for marinas include Environmental education and information including annual passive and active initiatives, water quality monitoring, establishing a marina management committee and environmental policy, and sensitive areas must be managed accordingly (Environmental Defence, 2016). The Green Marine Certification is achieved by marinas committed to reducing environmental footprint through annual self-evaluations, external verification, and fostering continual improvement and demonstrating this improvement year-after-year (Green Marine, 2019). This program claims that "By becoming a member of Green Marine, you can strengthen the North American marine industry's environmental performance through a process of continuous improvement, build stronger relations with stakeholders, and improve the awareness of the marine industry's activities and its environmental benefits" (Green Marine, 2019). Green Marine has 12 performance indicators for shipowners, ports and seaway, and terminals and shipyards including: Aquatic invasive species prevention, cargo residues, community impacts, dry bulk handling and storage, environmental leadership, garbage and waste management, oily water, greenhouse gas emissions, NOx, SOx and PM pollutant air emissions, and underwater noise (Green Marine, 2019). Providing specific objectives and targets using different levels of criteria to meet, Green Marine allows for an ever-improving method of reducing stressors caused through marinas. The many marinas on Lake Huron's southeastern shores need to participate in either of these well established, widely recognized programs to quantitatively monitor positive improvements they are making to reducing their impacts on Lake Huron. The Town of Goderich has become a member in the Green Marine program to hold themselves accountable for their environmental footprint of the marina and shipping port.

Figure 57 - Blue Flag Logo

Figure 58 - Green Marine Logo

5.2.1.6 HARDENED SHORELINES

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 across the Great Lakes, originally intended to 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 AUs 1 to 3 and in wetland dominant areas within AUs 7 to 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 1970s and 1980s due to high lake levels and the desire to 'protect' coastal properties from damage. However, many of structures were constructed with no long-term maintenance strategy and poor engineering practices, often using infrastructure inappropriate for the application. At this time and into the early 1990s, the Ministry of Natural Resources did not have a policy for groyne development on the Great Lakes (Baird, 1994) 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). 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 59 - 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 were historically installed to prevent beach erosion caused by coastal processes and high lake levels; 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). Installation and alteration to groynes require permits through the local CA, the MNRF, and DFO.

Figure 60 - 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). The installation or alteration of walls require permits from MNRF and the local CA.

Figure 61 - 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 destructive to the local habitat (USACE, 2003; Figures 60-62).

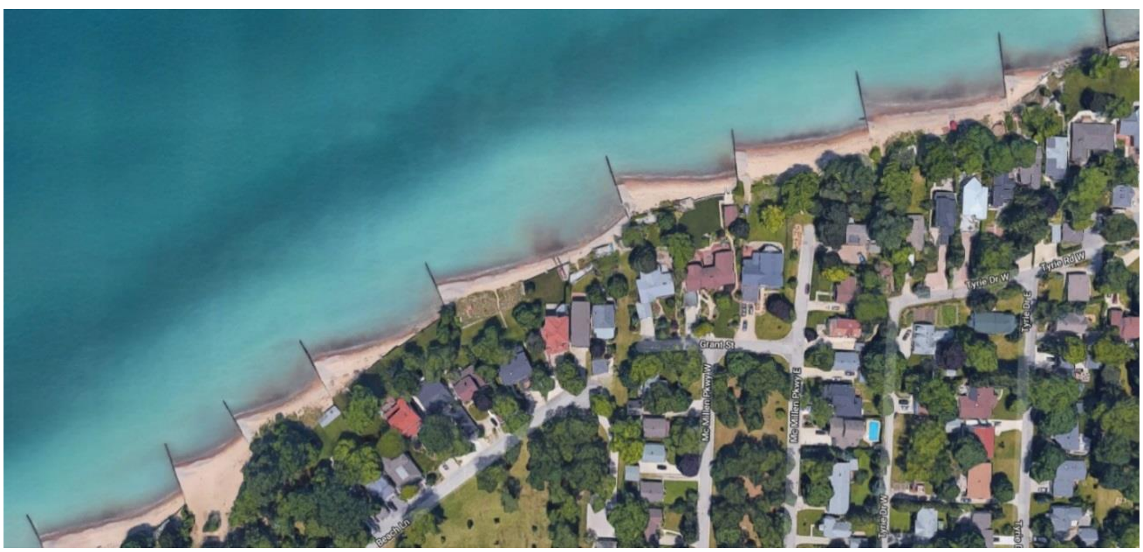
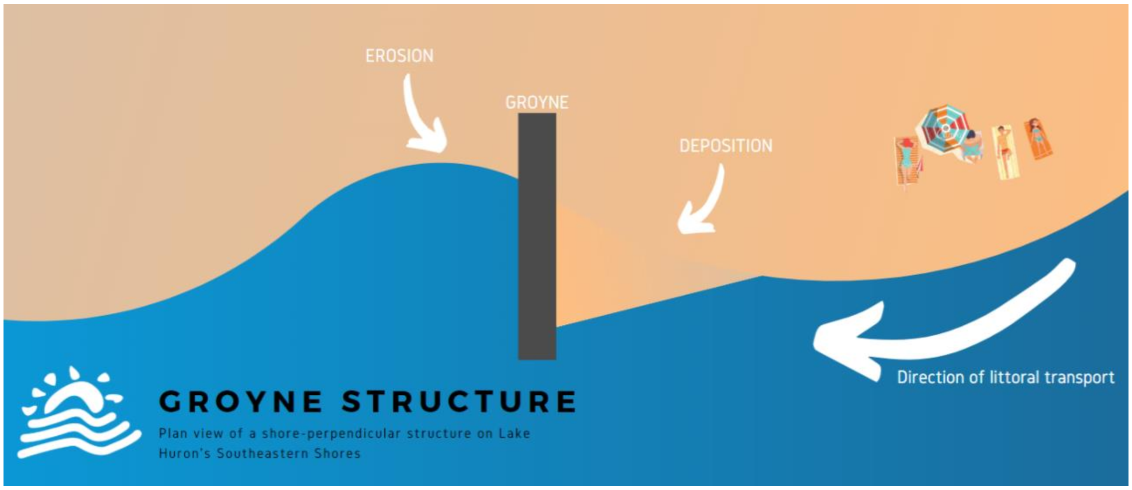


Figure 62 - Groynes in Lambton County

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 63). 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 63 - 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” (ABCA, 2019 [1]). Permits are required to build groynes, with work within nearshore waters requiring permission from the Provincial Government (MNRF) and CA’s.



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 64). 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.

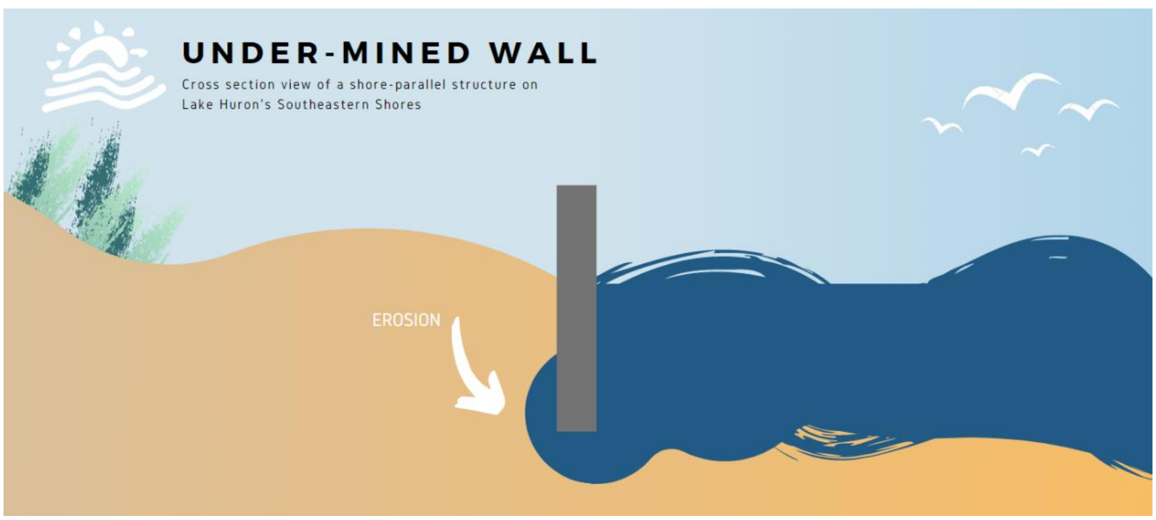


Figure 64 - Undermining of a sea wall on Lake Huron

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 65). 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). Most of these structures were installed in the 1970s and 1980s, 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. Consistently recommending and permitting whether shoreline hardening should or should not be permitted or endorsed is extremely important to sustainably manage the shoreline. 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 31.

Figure 65 – Derelict groyne

Table 31 - 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 31, built infrastructure have 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 but it is during low levels periods when structures are built. Experts cross-jurisdictionally agree that shorelines should not be hardened by building revetments to protect beaches or shorelines from wave erosion (USACE, 2003; ABCA, 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 are more successful in the long term at creating a resilient property (ABCA, 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 kilometre 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).

Table 32 - 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

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 less altered the shoreline is" (IJC, 2014; Table 32 & 33).

Table 33 - 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 natural state" (IJC, 2014). Given its adaptability to downscale to local situations, this method best-fitting for the CAP.

The second method used to determine shoreline condition is the number of structures per kilometre of shoreline within each AU. This measurement is challenging to find within relevant freshwater coastal ecosystem literature. Taking an average of the amount of structures per kilometre across the entire study area, and aligning this average with SAI ratings while considering types of nearshore sediment movement across the nearshore waters, and determining a feasible rating system for the structures/km based on this calculation. As shown in Table 33. The colours denoted to the categories of 'poor', 'fair', 'good' and 'excellent' are projected into the overall assessment within Table 34. The northern AUs have less hardened shoreline and less shoreline structures. 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 (AU) summary. To analyse the presence and concentration of hardened shorelines and shoreline structures on Lake Huron, calculations were made using air photos and orthophoto rectification; no current inventory of these structures exist in the relevant literature or Official Plans. Table 34 shows the prevalence of hardened shoreline and shoreline structures analysed by AU. Further breakdown of the types of shoreline structures and types of hardened shorelines are analysed in the Assessment Unit summaries attached to the CAP.

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 AUs 1 to 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.

Table 34 - 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

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, +140,000 visitors came to the Grotto [in Bruce Peninsula National Park], while +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). In Bruce County alone, 2.5 million tourists visit every year, contributing $299.1 million to the local economy and providing employment for 2,333 people (County of Bruce, 2018). In

Lambton County, 600,000 people visit Pinery Provincial Park each year, with 23,000 people attending Canada Day celebrations in Grand Bend (Lambton Shores, 2014).


Figure 66 - Tourists enjoying Flowerpot Island (Photo by H. Cann).

Visitation increases, changing visitor demographics, and trends in recreational activities will continue to modify visitor desires at current visitor nodes, requiring land managers in these areas to adapt 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, pers. comm.). Pinery Provincial Park has adjusted programming and staffing to support autumn visitation numbers (Donnelly, pers. comm.). Peak seasons in coastal communities start in May (14% of respondents believe peak season starts), and carry on through June (28%), July (44%), and ends between August (29%), September (40%), and October (17%) (County of Bruce, 2018).

Although many economies are sustained on tourism, the 2017 CAP online questionnaire found 24% of respondents said they feel tourism is important to them. In Huron County alone, (2016) there are +2,000 people working in the accommodation, food services, arts and entertainment sectors alone, which claim to have “an under-developed tourism market relative to other rural areas in southern and central Ontario” (County of Huron, 2016). The Sarnia Lambton Tourism Association claim 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 cause to t sensitive ecosystems, as outlined in their regional tourism study (Twenty31, 2017). 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 include dispersal strategies, enhancing marketing and messaging to attract quality tourists, extending shoulder seasons, educate tourism businesses, residents, visitors and municipality on sustainable tourism strategies, enhance collaboration, and improve involvement with First Nations communities. Example indicators used to examine improvements or continued degradation include 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 a component of their economy 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.

5.2.2.1 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 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;

- Environmental impacts (physical and biological)
- Experiential or Psychological impacts (visitor experience)
- Economic impacts (on community)
- Socio-cultural impacts on communities (changes to culture or local demographic)
- 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 these management initiatives, keeping communication between disciplines such as municipality-regional tourism office- and tour operators is key to ensuring 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

Shoreline development 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).

Table 35 - Severity of threats caused by coastal communities and development

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 to 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 to 30%. Most of the

	shoreline ecosystems have already been developed, and areas where 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 to 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 to 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 to 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 reduces ecological integrity, whether it come from litter, contaminants in the air, water, or ground. "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). Sharing responsibility among grass-roots, local, and regional governance to manage and regulate point and NPS sources of pollution entering coastal environments is essential to reducing risks to human health.

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). 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

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 (100CFU/100mL), 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

Table 36 - Beach postings on the southeastern shores

AU	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

Lake Huron's southeastern shores show some trends in the number of postings per assessment unit (Table 36). 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. 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 the three Health Units about 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 an indicator of 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).

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
	Boat wastes

Typical sources are from agricultural storage or manure field spreading, leaky septic systems, improperly constructed or maintained weeping beds, or municipal sewage overflow events.

5.3.1.1 Septic systems

Many coastal landowners rely on septic systems to hold waste from homes and cottages. However, in sediment that is well draining, like sand and karst, leaking septic systems can contribute to contamination of groundwater sources, leading nutrients into local water bodies, ending up in Lake Huron. Human excrement contains nitrates and phosphorus, contributing to algae growth in nearshore waters. To properly maintain septic systems and ensure they are in good working order with no leaks, maintenance and inspection should be completed every 3 years, however, when surveyed, coastal residents are not always aware of the maintenance requirements or how to properly inspect their system (BPBA, 2019a). Septic system inspection incentive programs currently exist within the coastal corridor (e.g. the Six Streams Initiative through Bruce Peninsula Biosphere Association [BPBA]), however, there is a need for municipal reinspection of septic systems. As described by BPBA, The Municipality of Northern Bruce does not currently have a septic re-inspection program, which could be contributing to a lack of knowledge on the part of the landowner to regularly inspect their septic systems for leaks and proper function. Introduction of re-inspection programs are successful at communicating the need for proper septic maintenance; "When a septic system re-inspection program was introduced in South Bruce for septic systems on a three year rotating basis, 25% of systems inspected in the first year required some type of upgrade and 10% of these systems needed replacement" (BPBA, 2019a). Incentivising landowners to mitigate this threat is also effective at raising awareness and encouraging maintenance and replacement of septic systems in adjacent watersheds. In 2016, BPBA received a $75,000 grant from MOECC offering incentive to complete septic tank inspections supplement the expense of system replacements. Municipalities within the coastal corridor should consider septic system inspection programs, with partner NGO's offering incentive programs to landowners to collaborate towards raising awareness and mitigating this source of point source pollution.

5.3.1.2 Buffer zones

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 of 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

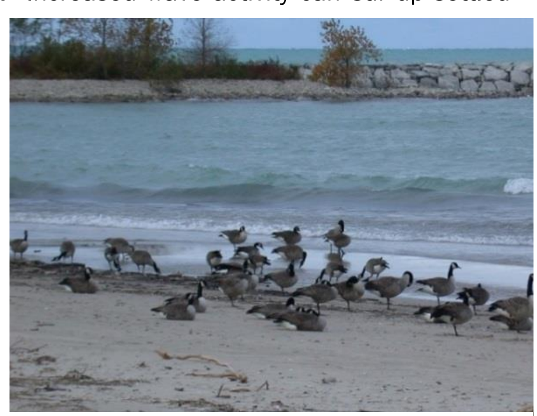


Figure 67 - Geese on Rotary Cove Beach in Goderich

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.

5.3.1.3 Algae blooms

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 heavy precipitation events are favorable for 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 autumn, 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 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 but are often over-used.

Figure 68 - Algae wash-up on Bruce Beach (2007)

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:

1. **Water sampling:**

Frequent water sampling allows land managers to make informed decisions on how a beach's *E-coli* levels are changing using larger data sets to see where changes 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 limitations for Health Units to complete these samples. Another limitation is the time between when the sample was taken and when results are reported to the community. Nutrients and bacteria causing a beach posting may have dissipated by the time the official posting is done.

2. Education and awareness around self assessment:

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 to 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.

3. Septic system inspections and incentives:

All municipalities within the coastal corridor should consider a septic system re-inspection program, with partner NGO's offering incentive programs to landowners to collaborate towards raising awareness and mitigating this source of point source pollution.

5.3.2 PLASTIC POLLUTION

The emerging issue of plastic pollution threatens the holistic health of the Great Lakes ranging from water quality, to human and wildlife health, 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 single-use 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 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 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 70).

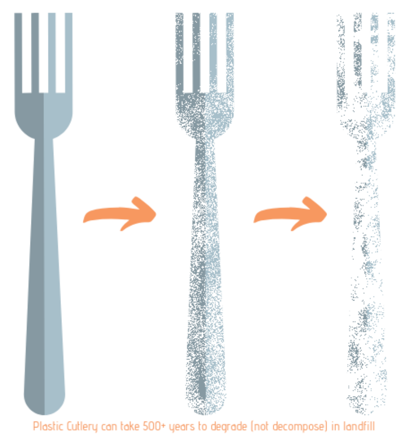


Figure 69 - Plastic cutlery fragmenting into microplastics

In recent studies of fish in the Great Lakes, almost all fish sampled contained forms of microplastics 5 millimetres and smaller, supporting 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 69). Plastic pollution enters the Great Lakes and enters coastal ecosystems through;

– Stormwater and agricultural runoff and through rivers and streams;
– Wastewater treatment plants lacking fine-enough filtration of effluent;
– Litter directly blown into the lake;
– 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.

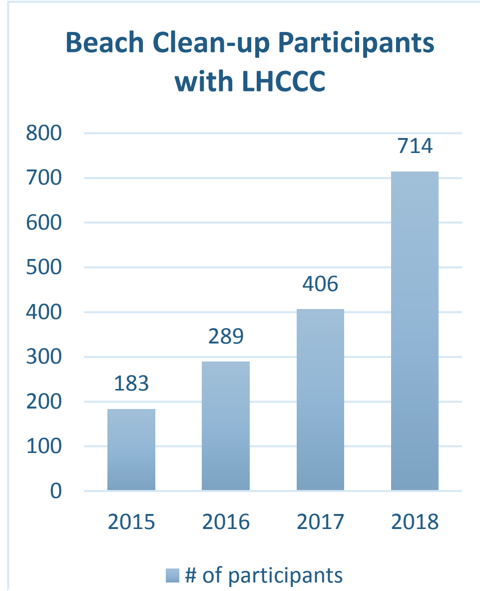


Chart 9 - Beach Clean-up Participants with LHCCC between 2015-2018

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 microfibre pollution through laundering synthetic fabrics will be harder to tackle, as controlling this requires consumer education, working with clothing companies to increase natural fibre clothing, and incentivising and installing micro-fibre filters on washing machines will captures these pollutants before they enter the waterways (TheOceanCleanup, 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 used daily, and 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 sustainable circular economy.

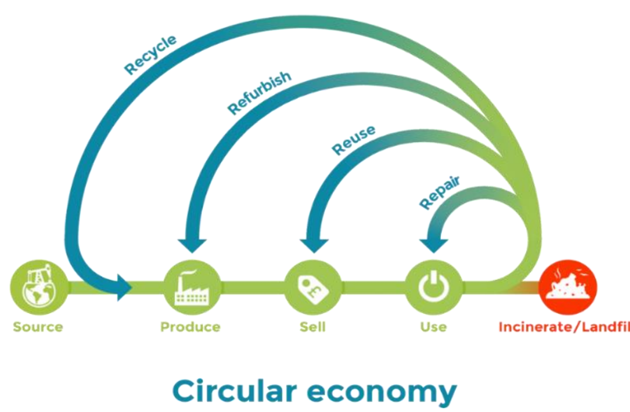


Figure 70 - Circular economy (Circular Tayside, 2017).

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. There has been a significant increase in the number of volunteers participating in LHCCC led beach clean-ups eager to keep Lake Huron's shoreline clean (Chart 9). 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. 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.

OPPORTUNITIES

Several communities along the southeastern shoreline have established single-use plastic bans in their community through local businesses to reduce unnecessary plastic waste and distribution 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 Great Lakes 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 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 communities forward and creating a culture of environmental awareness and action, it is the 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.

Figure 71 - Goderich water bottle refill station (2019)

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 fibres 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% to 90%] effective in reducing microfibre emissions to the environment. While further investigations are needed to understand the relative contributions of microfibres from other textile products and their pathways to the environment, textiles laundered in washing machines are one source of microfibres 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 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.

The LHCCC uses citizen science to monitor plastic pollution in Lake Huron. The Microplastic Awareness Project (MAP) analysed water samples taken in nearshore waters of Lake Huron for microfibres, plastic fragments, microbeads, and films. Engaging volunteers in the monitoring process by taking water samples, and sending them to LHCCC for filtration and analysis raised awareness about the presence of microplastics in the Great Lakes, with 68 samples collected, 91% containing plastic (LHCCC, 2019a). As a quickly-emerging point of study, there is appetite for continued study of the density and type of microplastics in Lake Huron. Recommendations for continuations of the MAP and similar study through academia and volunteer collaboration to continue monitoring the prevalence of plastic pollution in Lake Huron's nearshore waters.

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 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 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 to 2019, participants highlighted that grassroots organizations and committees can get initiatives funded and completed often before their governments are able because there is flexibility in time frame, budget, and private grants available. Much like other environmental challenges, plastic pollution reduction 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 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 the natural world, with the invention of stronger, brighter, and cooler toned lights. "Outdoor lighting became commonplace with the introduction of electric light and grew at an estimated rate of 3 to 6% per year during the second half of the 20th century" (Kyba et al., 2017). 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). Ten per cent of the Earth's surface now experiences light pollution from artificial sources, increasing by 2.2% annually (Kyba et al., 2017). Research indicates 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 73 illustrates the presence and intensity of light pollution in Southwestern Ontario, and the coastal corridor.

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.

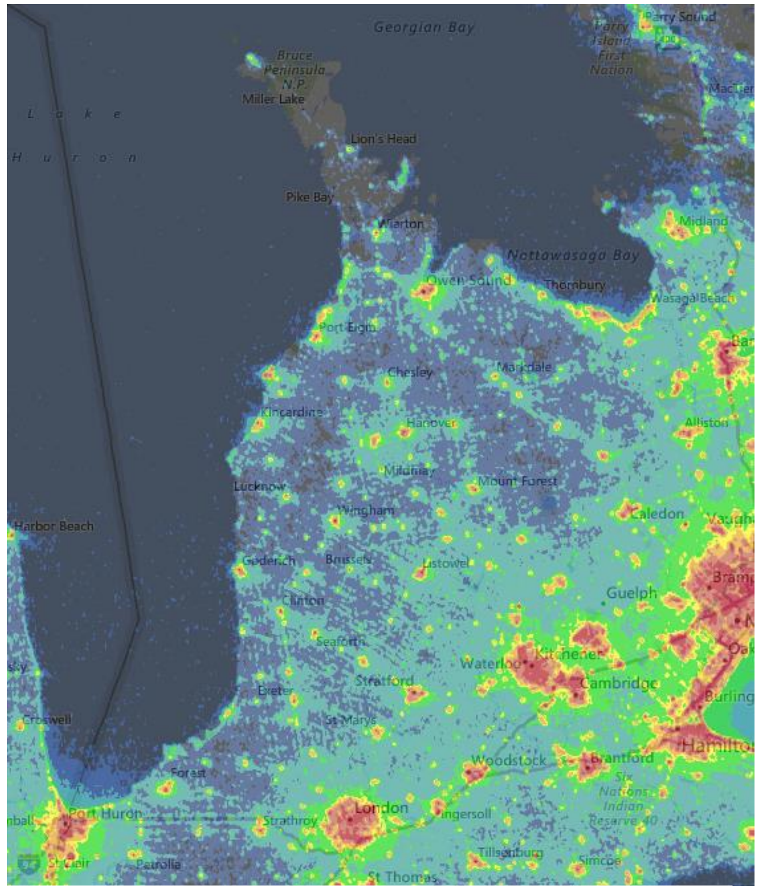


Figure 72 - Light pollution map from 2012 (www.lightpollutionmap.info)

Research shows 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).

Figure 73 - Dark sky certified LED lights (IDA, 2019)

Light pollution seems to be one of the easiest forms of NPS pollution to reverse simply by turning 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 corridor, 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 (Figure 74). 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).

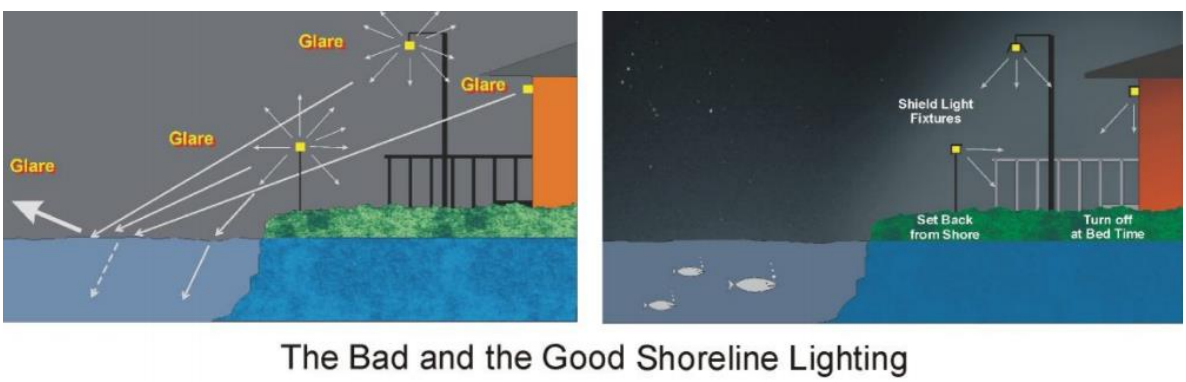


Figure 74 - Shoreline lighting comparison (RASC, 2018)

The amount of light in a pristine environment is limited to 1% of the natural background's darkness, through 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 will encourage less unnecessary light emissions around the residential, urban, and industrial areas of the Southeastern shores. There is 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.

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 dark skies 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 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)

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 through processes or inputs that alter the natural temperature of a water source or micro-habitat. Thermal pollution impacts species relying on specific temperatures to breeding or for the viability of their eggs. "*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. Increased consumption of shallow groundwater reserves is 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). These effects are rarely seen on Lake Huron 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 principles 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

Two harbours rely on shipping for their economy on the southeastern shores; Sarnia and Goderich. The shipping industries on Lake Huron between Ontario and Michigan, "contribute +90,000 jobs and $13.4 billion (CAD) to both economies" (ECCC & USEPA, 2018). The Port of Goderich receives 250 shipping vessels annually, receiving and sending commodities including grain, salt, and calcium chloride (County of Huron, 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). Fluctuating lake water levels has encouraged dredging, 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, 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 has 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 E). Using the LAMP threat rating criteria (ECCC & USEPA, 2018), these threats are rated for their severity trend into the near future (10 years).

Table 37 - Severity of threats caused by point and non-point source pollution	
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 to 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 plastic use is stopped and plastic currently in ecosystems is cleaned.
	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 +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 microfibres and microbeads already in 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 the environment every year.
Light pollution	**Scope:** VERY HIGH – the proportion of area currently, and expected to be affected by light pollution is 71 to 100% of the shoreline. As 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 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 to 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 southwestern Ontario homes 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 to 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 to 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 to 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 to100 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. 22,101 ha or 26% of the coastal corridor is categorized as agricultural, primarily land used for commercial crops. 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). "Huron County is recognized as the most agriculturally productive county in Ontario, boasting the most census farms (3,260) and more acres of farmland (711,525) in Ontario" (County of Huron, 2018a). Bruce County Agriculture hosts 2,720 farm operators on 1928 farms producing cattle (1,039 farms), cow (731 farms), poultry (329 farms), dairy (210 farms), sheep and lamb (138 farms) maple (122 farms), and other vegetable, fruit and field crops (County of Bruce, 2018a).

When settlement of the Great Lakes basin occurred, swaths of the mixed-wood plains were converted to agriculture owing to 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 to 150-acre family farms, to farming operations working 400 to 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. The variety of stressors created by agriculture result in effects and threats to the surrounding landscape including:

- 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).

Other considerations for stressors caused by agriculture include pastured animals entering watercourses and greenhouse gas emissions. Greenhouse gas emissions from agriculture consume 3% of the total GHG emissions, broken down into categories, the largest being synthetic fertilizers (35%), enteric fermentation (27), manure (22%), cultivation of organic soils (9%) and crop residues (8%) (Climate Transparency, 2019). Recommended thresholds to meet to stay within the limit of 1.5 degrees Celsius limit for climate change include reducing global methane emissions by 10% (2030) and 35% (2050) from 2010 levels (Climate Transparency, 2019). Nitrous oxide emissions from fertilizers and manure need to be reduced by 10% (2030) and 20% (2050). Recommended changes include dietary shifts of humans consuming less meat, increased organic farming, and a significant reduction in the use of synthetic fertilizers (Climate Transparency, 2019). These types of societal and industry changes take time to adopt, but are needed to reduce impacts caused by climate change.

CASE STUDY 1: HURON CLEAN WATER PROJECT

Some counties have incentive programs with funding available to landowners to complete stewardship projects such as the Huron Clean Water Project. In Huron County, the Clean Water Project grant has enabled 305 hectares of trees to be planted in 643 tree planting projects, cattle fencing erected over 20 kms of stream, planting of 172 kms of windbreaks, decommissioning of 91 liquid mature storage tanks, upgrades to 500 unused wells, 10,000 acres of cover crops planted, all over the course of 11 years (County of Huron, 2018b). This funding program provides grants of $500 to $5,000 to landowners, covering up to 50% of the project cost depending on the project, providing huge financial incentive to landowners and agricultural producers wishing to complete stewardship projects to improve water quality (County of Huron, 2018b). With projects directly improving coastal ecosystem habitat, such as wetlands, woodlands, and watercourses, this project is a successful tool which can be used to meet recommended thresholds for habitat cover and buffers.

This program is a collaboration between the County of Huron, Maitland Valley Conservation Authority, and Ausable Bayfield Conservation Authority, along with the participation of landowners, local business, and the agricultural community. The Huron Clean Water Project is another clear example of how collaboration and partnership, along with education and incentives can be a powerful tool to execute positive mitigation projects to protect coastal ecosystems in the coastal corridor. Recommendations for comparable programs available to landowners in Lambton and Bruce Counties to provide incentives and programs along the entire southeastern shores. Collaboration and communication between counties could enable this type of program to be built upon and continued to promote coastal stewardship within and adjacent to the coastal corridor.

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 reflects a decrease in the number of farmsteads and small fields with windbreaks surrounding them, typically placed on property lines, which historically acted 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 than one third of farmland is rented rather than owned by the farmers working the land. Landowners may be the 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. There is less incentive for farmer investment in stewardship on short-term rentals than on land owned by the farmer; stewardship leases are one tool to address this. Feasibility and effectiveness of other tools, such as increased education and incentives, need further examination (OMAFRA, 2019).

5.4.2 RURAL STORMWATER MANAGEMENT

Managing water flowing across the landscape if of utmost importance to landowners across the coastal corridor and adjoining watersheds. Slowing down water from storm events to preserve soil quality, water quality, and nutrient retention on landscape is important on tilled land, and for those accessing water downstream. Historically, the Drainage Act permitted the draining of marginal farmland, swampy areas, and wetlands to increase the productivity of agricultural land. Today, it is used to balance the need for drainage in agricultural and rural areas while maintaining existing wetlands and restoring degraded wetlands. Under the Drainage Act (1990), 'drainage work' includes all constructed drains, including the improving of a natural watercourse and work necessary to regulate water levels of a drain, reservoir, lake or pond, and includes a dam, embankment, wall, protective works or combinations of these (Drainage Act, RSO 1990). 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). There are several local and provincial funding programs that encourage the construction of these projects. Raising awareness of these programs through outreach campaigns and demonstration plots, such as the one in effect at Huronview (Clinton, ON), increase stormwater management structures and strategies.

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 groundwater, nearby creeks and rivers, and eventually the nearshore environments. The Great Lakes have experienced more algae blooms, beach postings, and drinking water advisories in the past 60 years. 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 agricultural producers currently employ best management practices (BMPs) on their farms, and 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.

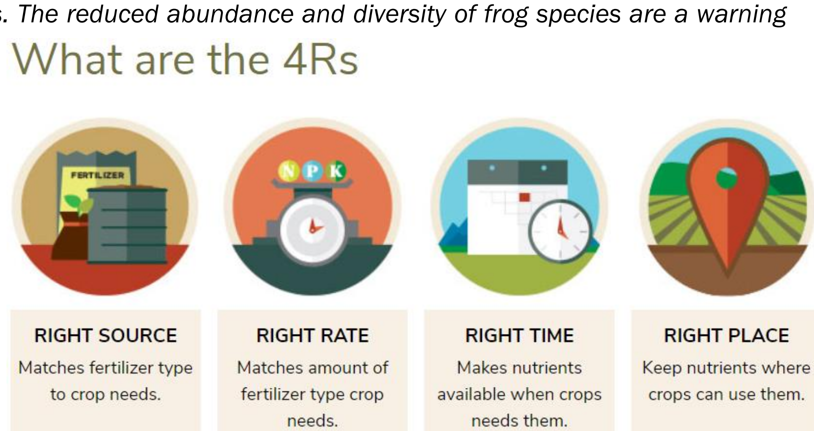


Figure 75 - The 4R`s (The Fertilizer Institute, 2017).

One proven and well-known BMP in the agricultural sector is the principles of the '4R's': Right fertilizer source, and the right rate, at the right time, in the right place (The Fertilizer Institute, 2017). This practice, "provides a framework to achieve cropping system goals, such as increased production, increased farmer profitability, enhanced environmental protection, and improved sustainability" (The Fertilizer Institute, 2017; Figure 76). By employing best management practices, ecological protection and integrity of coastal ecosystems can occur simultaneously with land practices such as agriculture, marrying the two needs of the landscape.

Another BMP commonly employed by cash crop producers are 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 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 >10,000 acres of cover crops between 2016 to 2017 (ABCA, 2018). Educating landowners about the benefits of cover crops and incentivising their use through funding programs protect water quality by reducing sedimentation and erosion annually.

CASE STUDY 2: 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 kms 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).

Other agencies and grass-roots NGO's are working on cattle fencing to abate the threats to water quality entering Lake Huron along the southeastern shores. Bruce Peninsula Biosphere Association addressed cattle fencing in their Six Streams Initiative, through partnerships with agricultural producers installed 67 alternate water systems, 12.5 km of cattle fencing, re-vegetated buffers on streambanks, reduced one tonne of phosphorus contribution to stream water, and controlled 4,900 cattle from entering streams on the Bruce Peninsula (BPBA, 2019a). This Six Streams initiative is another example of successful collaboration between the landowner, a grass-roots NGO, and funding provided by regional governance (MOECC, ECCC, OTF, OMA, MNRF, Bruce County and others) (BPBA, 2019a). This project is proof that these partnerships and methods of collaboration yield successful conservation results that directly improve the water quality of Lake Huron.

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). Crop diversity controls pests, effectively manages nutrients, and improves soil and yields, increasing long-term profitability. 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).

As family farms have grown, windbreaks were removed and workable acres with no impediments have also created less barriers for water to be slowed down, absorbed, and filtered. Many 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 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 metre) 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. However, the quality of water moving through tiles and entering low-lying lands and drainage ditches is still not fully understood. Theoretically, water moving faster off the landscape without the married use of cover crops, water retention structures, and opportunity for flood mitigation and containment, would pose an increased risk to the water quality of coastal ecosystems lying adjacent to the watercourses experiencing tile-exit points.

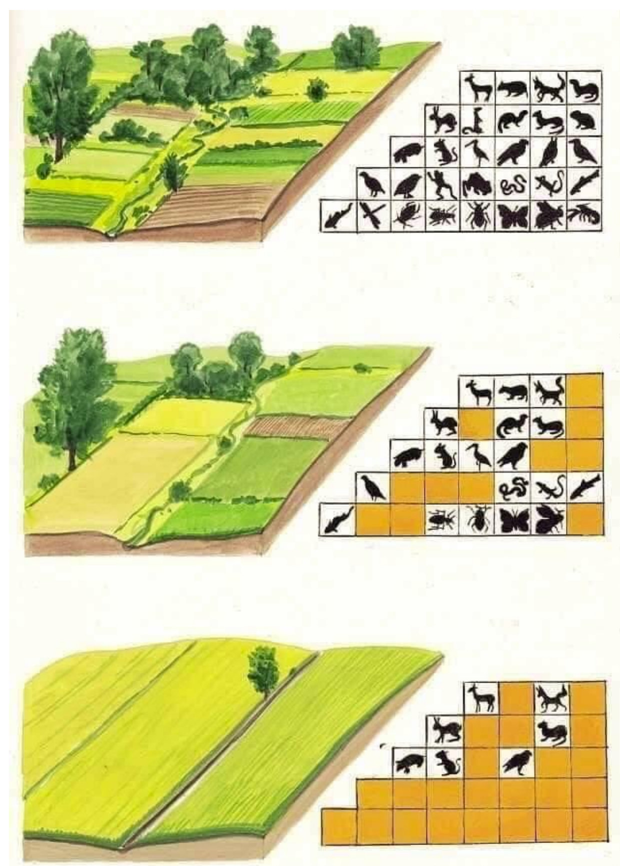


Figure 76 - Image by Ecological Consciousness

5.4.5 SEDIMENTATION, EROSION, AND CARBON SEQUESTRATION

Agriculture and Agri-food Canada's Agri-environmental indicators suggest that soil health and conservation are not improving in Ontario (OMAFRA, 2019). 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 CO_2 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 annual crops (three main annual crops increased from 28% to 61% of crop and pasture lands 1976 to 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 to 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 efficiently harvest land by using bigger, heavier equipment (Ontario, 2018). The expansion of workable acreage causes an increase in aeolian erosion and water flow across landscapes creating negative effects such as 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 is 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).

Table 38 – Severity of threats caused by agriculture

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 to 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 to 30%. With no action, and continuation of current circumstances and trends (e.g. nutrient inputs, topsoil erosion, sedimentation, straightening of watercourses, and removal of woodlots, windbreaks, and wetland areas). However, if best management practices are adopted, this trend may be reversed, and threats reduced.
	Irreversibility: MEDIUM – Effects of threats caused by agriculture can be reversed and the habitat restored (somewhat) taking 6 to 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.

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.

1. **Adopting 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. A few BMPs covered in this section are having success with implementation and application, assisted by incentive programs and awareness campaigns. "*When responsibly farmed, agricultural lands use drainage systems that mimic natural conditions while still allowing for seedbed preparation and planting. Using buffer strips, cover crops, grassed waterways, and two-stage ditches 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, continuing efforts are needed to ensure BMPs are continually being implemented to reduce impacts of point and NPS pollution on the southeastern shores.

2. **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";
- Resilient to 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.

3. **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, limiting 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 2 outlines how creating buffers and dividing fields promote water quality flowing into Lake Huron.

4. **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 principles can work simultaneously is important to increase uptake of incentive programs and sustainable land-use practices. Three strategies are recommended to increase uptake of positive action and prevent negative action; in this order;

(1) Education and nurturing awareness;
(2) Incentivize alternatives;
(3) Enforce regulations and bylaws.

Opportunities for farmers and producers to become 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.

5. 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 a financial subsidy or incentive. The, "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 imperative to the success of BMP opportunities. As discussed earlier in this section, incentive programs for cover crops are successfully making these a viable option for farmers. However, there are many incentive programs opportunities that exist, and should be continually supported 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, shaping and influencing soil, vegetation presence and society. Weather is the short-term characteristics over several days when describing temperature, precipitation and wind. Changes to the climate alter weather patterns, making it warmer, wetter and more unpredictable. This altered state of climate has already caused more frequent and severe storms in southern Ontario. The Great Lakes basin (GLB) experiences "lake effect" weather, meaning that air masses and weather systems build or diminish in intensity when crossing the Great Lakes 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, specifically Lake Huron's bordering land masses (SWG, 2013) including:

- Increased 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;
- 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;
- Earlier onset of spring and summer and an increased growing season.

Evidence suggests that these changes are already underway, including increases in summer open-water temperatures, 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 routinely measured as part of the meteorological observation 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 rising 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 illustrated in Figure 77. These reports also specify that the GLB will be hit the hardest in terms of increases and duration of temperature and seasonal shifts (Figure 78).

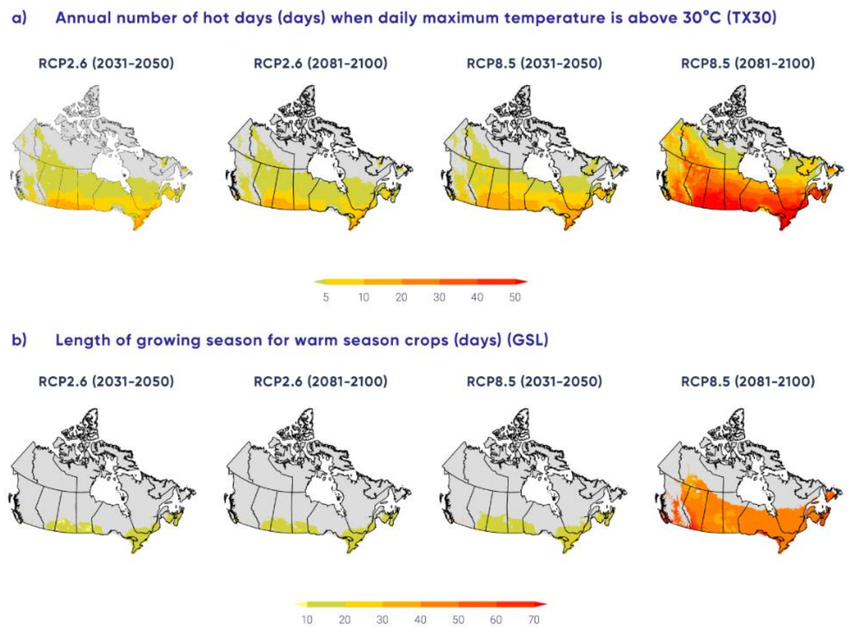


Figure 77 - Multi-model median projected changes (Zhang et al., 2019)

Historical climate warming has led to changes in rain and snow, river's and lakes, and ice cover, challenging what a "normal" climate is. The task 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 coastal communities. Natural Resources Canada is undertaking a series of reports to assess impacts and adaptation response across regions and sectors. Figure 78 shows past and future projected changes in the seasonal distribution of streamflow in many snow-fed rivers basins across Canada. 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 sporadic lake level changes, frequent and extreme storm events, changes to water temperatures, altered seasonal precipitation patterns, and reduced water quality.

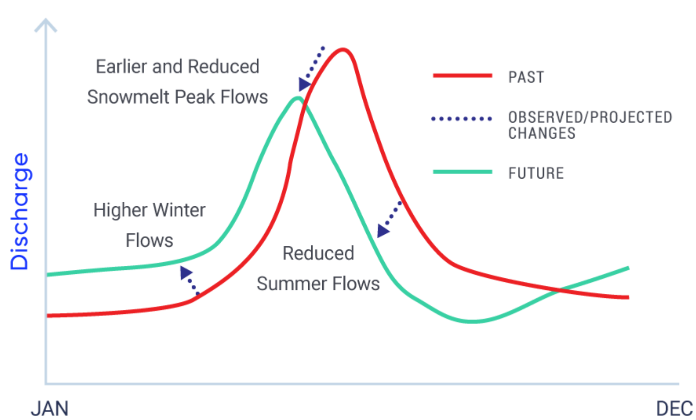


Figure 78 - Projected changes in seasonal distribution of streamflow (Zhang et al., 2019).

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 m) 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). Continuation of these effects will cause shorelines to become more prone 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 ways Lake Huron is used could change from a recreation and sustenance perspective (SWG, 2013; LSBP, 2012). Although designed broadly for coastlines, this summary of the impacts a changing climate can have on coastal ecosystems and communities has been compiled (Table 39). Land managers and planners can use this information to inform policy and land-use decisions, including implementing adaptation policies and regulation to become resilient to these changes and foster a healthy and safe community.

Table 39 - Impacts a changing climate has 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 (Table 39), 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

Lake Huron's water levels have been monitored for over 100 years by Canadian and American federal agencies. Tobermory and Goderich are the only Canadian sites on Lake Huron with water level gauges providing readings. Lake water levels vary due to natural climate variations, and 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 m (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 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 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 rampant, causing 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 m 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

For shipping and recreation using harbours, lower water levels are detrimental to the income which can be made by the marina. However, lower water levels may increase beach and shoreline tourism thereby increasing revenues in this area.

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 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 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 40 describes how climate change will affect Lake Huron's water level fluctuations, as determined by the International Joint Commission (2014).

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 less reliable, however, changes will be monitored and actions put in place to better protect human safety and ecosystem services required for protection.

Table 40 - 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 autumn (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 temporal trends 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 autumn 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

5.5.2 LAKE TEMPERATURE AND STRATIFICATION

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). Freshwater 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 autumn 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 autumn (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 more beach postings due to the presence of these bacteria and algae. Increases in algae, and decomposition of vegetation in the lake will cause Lake Huron to experience reduced dissolved Oxygen which 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 locations where warming is occurring can 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

Great Lakes ice cover is a reliable indicator of climate change, as it has a long-term data set of monitoring by the National Oceanic and Atmospheric Association (NOAA) since 1973. Land managers and environmental planners use this data set to infer predictions about how climate change will alter the amount of ice cover Lake Huron has each year, which influences the evaporation over winter months, potentially leading to higher spring precipitation or lower lake water levels. 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 indicators scoring annual ice cover levels based on the comparison of monthly ice cover amounts to an average rating. If ice cover is;

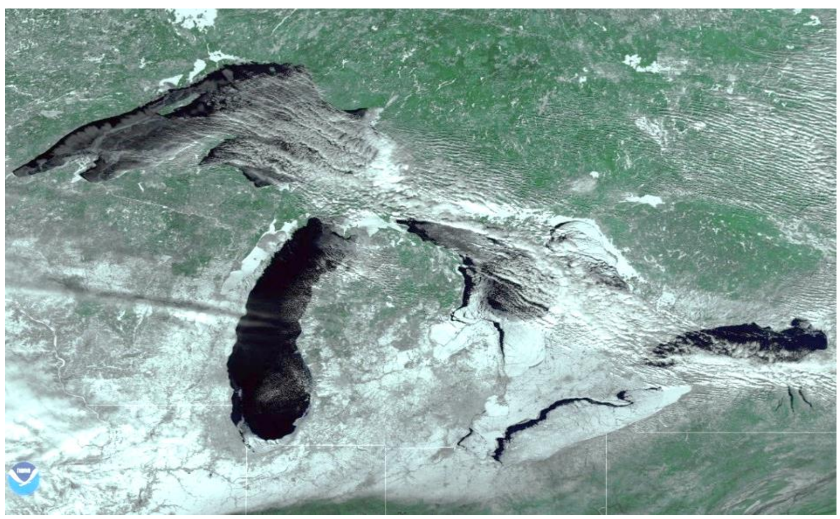


Figure 79 - Ice cover on Great Lakes (NOAA)

Length of time ice is on the lake:	Rating
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 rating ice cover is not as specific as analysing a graph for trends. An ice cover rating is below average also does not necessarily mean there is cause for concern as ice cover, like lake levels, have natural cycles (Chart 10). However, outliers farther from average will trigger concern and reactive management decisions if trends of increased or decreased levels are noted, indicating of changing climate. NOAA's data showing historical ice cover annual maximum levels on Lake Huron charted a trend line showing the overall ice cover is decreasing from 72% to 58% average annual maximum ice cover (NOAA, 2019; Chart 10). NOAA have been tracking ice cover from 1973 to present day, along with Great Lakes water levels since 1918. Therefore, this data represents the most reliable depiction of ice cover for Lake Huron.

Lake ice cover is an indication of climate change and warming patterns. Funding ice cover and lake level monitoring programs is imperative to continue recording and researching the cause and effect cycle of these parameters. Other Non-Government Organizations such as the Ontario Biodiversity Council use Great Lakes ice cover as one of five 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.

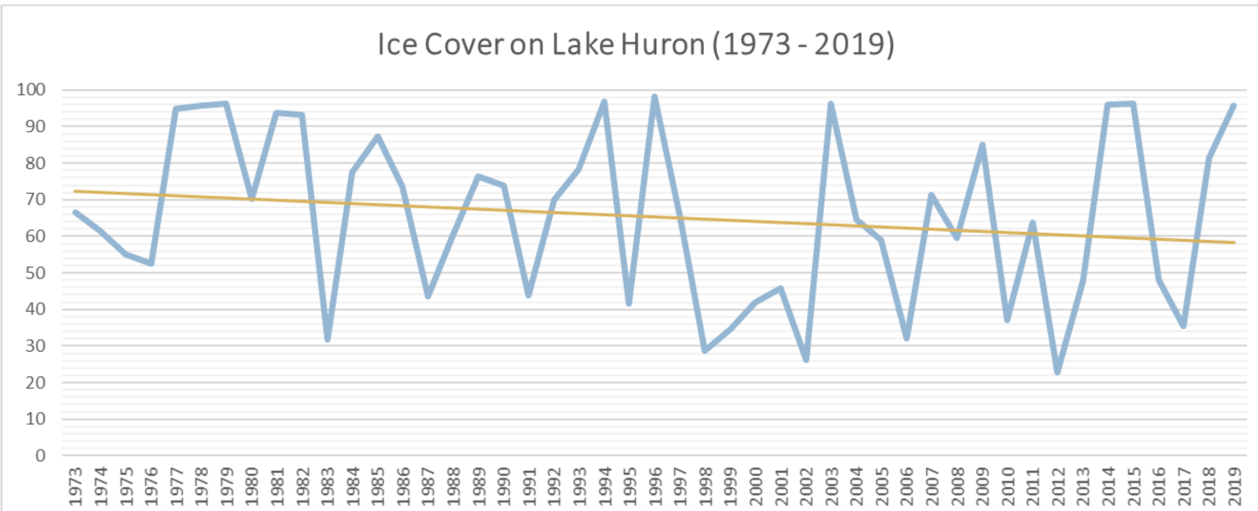


Chart 10 - Historical ice cover maximums on Lake Huron (NOAA, 2019)

5.5.4 CLIMATE CHANGE EFFECTS ON LAKE HYDROLOGY

Climate change will affect the way water enters Lake Huron. Changes to weather patterns cause less snow build-up on the landscape and a gentler spring freshet with increased precipitation and rain, causing higher mean streamflow and precipitation falling directly on the lake (Cherkauer & Sinha, 2010). In the main river watersheds entering Lake Huron's southeastern shores (Maitland, Ausable, Bayfield, Saugeen, Sauble Rivers), annual peak flows are predicted to occur earlier in the season, triggering frequent low-water advisories further into the growing season (ELPC, 2019). Smaller watersheds like the gully tributaries in Huron County will have increased frequency and magnitude of storms during 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 also be lower than historical observations by the end of the century (ELPC, 2019). Increased intensity of summer storm events is likely to increase the flashiness, or day-to-day variability of river discharge (Cherkauer and Sinha, 2010). There will be an enhanced need for natural stormwater management and storage systems such as rain gardens, wetlands, and rain barrels to reduce storm flow rates, and storing this water for low-water periods. Proactively adopting infrastructure will enable established systems to tolerate impacts from intense storms and precipitation events. Increasing the awareness of this issue among landowners and municipalities and providing incentive programs to encourage installation will improve the understanding of the necessity of natural infrastructure to ensure communities are resilient to climate changes.

Higher summer and fall air temperatures increase evaporation during the growing season. Water storage in the landscape, as soil moisture, aquifer recharge, and refilled wetlands and small lakes will change as evaporation continues to intensify during the growing season and as development and crop tiling increases (ELPC, 2019). The Environment, Law, and Policy Centre (ELPC) estimates soil moisture storage will decrease by 8% in Autumn, (September and October) by the end of the century under a high greenhouse gas emissions scenario (ELPC, 2019). In the same scenario, soil moisture storage is predicted to increase by 10% in spring (February and March) by the end of the century. These changes to soil moisture will drastically affect how agricultural crops are planted, grown, irrigated, and harvested. Industries reliant on growing seasons, water flow, and water catchment will experience the need for innovations to continue current practices across the coastal corridor. Improving natural infrastructure (shade) to reduce landscape and waterway temperatures will be important to reduce evaporation to keep water in the soil. Increasing vegetated buffers and tree canopy cover around residential and built environments, streams, and gullies, will improve soil moisture regimes enabling plants and crops to grow without 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).

A climate change adaptation strategy will be crucial to adapt to changing patterns across the southeastern shores. Habitat protection, vegetated buffer zones, landscape corridors, and reversing negative impacts from urbanization will be necessary, not optional, to protect 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 translate 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 resulting from the need to change the composition of asphalt in roads to handle higher temperatures and different freeze-thaw patterns. Frequent replacement costs will put municipalities in a 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 and transmission (e.g. hydro electricity, nuclear power, etc.) is constructed for long-term operation, however, the size of current energy infrastructure was 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 over-heating (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 will require 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.

5.5.7 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).

Table 41 – Severity of threats caused by climate change

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 to 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 to 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 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 current systems, efforts and community infrastructure to be responsive to changing climate, associated weather patters and the effects to the coastal corridor. Adapting 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 81, adapted from Beavers et al., 2016 illustrates how vulnerability is related to exposure and impact.

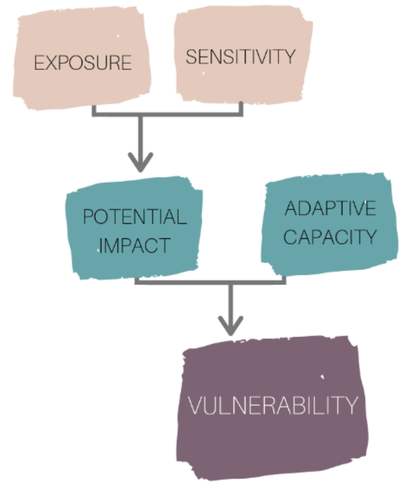


Figure 80 - Vulnerability framework (Adapted from Beavers et al., 2016)

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 coastal resiliency. Adaptation is best done as a consorted effort between all shoreline groups, making cooperation and communication imperative to tackle challenges. Reports from the United Nations International Panel on Climate Change (IPCC), and climate activists such as the Swedish student, Greta Thunberg (Figure 82), 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).

Proactive action 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, adjusting and rebuilding dunes and natural defences during low water levels is easier to prepare for high water levels in years to come (USACE, 2003). "When high water levels occur with intense and frequent precipitation events and periods of damaging storm waves, adaptation will be challenging" (USACE, 2003). Therefore, climate change adaptation recommendations from Environment and Climate Change Canada, and the Ministry of Environment, Conservation and Parks, and environmental groups focusing on climate change, should be implemented by coastal communities to ensure resiliency to changes. "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). Understanding the impacts of a changing climate and working in partnership with grass roots, local, and regional agencies will increase the ability for communities to manage risks.

Figure 81 - 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 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 application 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 are implementing projects related to climate change research, mitigation, and adaptation planning. For example, in 2010, Huron County released the framework document, *Take Action for Sustainable Huron,* highlighting the importance of natural environment features within the County. The County of Huron began a formal 5 year review process in 2019 to ensure that community vision and values, direction, policies, and actions in this Plan meet the future needs of the community including new policies to reflect changes. A new theme identified by the community in Huron County's Official Plan review is climate change. Individuals identified priorities including a Climate Change Action Plan, along with specific best management practices for the agricultural sector. The community supported 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.

CHAPTER 6: ASSESSMENT UNIT ANALYSIS

Eleven Assessment Units have been 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 1980s. 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 ha of diverse habitat.

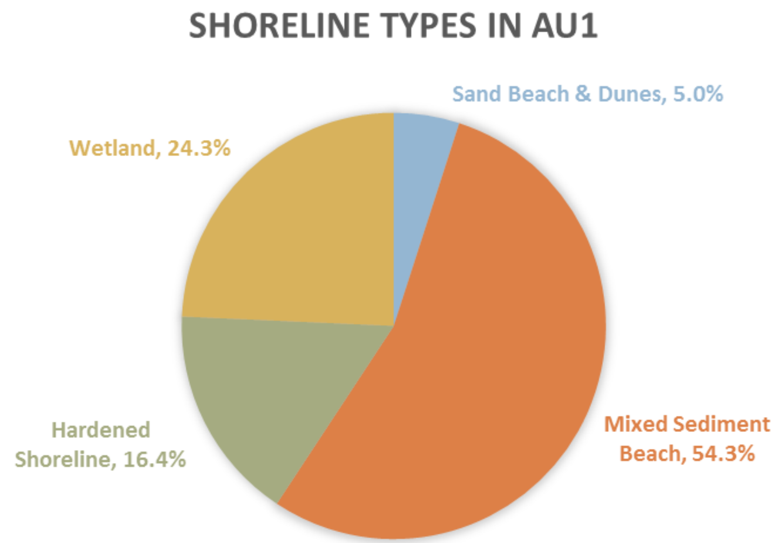
Defining Features

- 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%

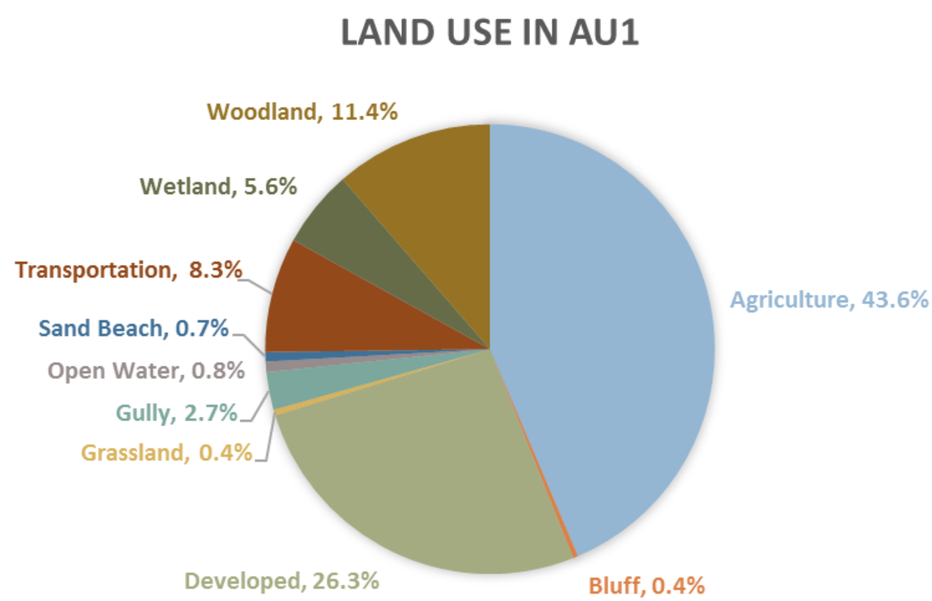
MAP 1: Shoreline Types in AU 1



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

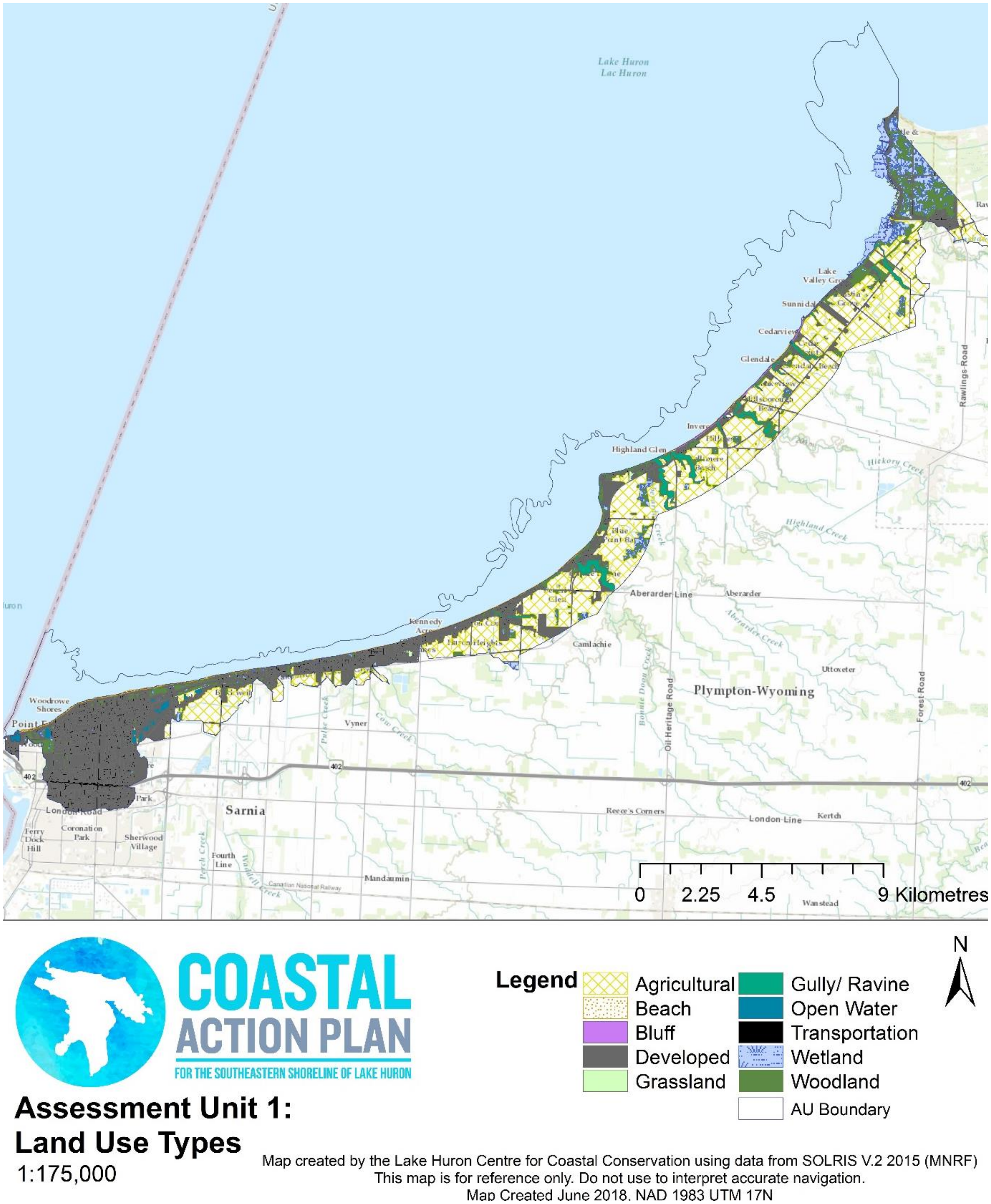
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<20%	20-40%	40-70%	>70%
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	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 Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Area of transportation corridor (%, ha)	8.3%, 707.76 ha			
*** Coastal corridor is 34.52% developed, including transportation.* *** Road density is high:4,131.32m/km²*					

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.
Lack of strict regulation and bylaw.	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.


Lake Huron
Lac Huron
Kettle & Stony Point
Kettle Point
Lake Valley Grove
Gustin Grove
Sunnidale
Cedarview
Cedar Point
Glendale
Glendale Beach
Lakeview
Hillsborough Beach
Invernairn
Hillcrest
Highland Glen
Gallimere Beach
Blue Point Bay
Bonnie Doone
Beverly Glen
Aberarder Line
Aberarder
Errol
Kennedy Acres
Elton Court
Huron Heights
Camlachie
Bird Lakes
Bright's Grove
Lakeshore Road
Blackwell
Woodrowe Shores
Oakwood Corners
Point Edward
Vyner
Plympton-Wyoming
Uttoxeter
Sarnia
London Road
London Line
Reece's Corners
Kertch
Ferry Dock Hill
Coronation Park
Sherwood Village
Fourth Line
Mandaumin
Wanstead
Indian Road North
Oil Heritage Road
Forest Road
Rawlings Road
Kinnaird
Ravenswood
Ipperwash Beach
0 2.75 5.5 11 Kilometres
N
COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON
Assessment Unit 1:
Shoreline Biodiversity Features
1:180,000
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
Legend
Man-Made Permeable
Man-Made Solid
Sand Beach
Wetland

MAP 2 – Land-Use Types in AU 1



ASSESSMENT UNIT 2: KETTLE POINT TO GODERICH

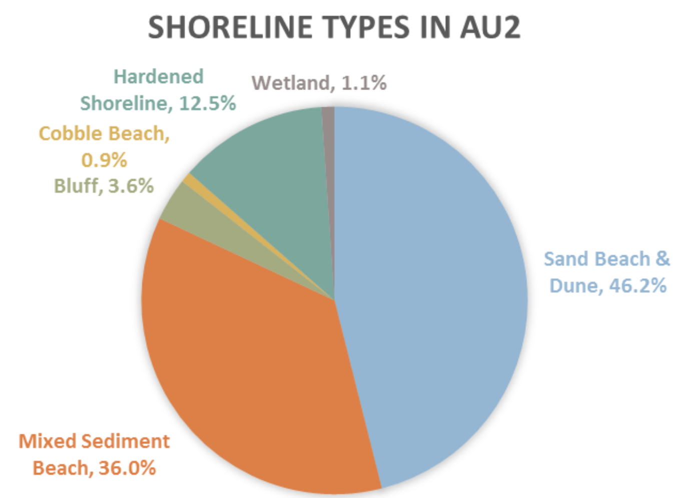
The Kettle Point to Goderich Assessment Unit 2 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 2 (AU2) has 120.85 km of shoreline, with the coastal corridor covering 8,939.55 hectares of diverse habitat.

Defining Features

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

SHORELINE COMPOSITION IN ASSESSMENT UNIT 2

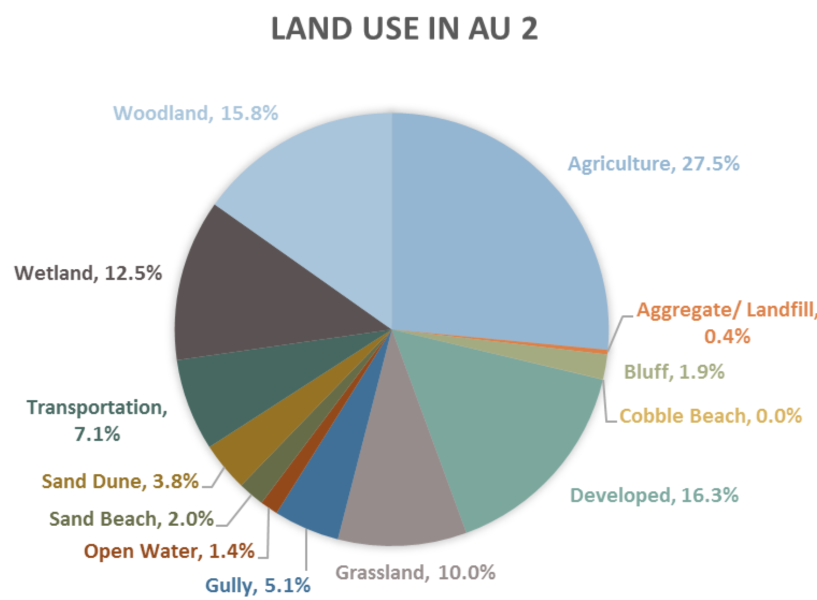
Total km	Sand beach &	Mixed Sediment Beach	Bluffs	Cobble Beach	Hardened Shoreline	Wetland	River mouths
120.1	55.5	43.2	4.3	1.1	15.0	1.3	9
% coverage:	46.2%	36%	3.6%	0.9%	12.5%	1.1%	0



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%



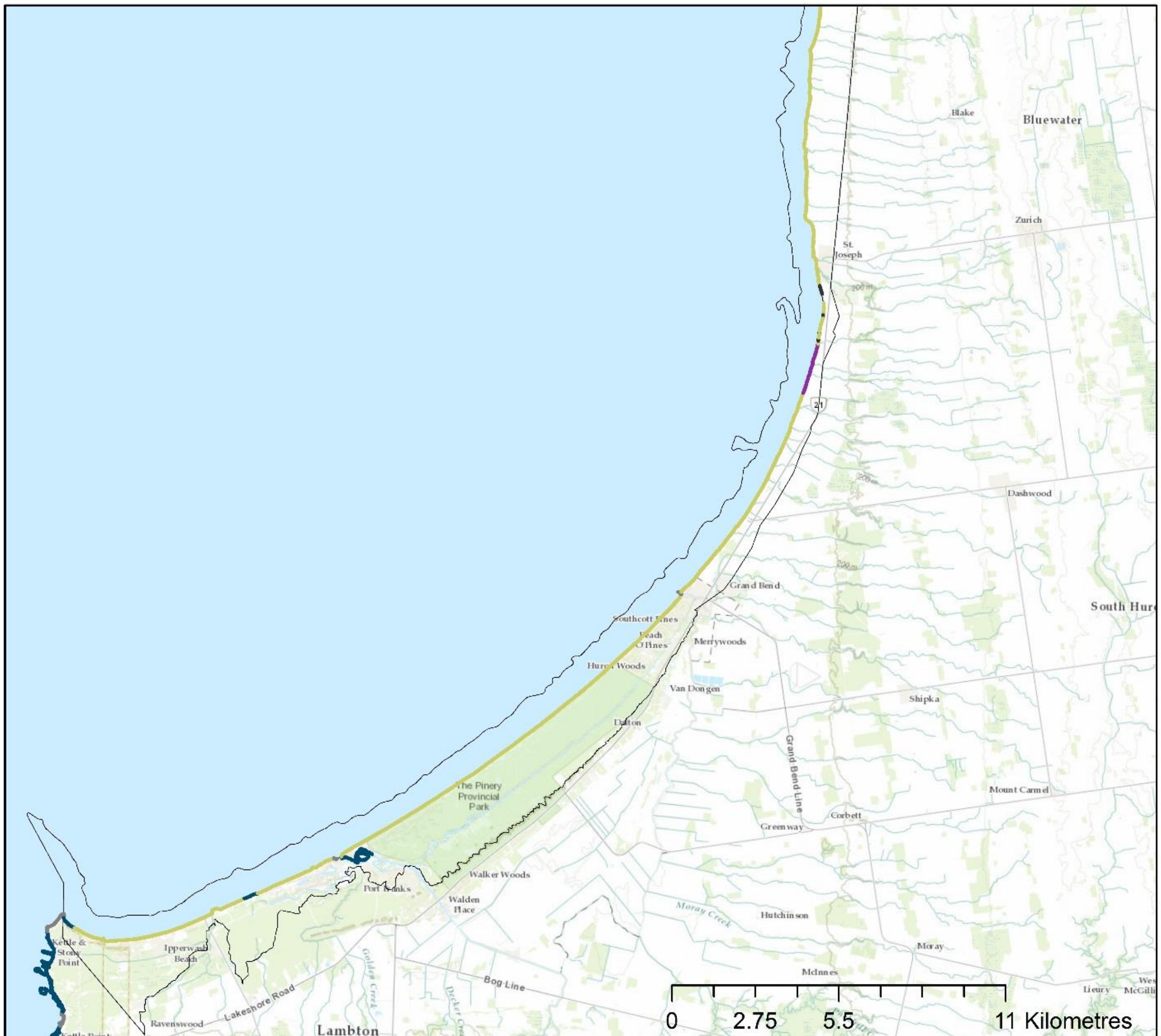
MAP 3,4 & 5: Land-Use Types in AU 2

Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Area of transportation corridor (%, ha)	7.12%, 363.66 ha			
*** Coastal corridor is 23.4% developed, including transportation. ** Road density is high: 4,247.45/km²*					

Key stressors and Opportunities

Stressors	Opportunities
Lack of buffer zones between development and	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.



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 2(a): Shoreline Biodiversity Features

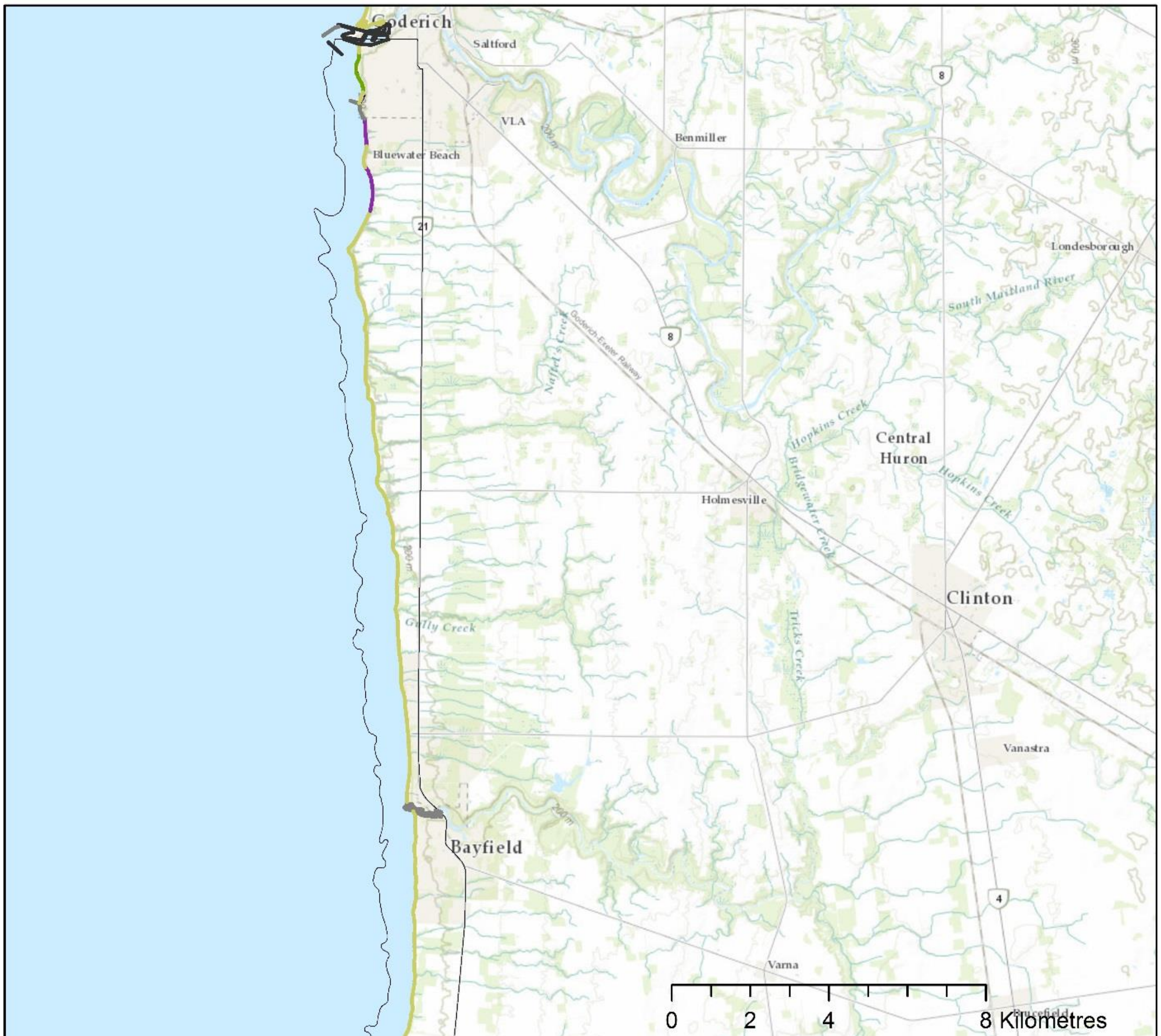
1:180,000

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

- Bluff
- Cobble Beach
- Man-Made Permeable
- Man-Made Solid
- Sand Beach
- Wetland



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 2(b): Shoreline Biodiversity Features

1:139,000

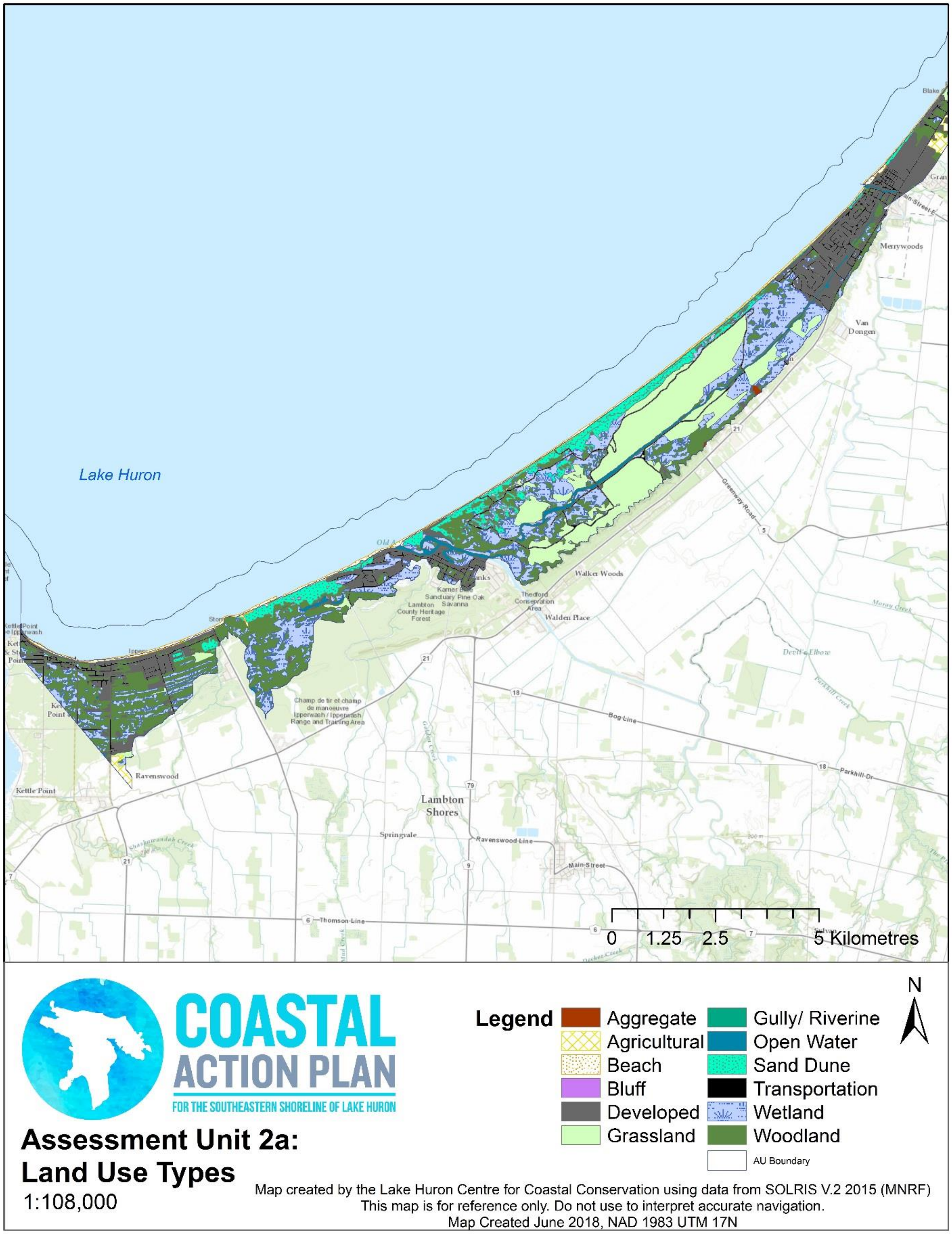
Map created by the Lake Huron Centre for Coastal Conservation using data from Ontario Shoreline Segmentation Layer (Environment Canada).
This map is for reference only. Do not use to interpret accurate navigation.
Map Created May 2018, NAD 1983 UTM 17N

Legend

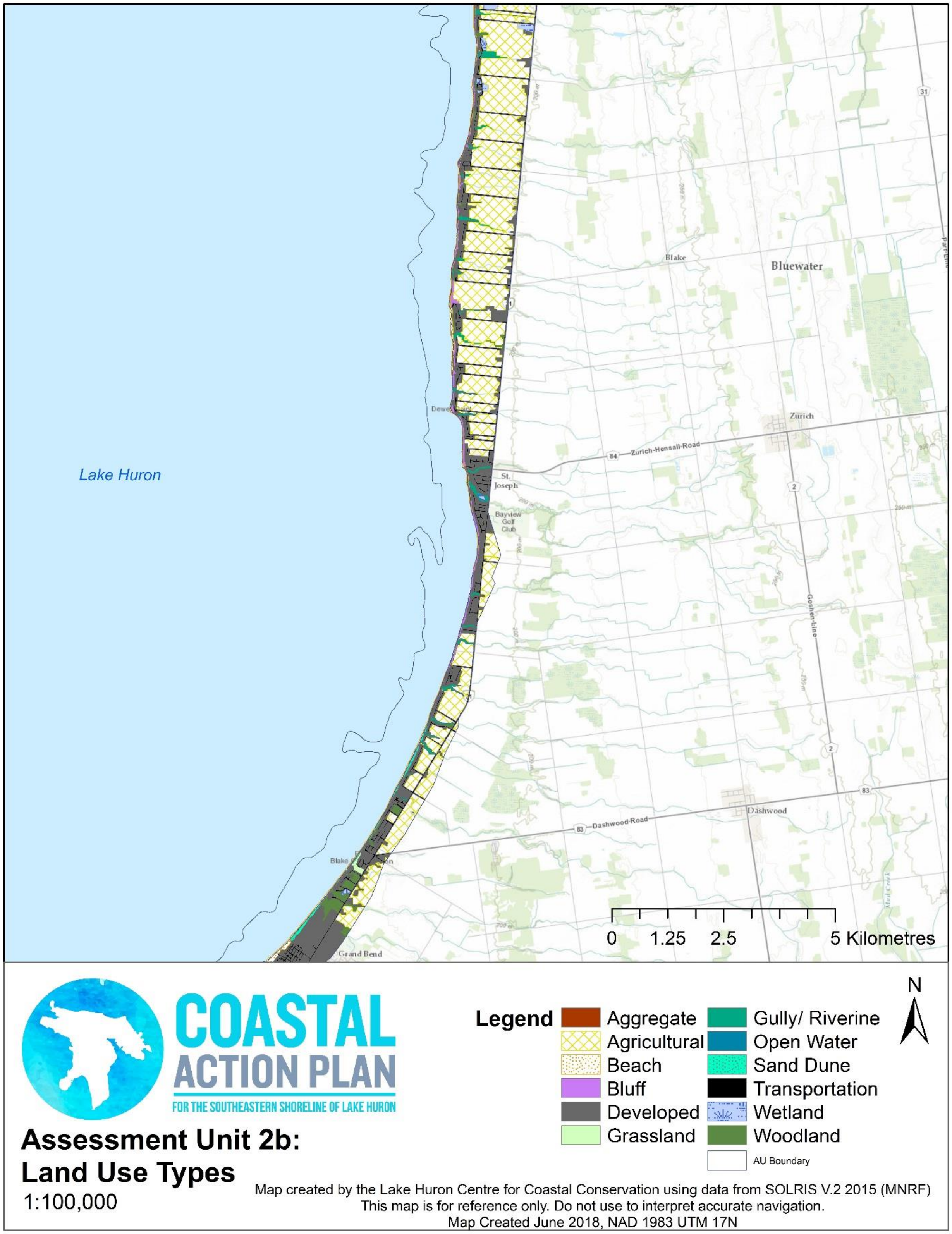
N

- Bluff
- Cobble Beach
- Man-Made Permeable
- Man-Made Solid
- Sand Beach
- Wetland

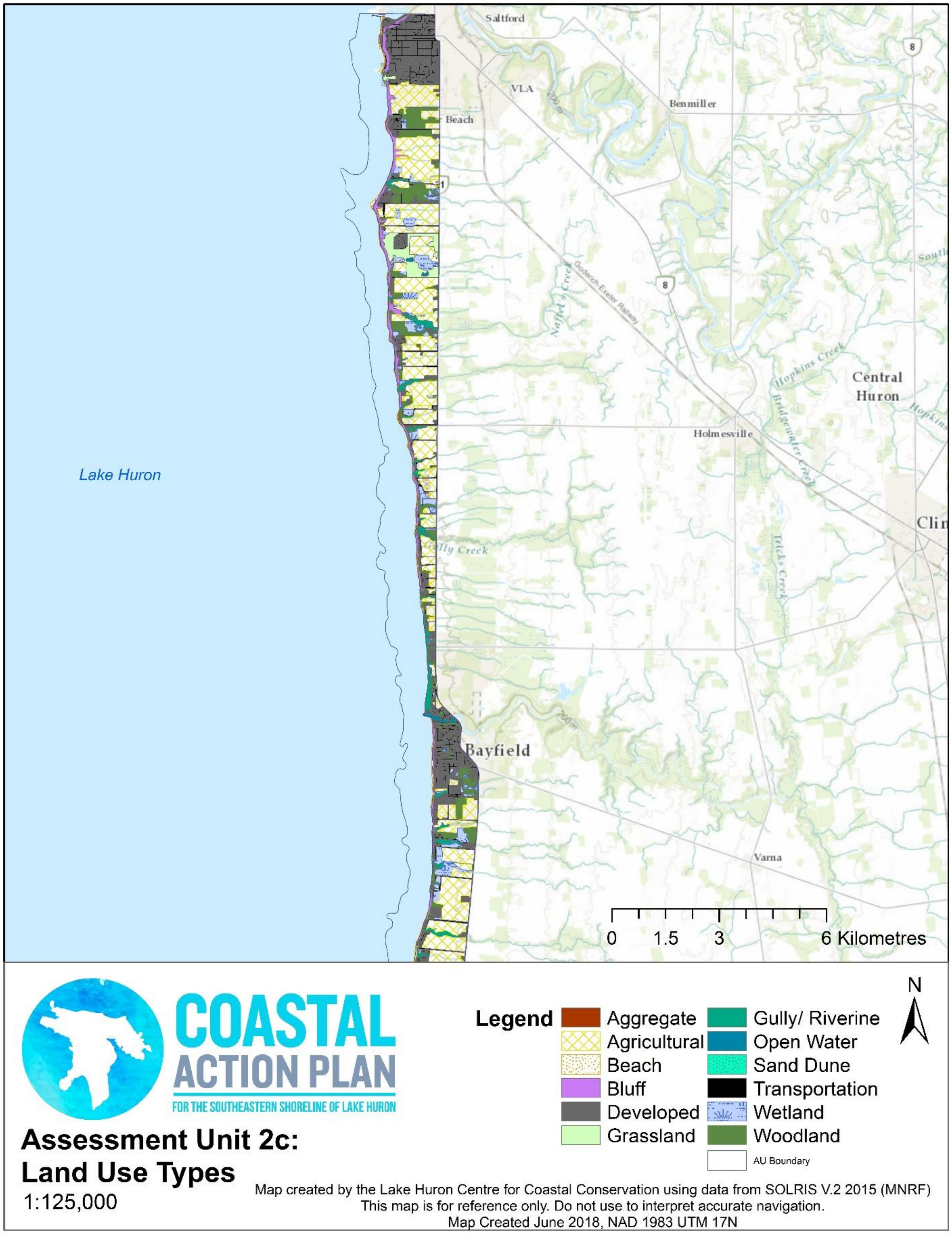
MAP 3 – Land-Use Types in AU 2



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.

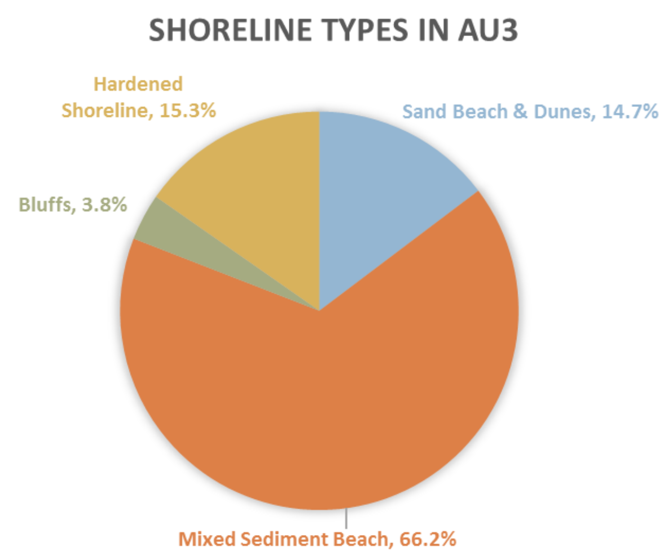
Defining Features

- 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

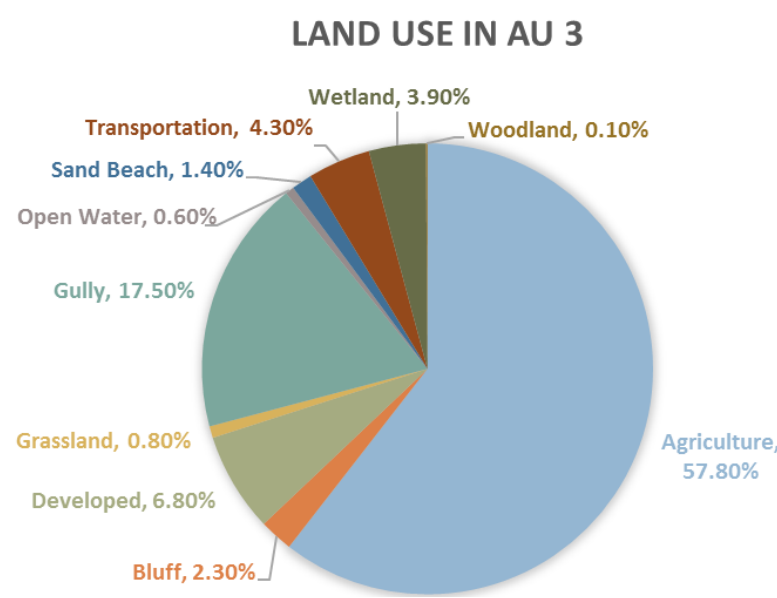
MAP 1: Shoreline Types in AU 3



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



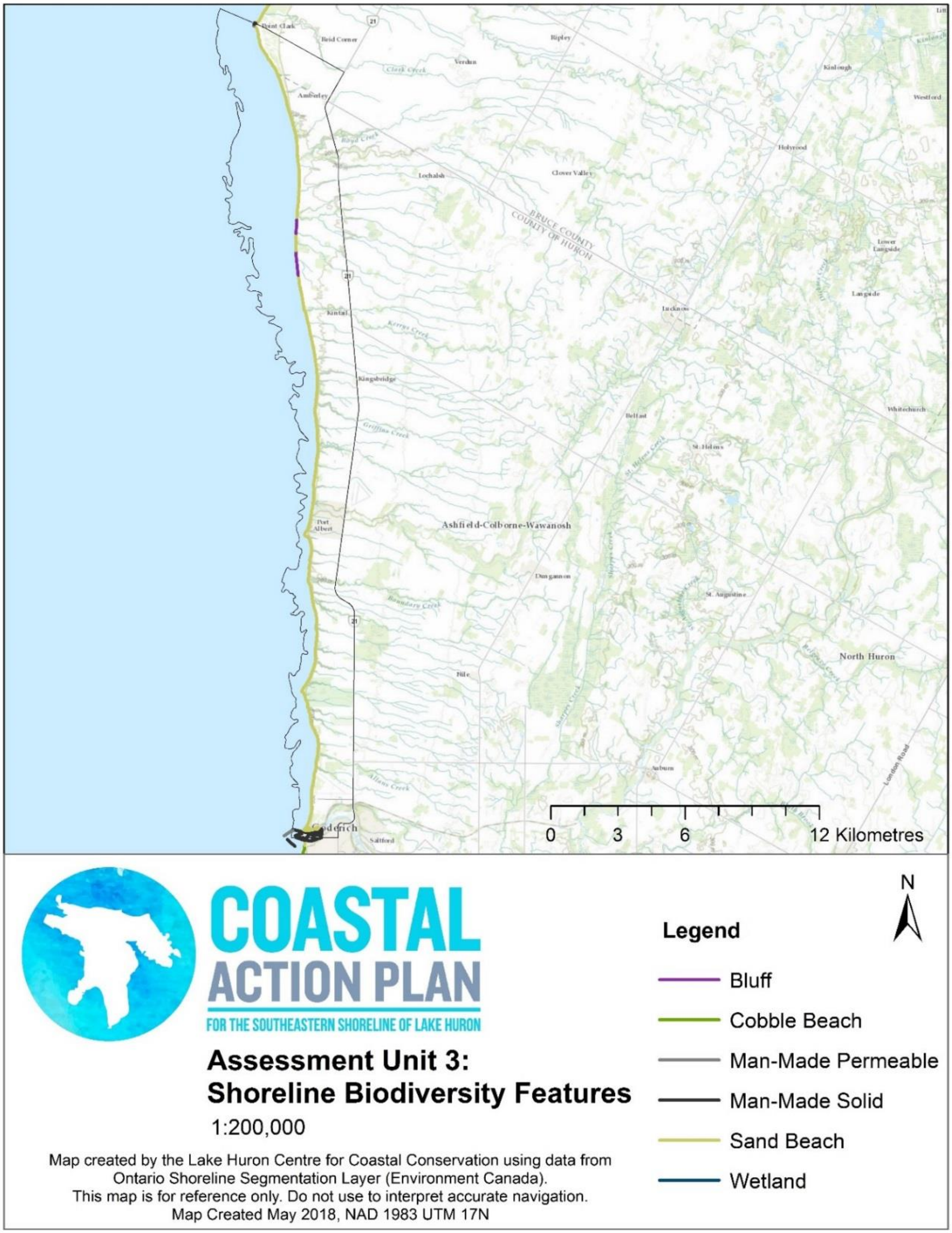
Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	4.3%, 315.82 ha			
** Coastal corridor is 11.2% developed, including transportation. ** Road density is high: 2,175.41/km²					

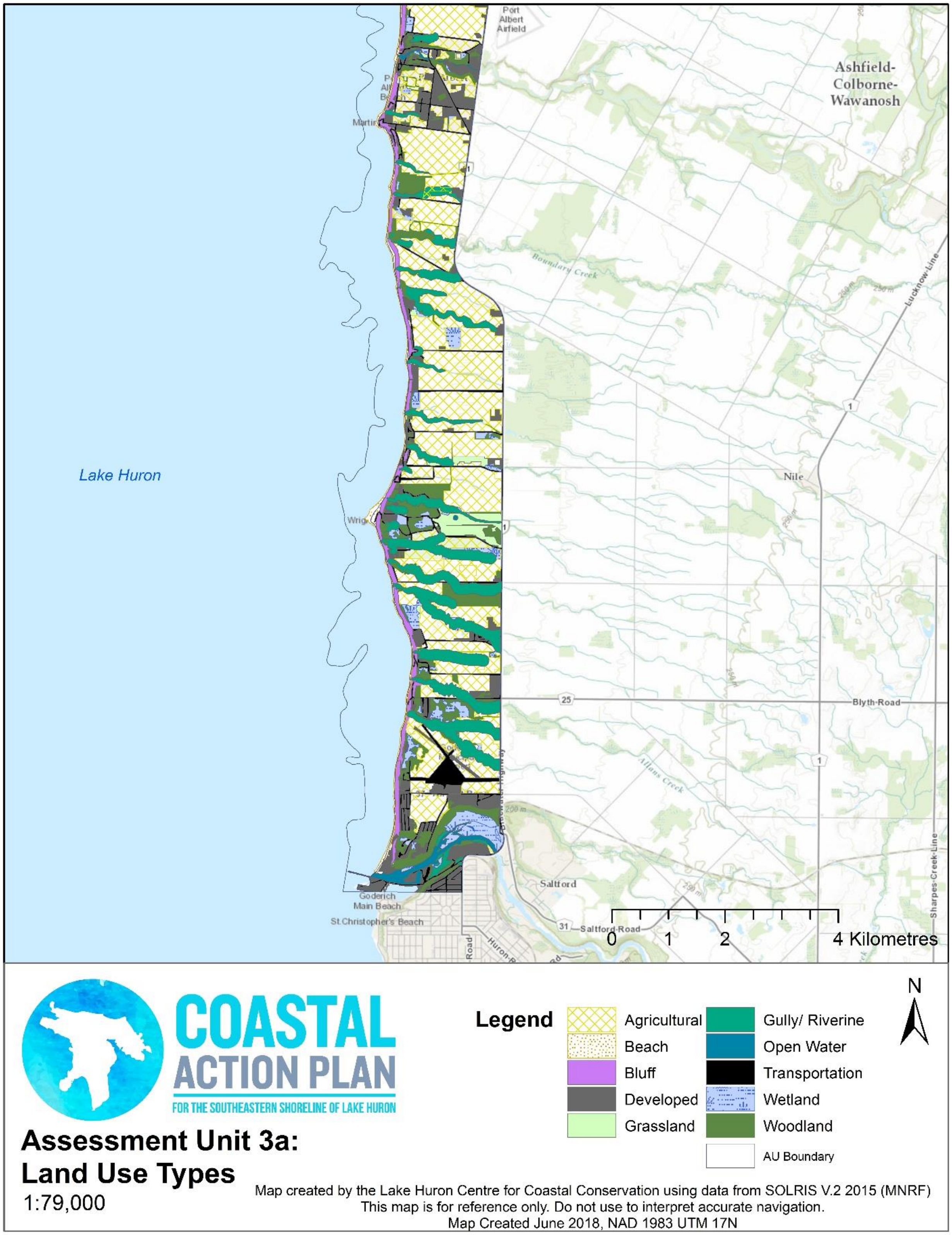
Key stressors and Opportunities

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.

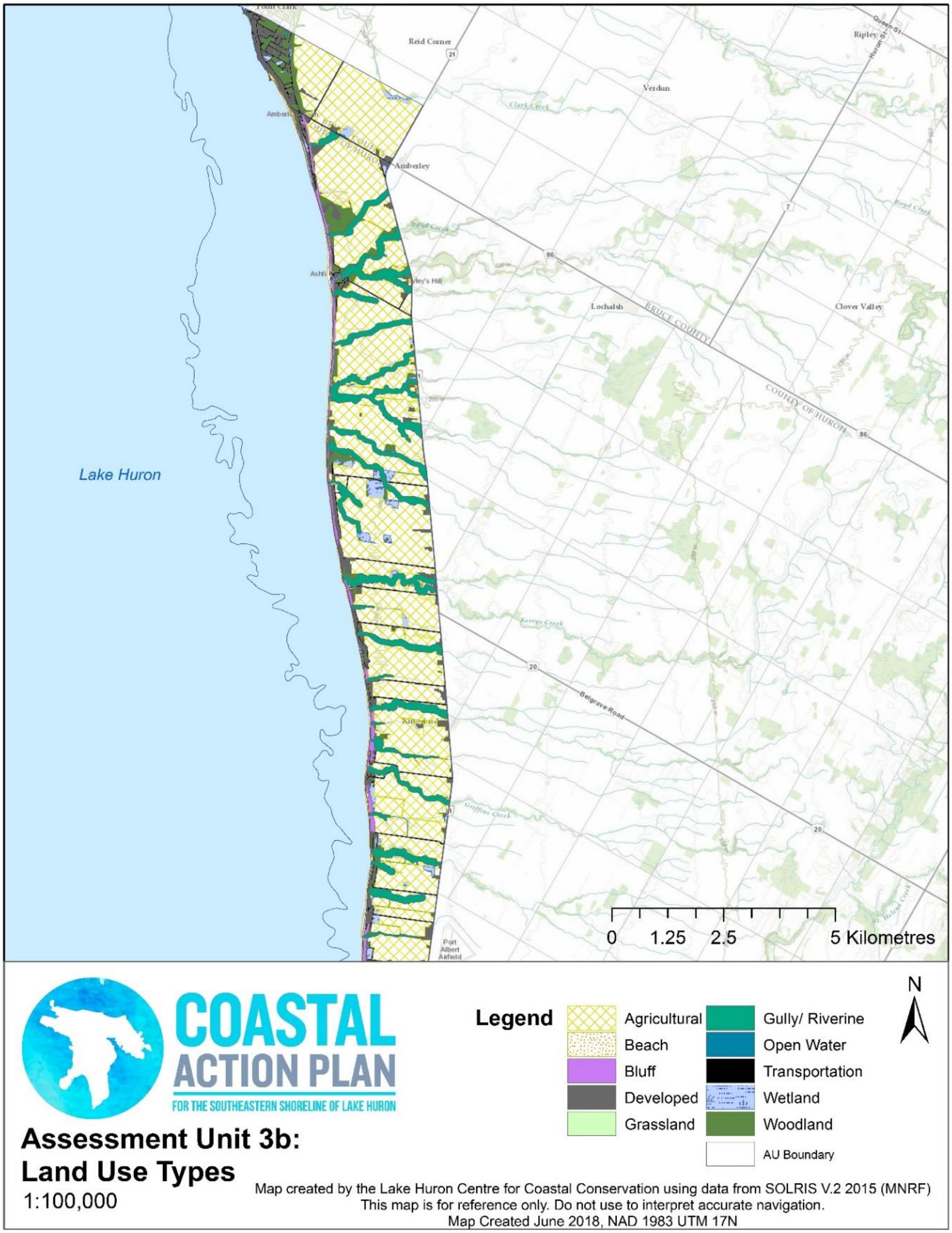
MAP 3 - Shoreline Types in AU 3



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.

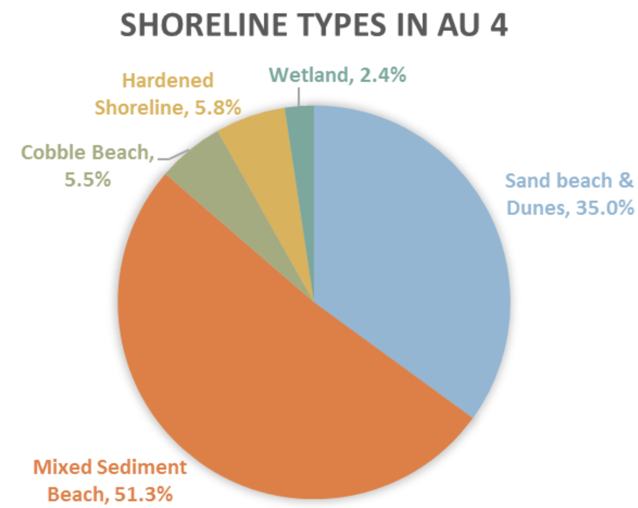
Rivers - Pine and Pentagore.

Developed community of Kincardine.

Great Lakes St. Lawrence Hardwood woodlands.

SHORELINE COMPOSITION IN ASSESSMENT UNIT 4

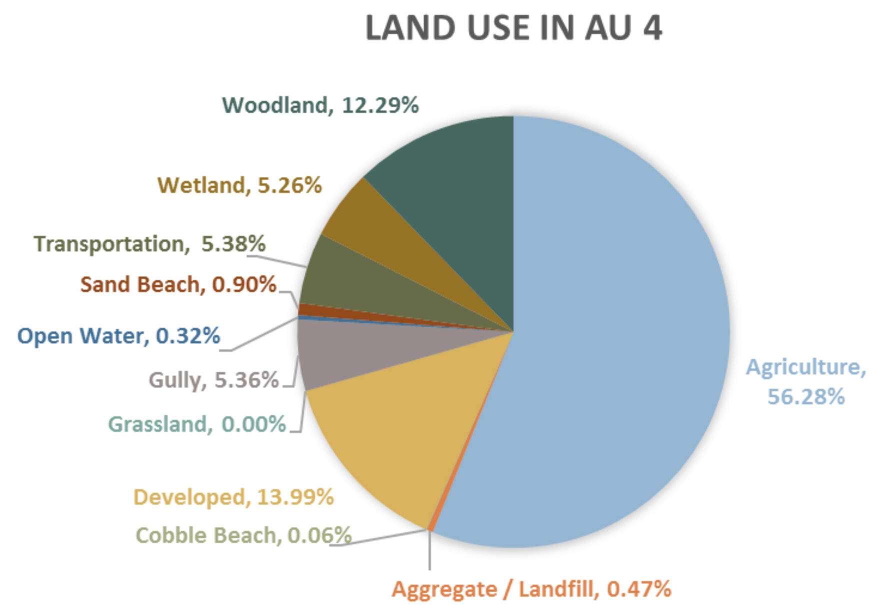
Total km	Sand beach & Dunes	Mixed Sediment Beach	Cobble Beach	Hardened Shoreline	Wetland	River Mouth
39.76	13.92	20.39	2.2	2.3	0.96	2
% coverage:	35%	51.3%	5.5%	5.78%	2.4%	n/a



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

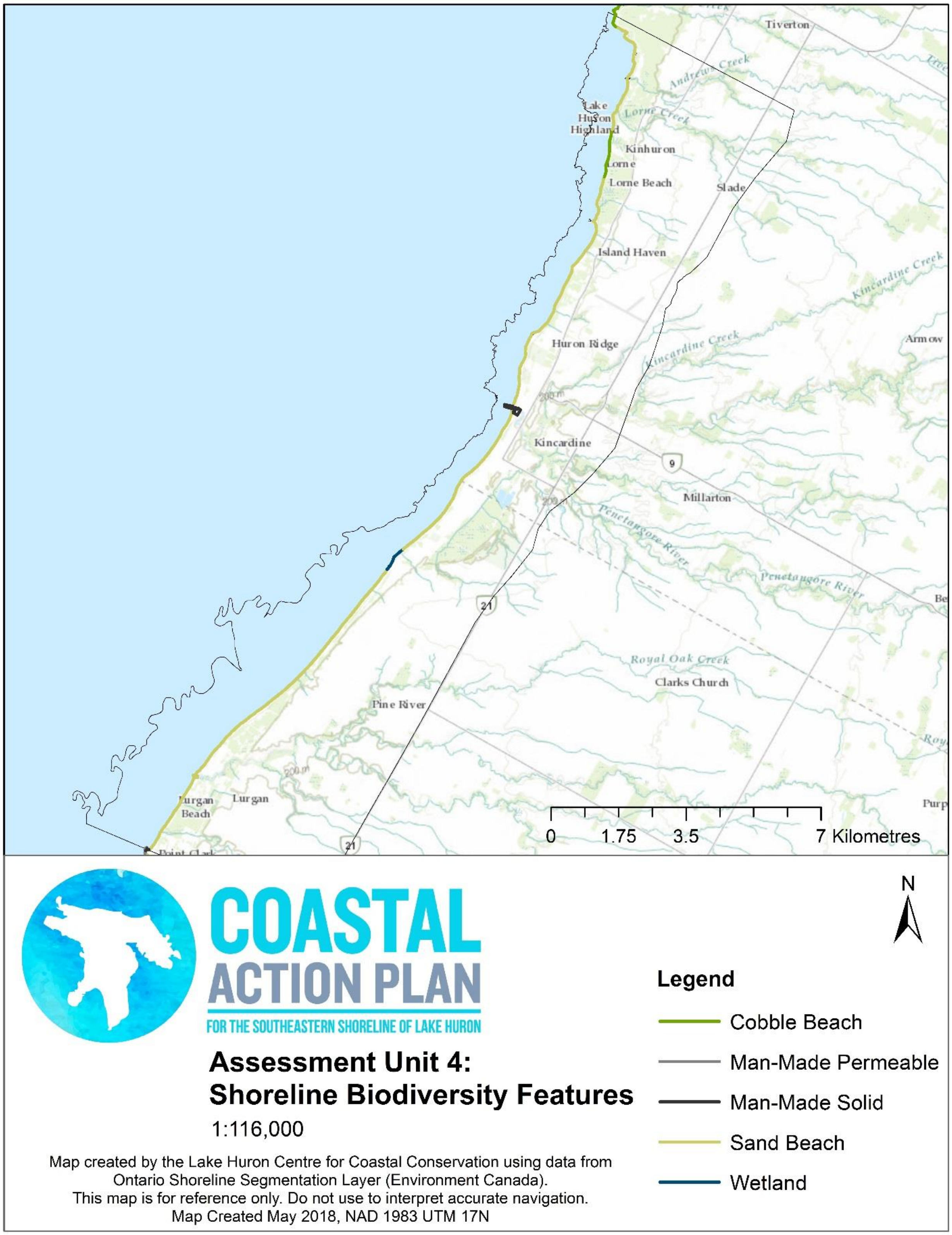
Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km^2)	>2000m /km^2	700-1,999 m/ km^2	100-690 m/ km^2	<100 m/ km^2
	Presence of transportation corridor (%, ha)	5.38%, 467.47 ha			
*** Coastal corridor is 19.37% developed, including transportation.* *** Road density is high: 2,240.64/km^2*					

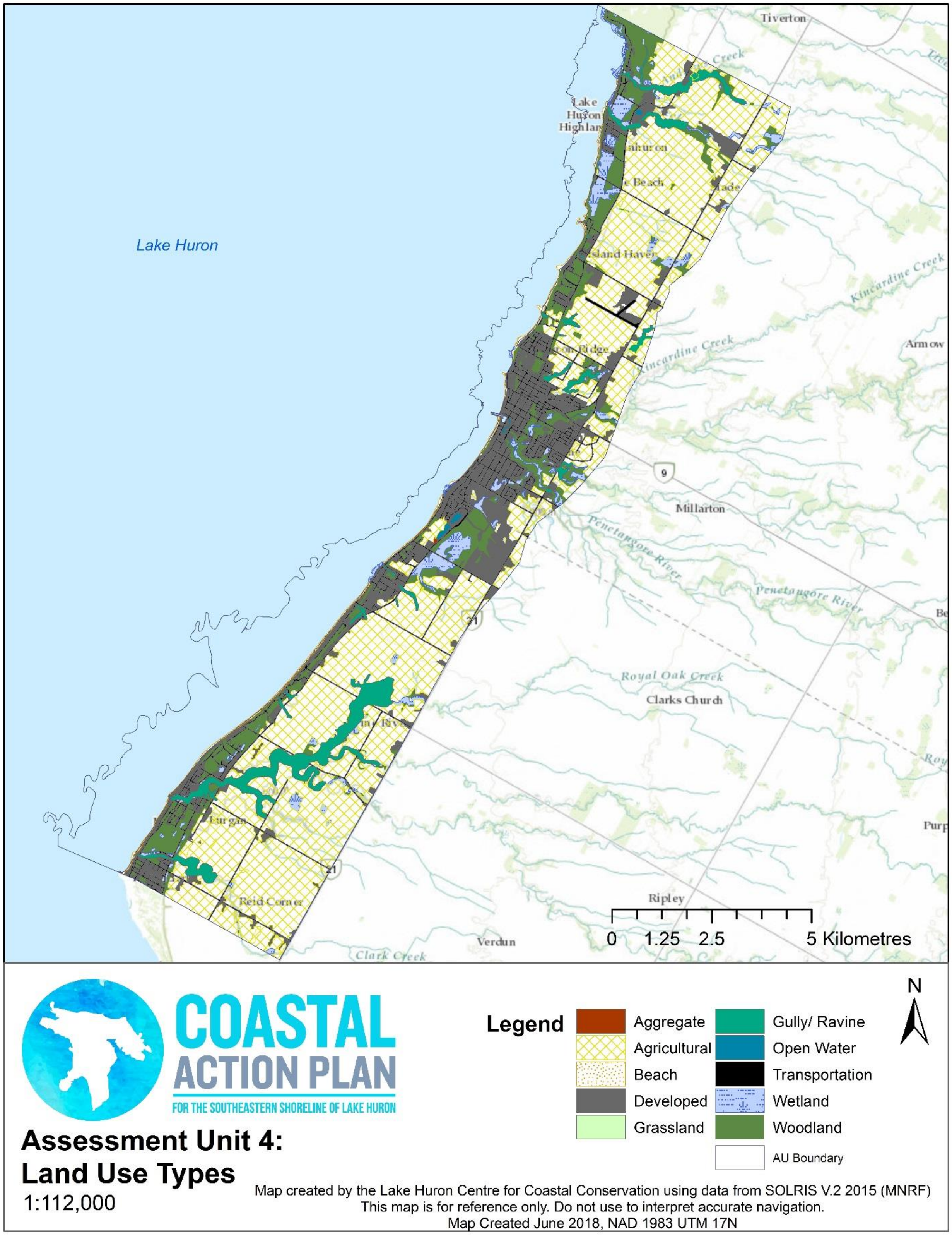
Key Stressors and Opportunities

Stressors	Opportunities
Presence of Invasive species.	Restoration of shoreline through structure/hazard removal.
Lack of naturalized ecosystems along	Need beach and dune restoration.
Invasive species.	Increase invasive species awareness program and treatment
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.

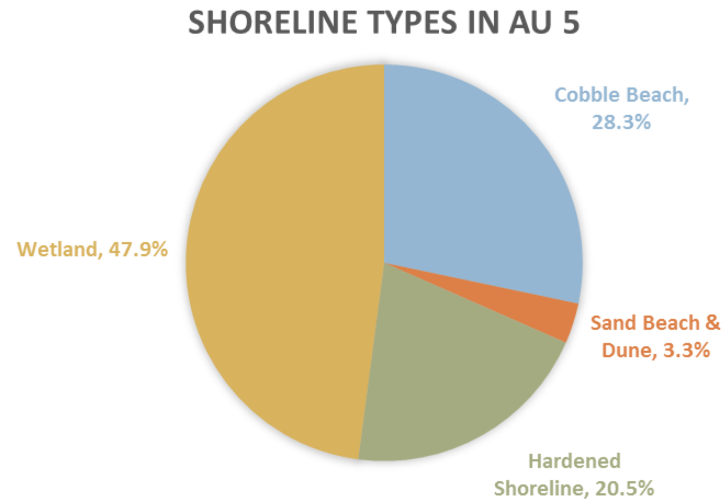
Dominated by coastal wetlands and forests.

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

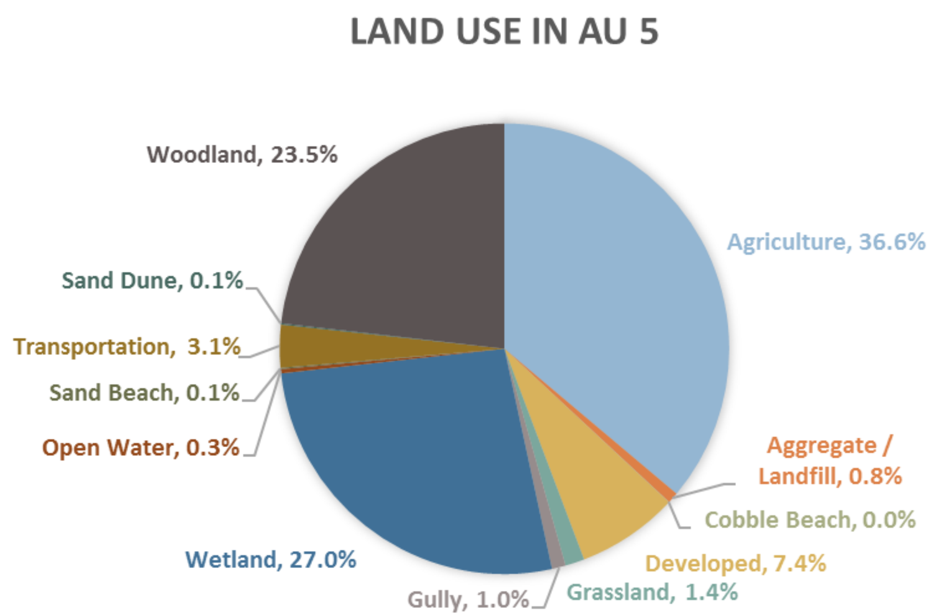
MAP 1: Shoreline Types in AU 5



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

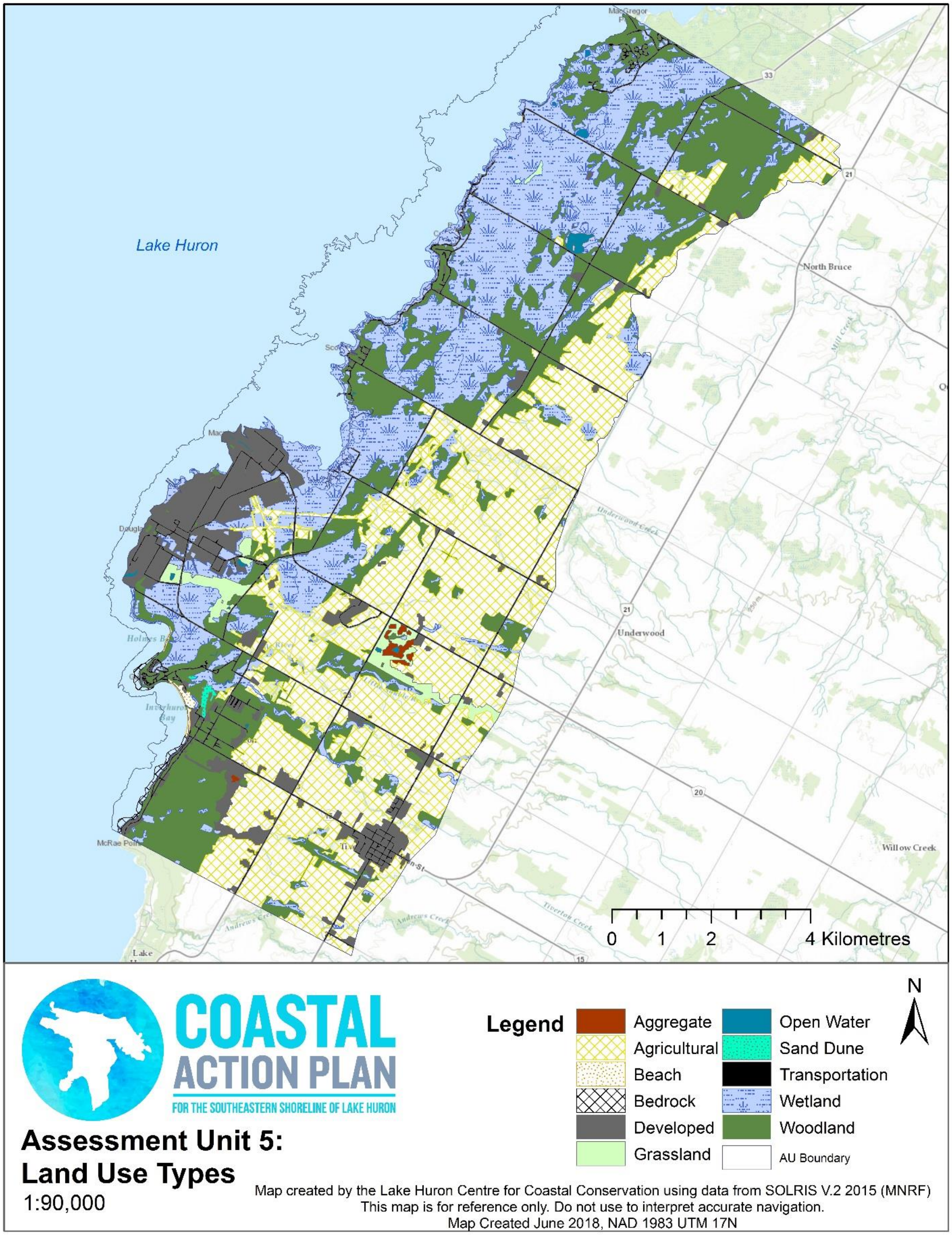
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<20	20-40%	**40-70%**	>70%
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	**<29%**	30-39%	40-49%	>50%
	Number of large forest patches (+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 Detritus	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 development (%)	>26%	**11-25%**	1-10%	0%
	Road density (m/km²)	>2000m /km²	**700-1,999 m/ km²**	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	3.11%, 338.41 ha			
*** Coastal corridor is 10.47% developed, including transportation. ** Road density is high: 1,376.07/km²*					

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.


MacGregor Point
Provincial Park
North Bruce
Baie
du Dore
Inverhuron
Provincial Park
Inverhuron
Underwood
Tiverton
0 1.5 3 6 Kilometres
COASTAL
ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON
Assessment Unit 5:
Shoreline Biodiversity Features
1:100,000
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
Cobble Beach
Man-Made Permeable
Man-Made Solid
Sand Beach
Wetland

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.

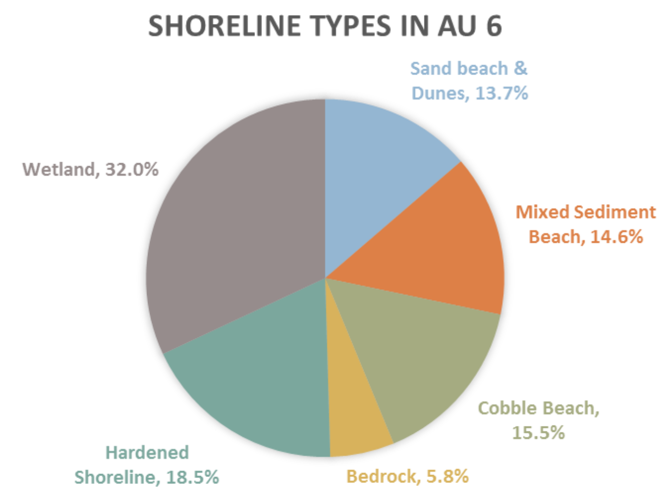
Agricultural productivity.

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

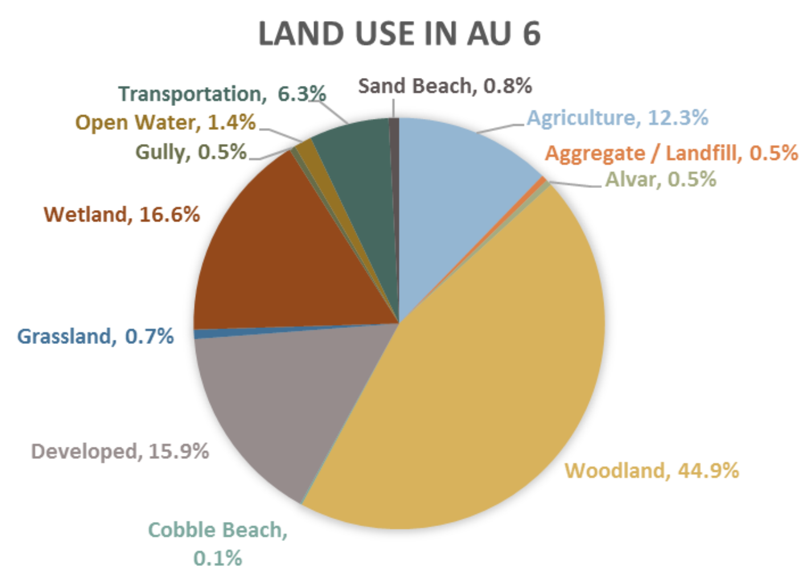
MAP 1: Shoreline Types in AU 6



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

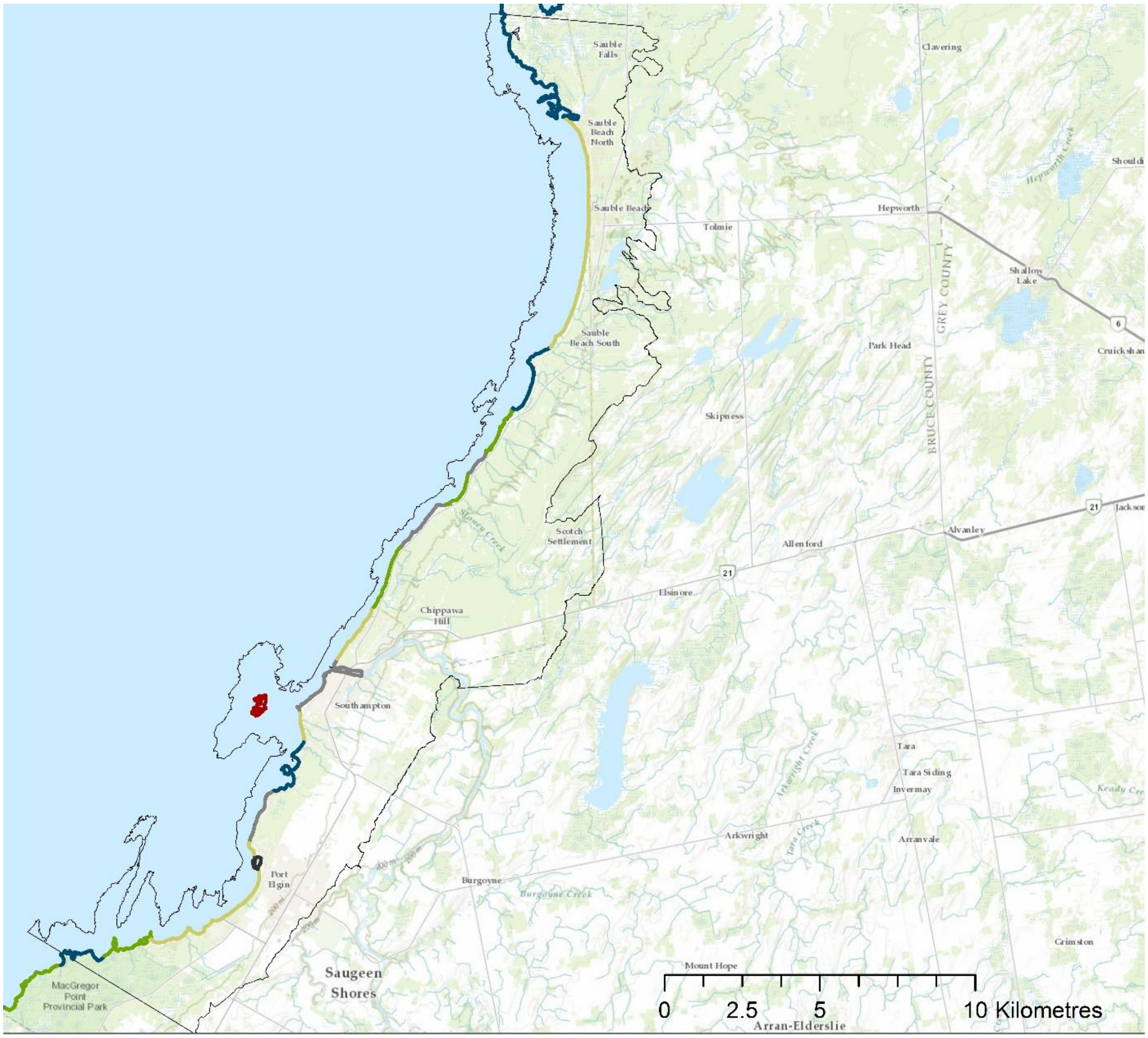


Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 Detritus	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 development (%)	>26%	**11-25%**	1-10%	0%
	Road density (m/km²)	**>2000m /km²**	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	6.30%, 751.30 ha			
*** Coastal corridor is 22.16% developed, including transportation.* *** Road density is high: 2,904.53/km²*					

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
Beach grooming.	Re-build dunes and natural shoreline 'structures' such as wrack lines, mature dunes, and shoreline buffers.



N

Assessment Unit 6:
Shoreline Biodiversity Features

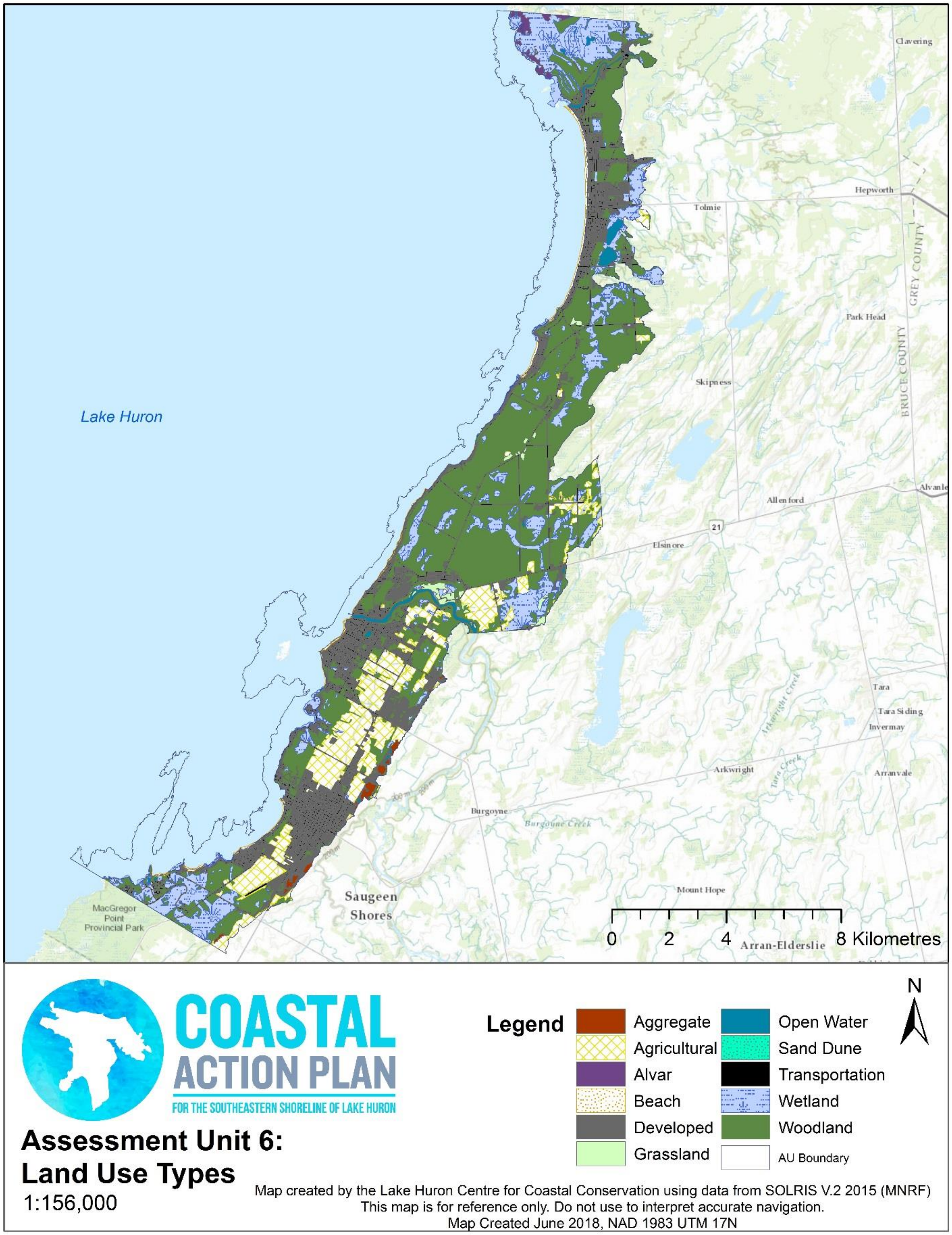
1:175,000

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

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.

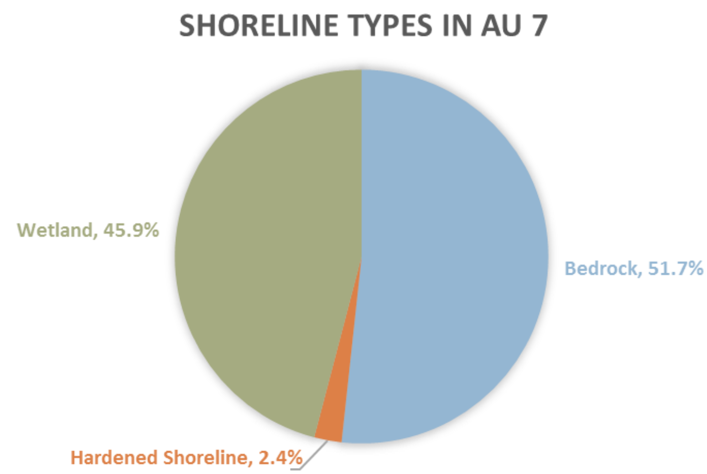
Great Lakes, St. Lawrence Forest Region dominates landscape.

Petrel Point Nature Reserve.

Provincially Significant Wetland - Red Bay.

SHORELINE COMPOSITION IN ASSESSMENT UNIT 7

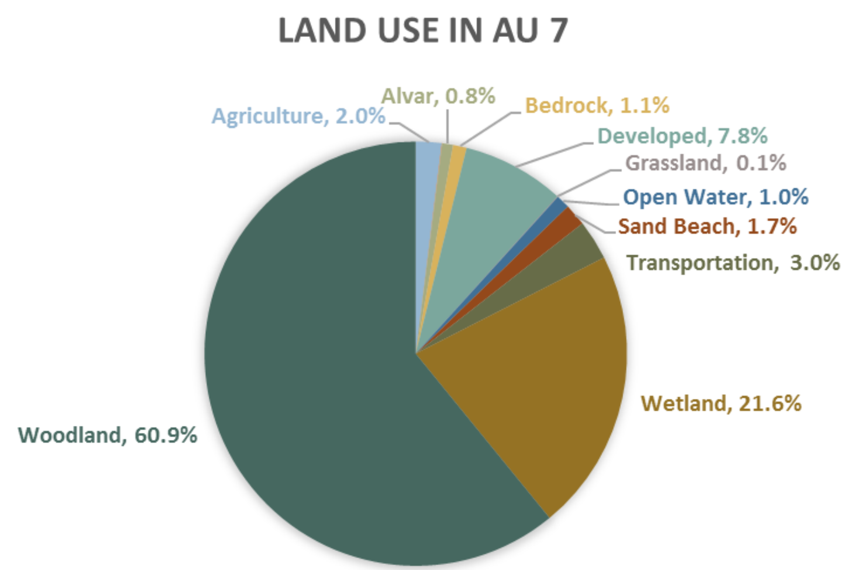
Total km	Bedrock	Hardened Shoreline	Island	Wetland
191.43	98.97	4.55	87	87.91
% coverage:	51.7%	2.37%	45.45%	45.9%



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

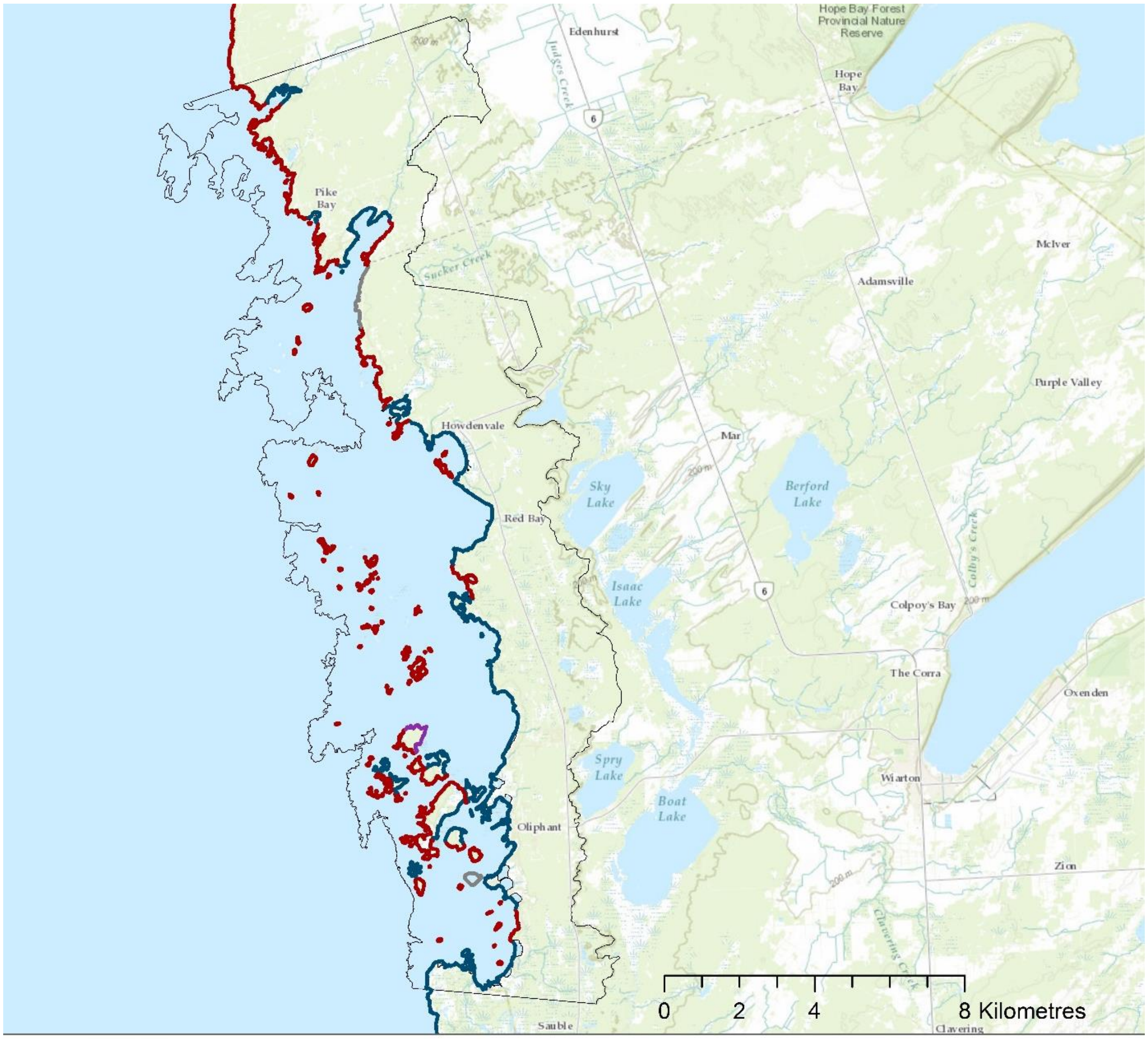
Ecosystem Health Analysis

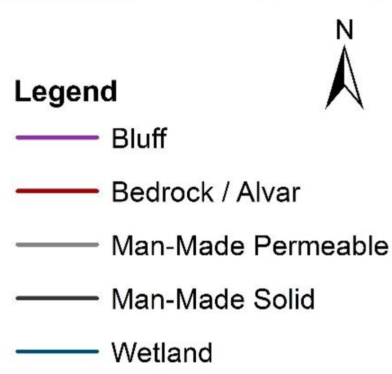
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<20	20-40%	40-70%	>70%
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	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 Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	3.04%, 253.84 ha			
** *Coastal corridor is 10.86% developed, including transportation.* ** *Road density is high: 1,407.96/km²*					

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.
Presence of invasive species.	Increase invasive species awareness program and treatment

MAP 11 - Shoreline Types in AU 7





COASTAL ACTION PLAN

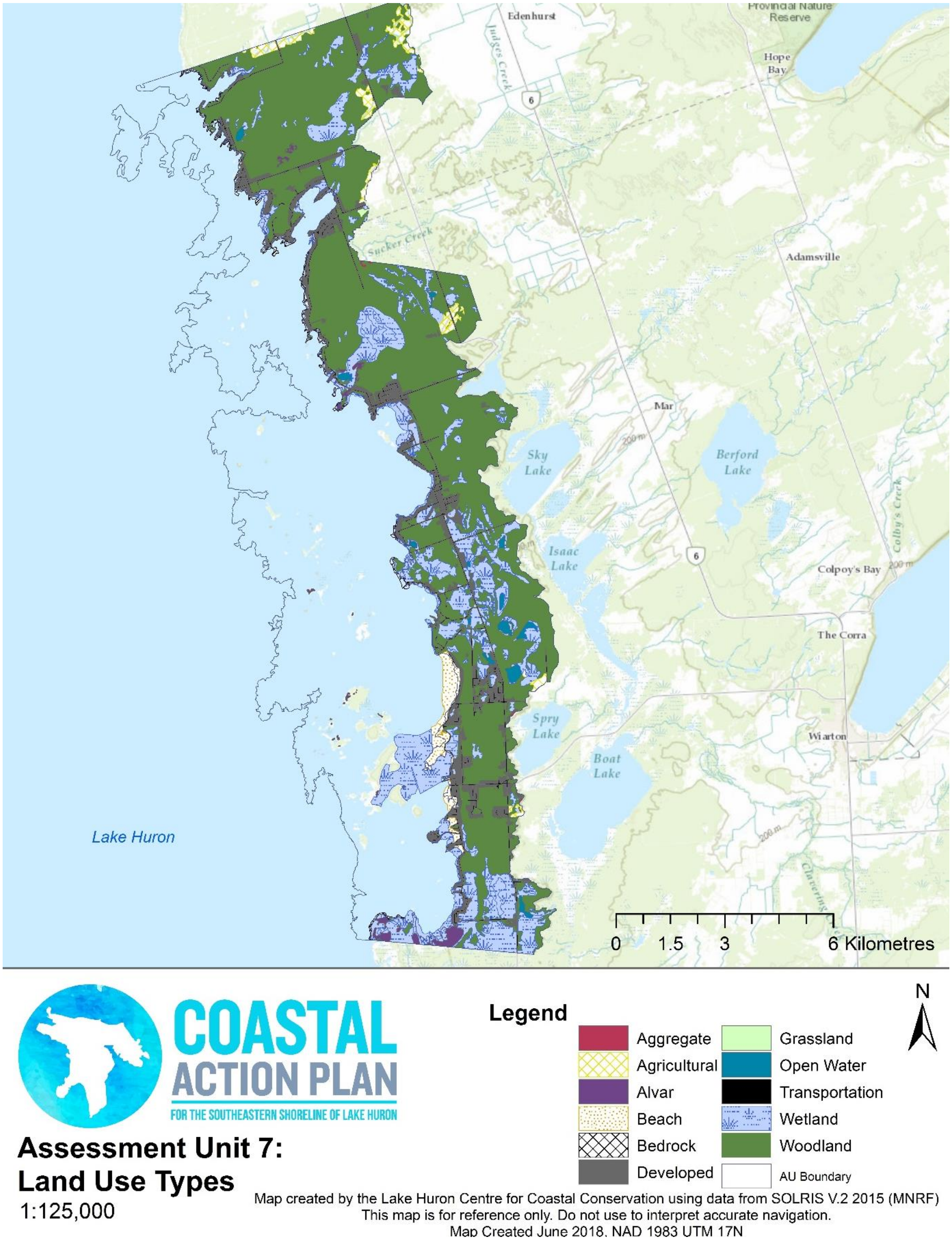
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 7:
Shoreline Biodiversity Features

1:145,000

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

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).

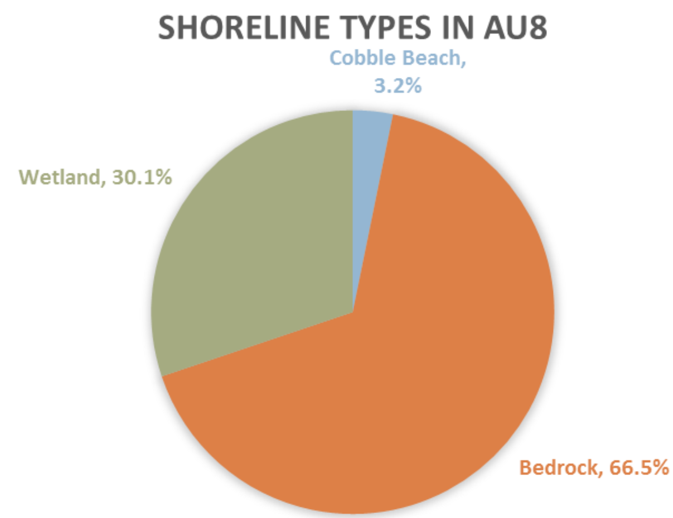
Steep Bathymetry.

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

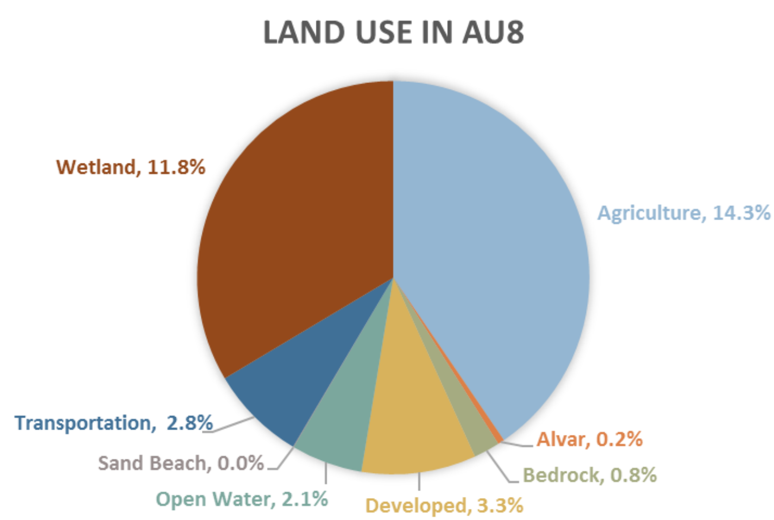
MAP 1: Shoreline Types in AU 8



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

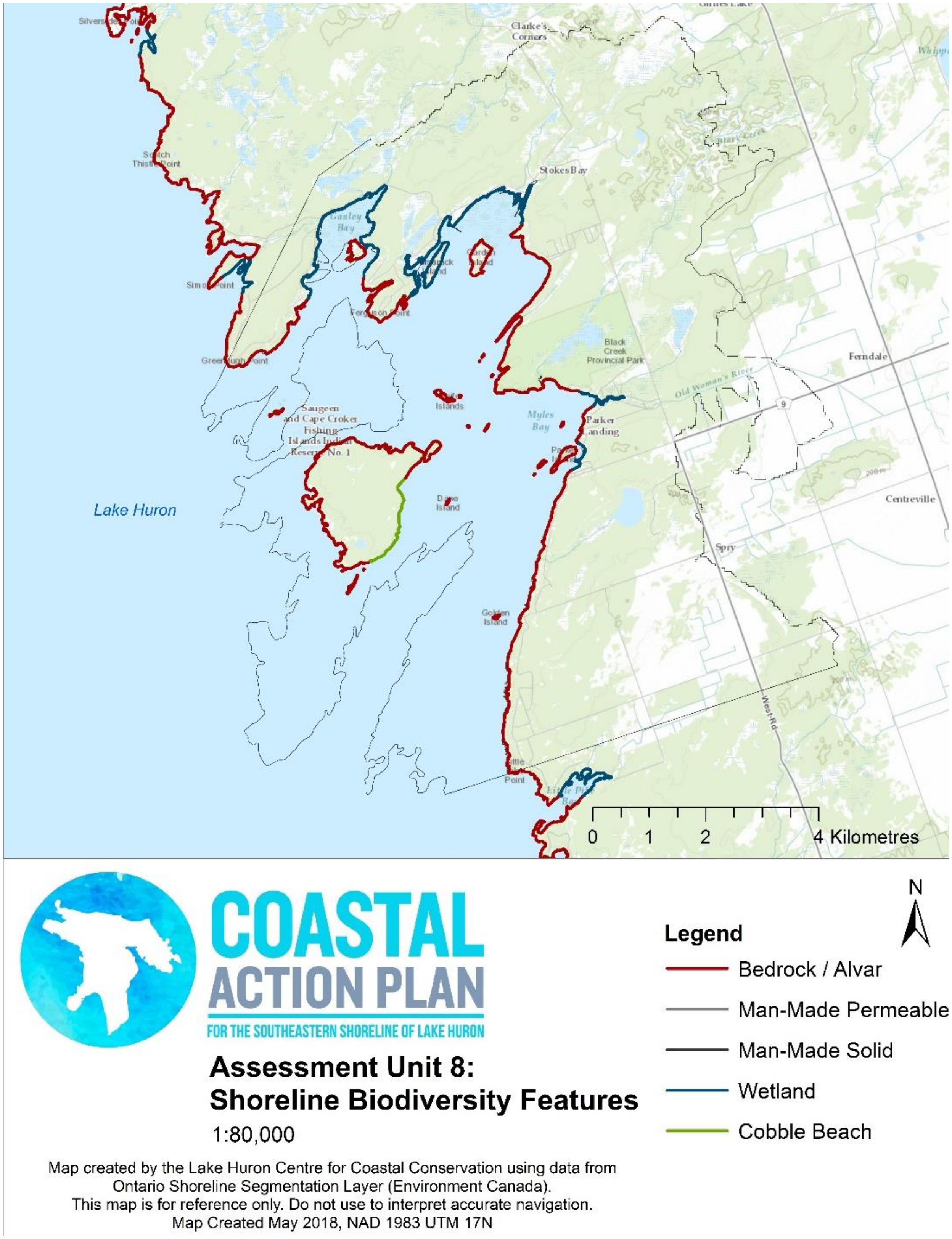


Ecosystem Health Analysis

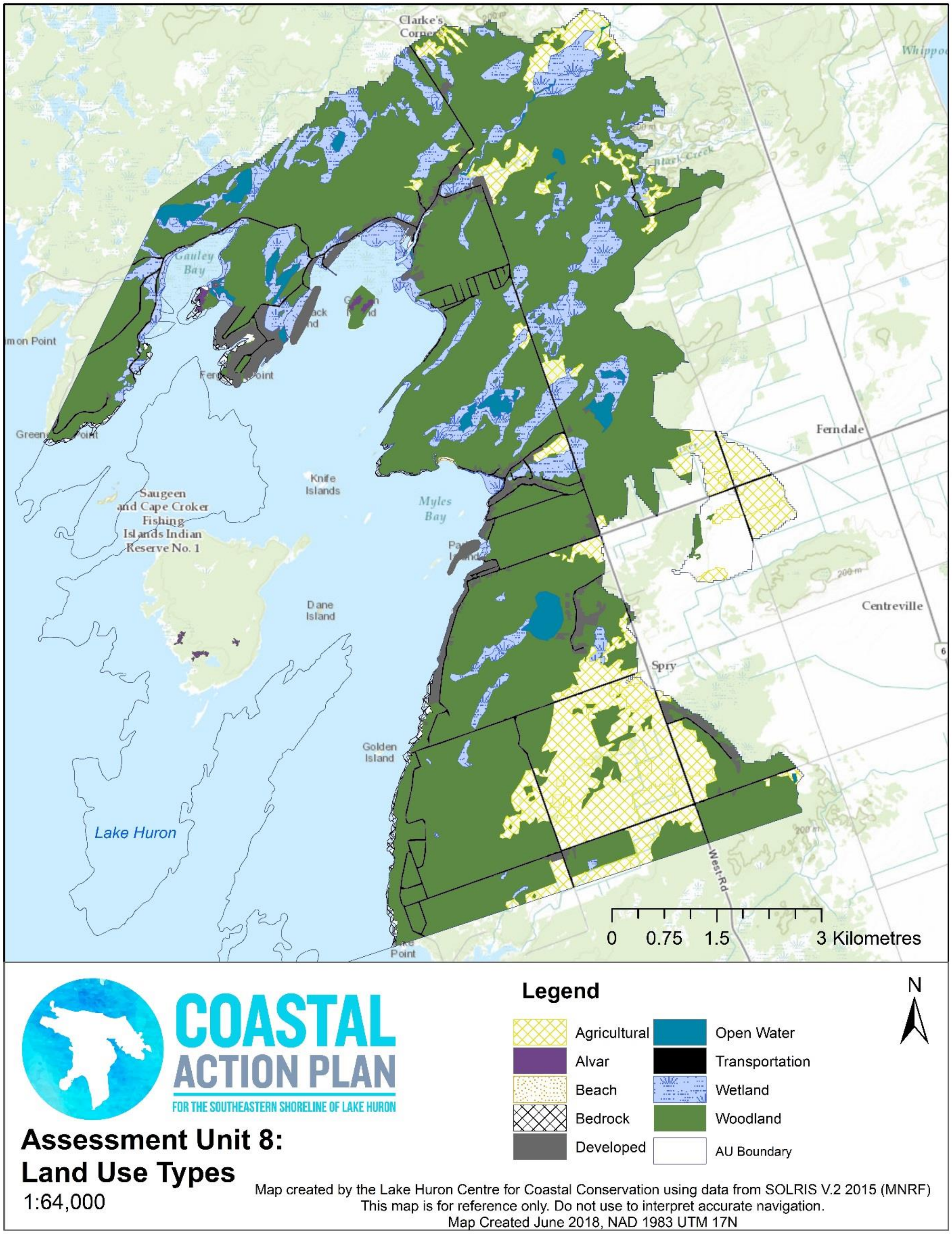
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<20	20-40%	40-70%	**>70%**
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	**>50%**
	Number of large forest patches (+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 Detritus	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 development (%)	>26%	11-25%	**1-10%**	0%
	Road density (m/km²)	>2000m /km²	**700-1,999 m/ km²**	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	2.78%, 155.22 ha			
*** Coastal corridor is 6.12% developed, including transportation. ** Road density is high: 1,229.21/km²*					

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.


Clarke's Corners
Stokes Bay
Scotch Thistle Point
Gauley Bay
Simon Point
Ferguson Point
Greenough Point
Black Creek Provincial Park
Ferndale
Old Woman's River
Myles Bay
Parker Landing
Saugeen and Cape Croker Fishing Islands Indian Reserve No. 1
Lake Huron
Centreville
Spry
Golden Island
West Rd
Little Point
0 1 2 4 Kilometres
N
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
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.

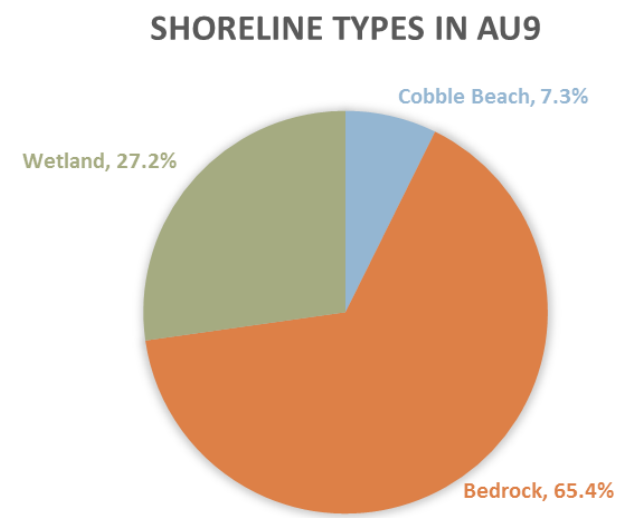
Steep bathymetry.

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

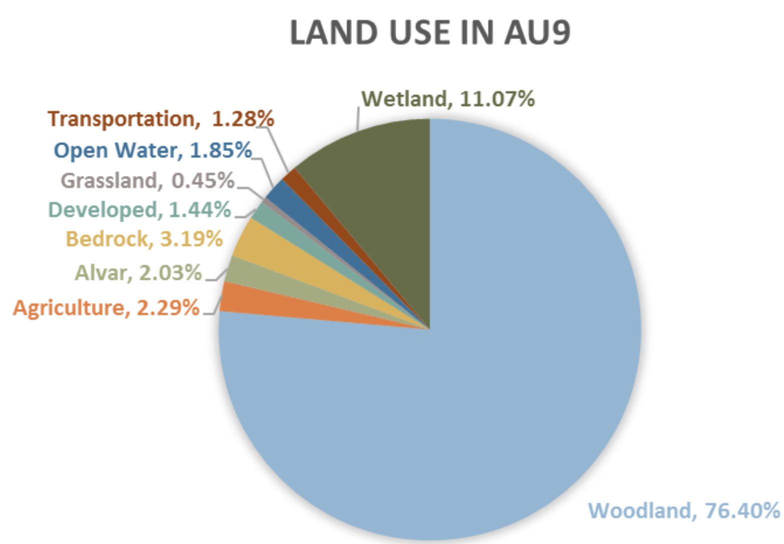
MAP 1: Shoreline Types in AU 9



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

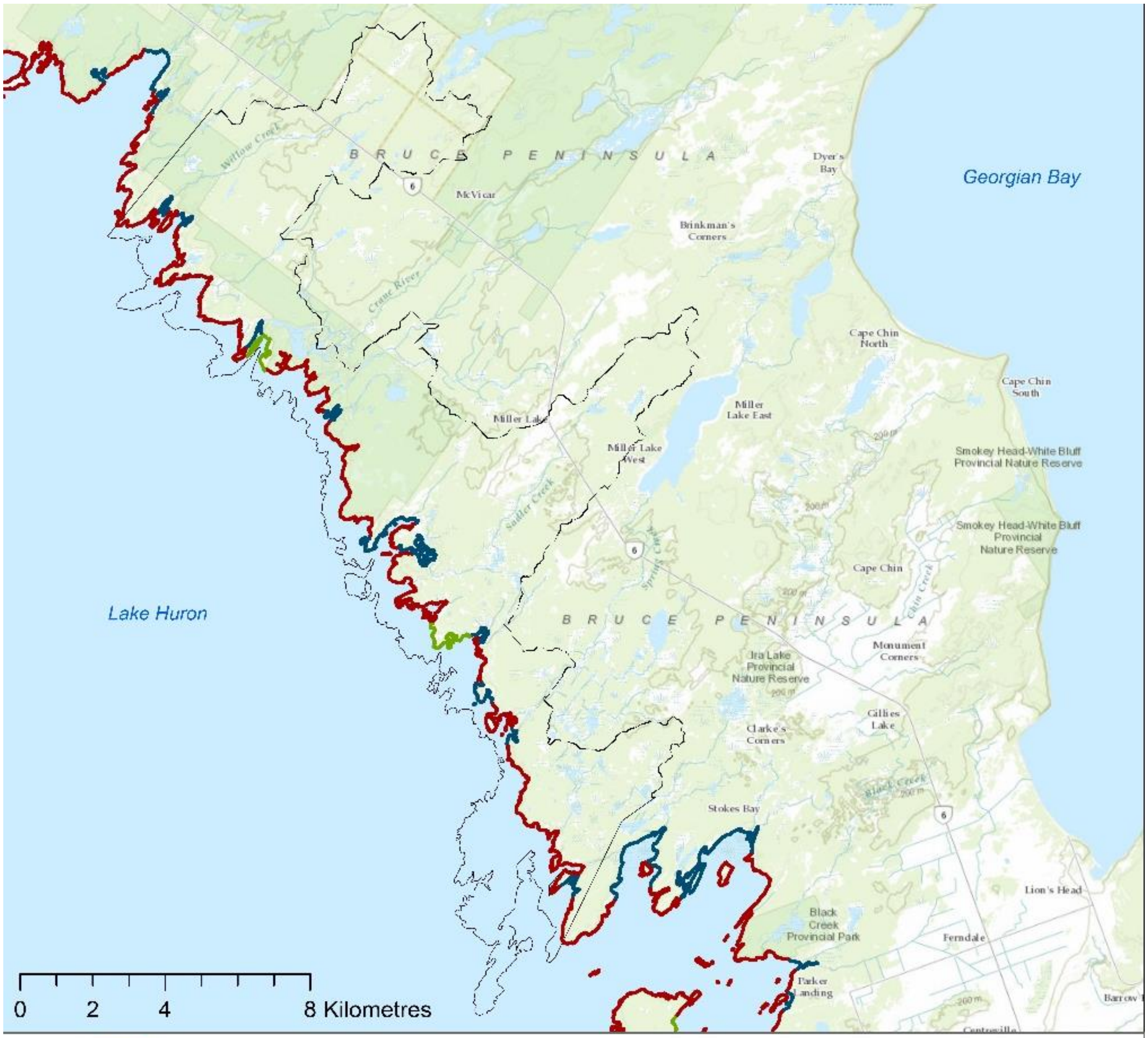


Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	1.28%, 129.46 ha			
*** Coastal corridor is 2.7% developed, including transportation.* *** Road density is high: 559.56/km²*					

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.



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

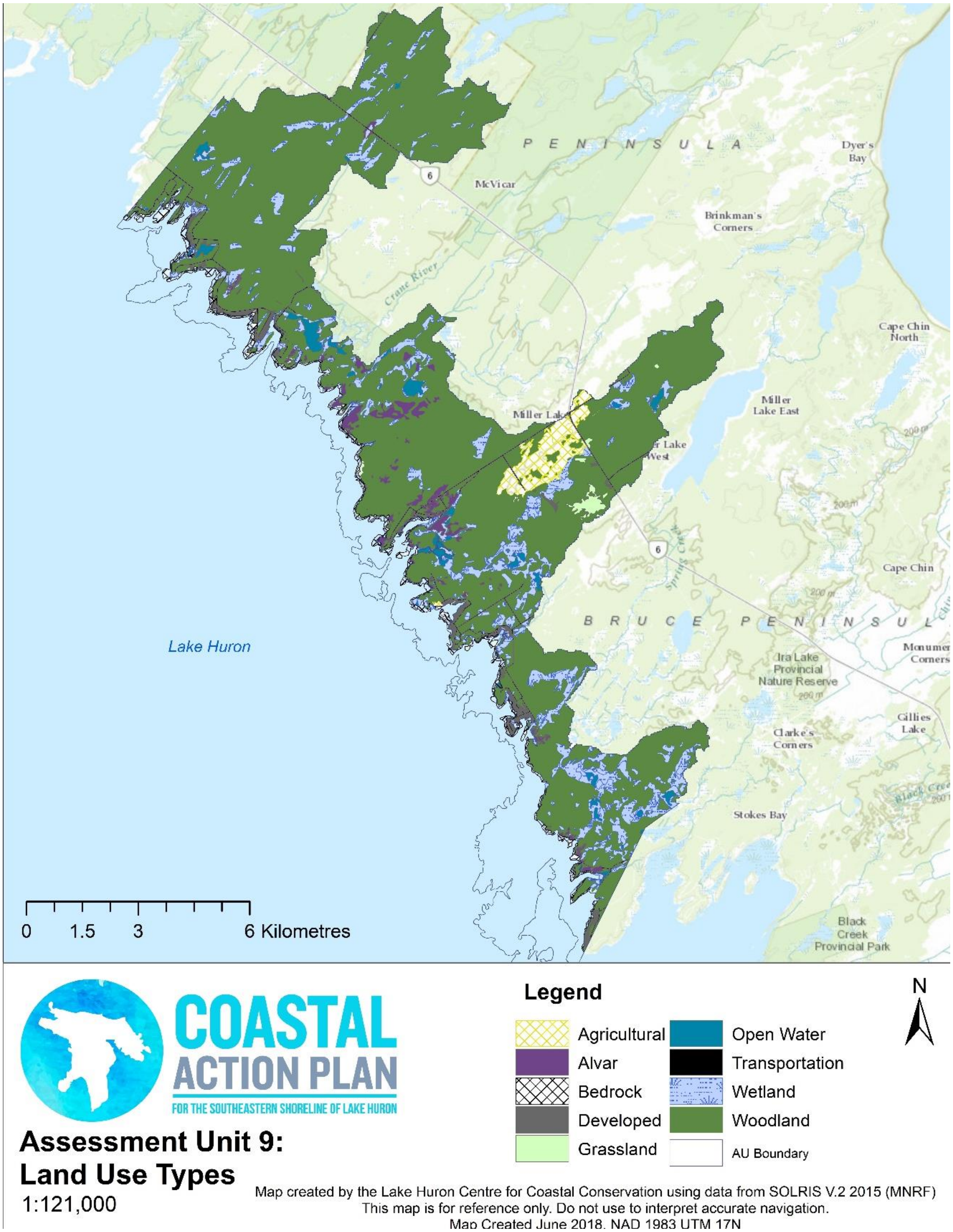
Assessment Unit 9:
Shoreline Biodiversity Features
1:150,000

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

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.

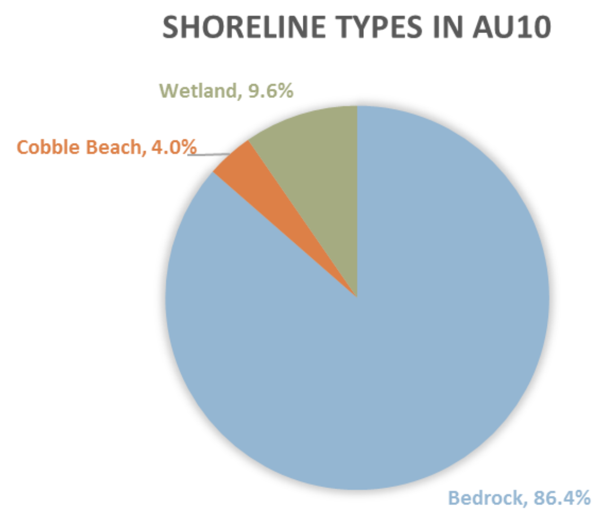
Heavy development by cottage communities.

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%	

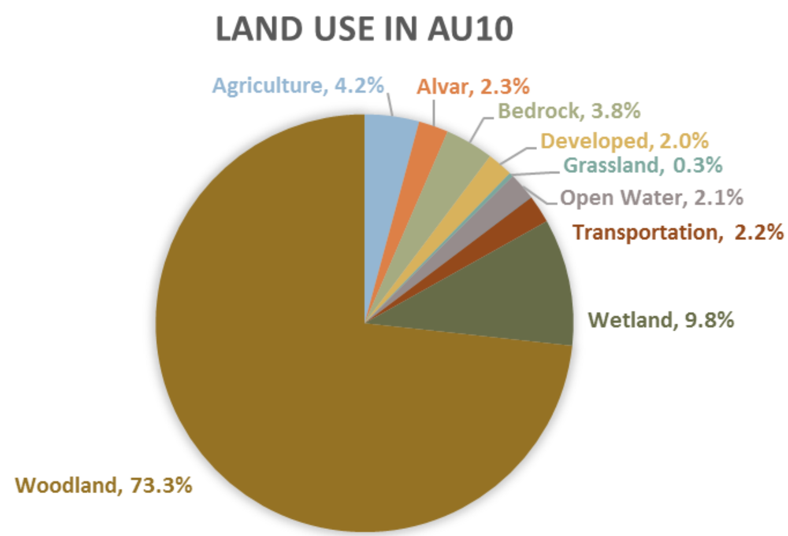
MAP 1: Shoreline Types in AU 10



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



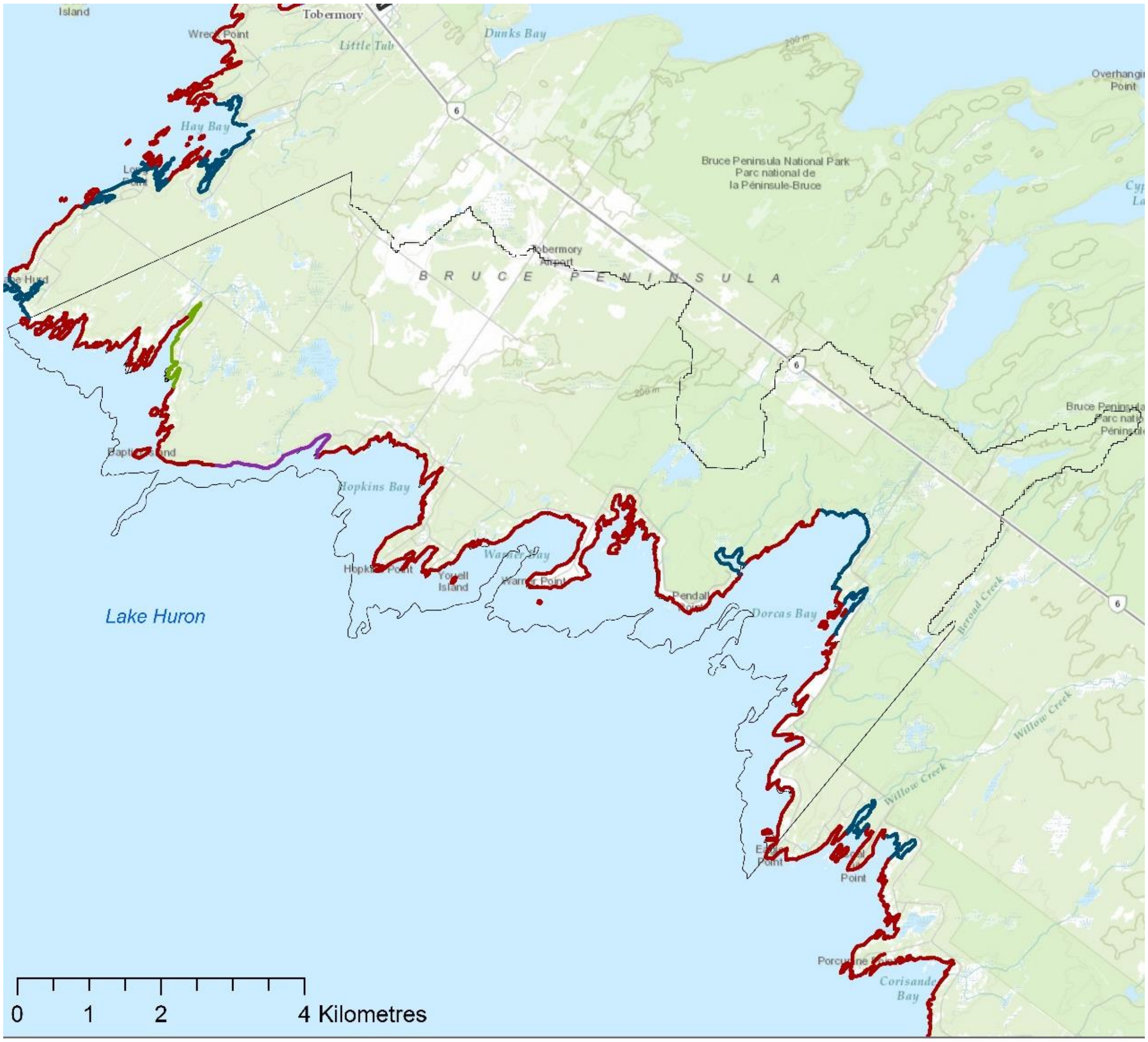
Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 4.1%, with 4.2% agriculture, leaving 91% natural land cover. ** Woodland cover is 73.3% 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. 0 detected hardened structures in water or parallel hardening structures. 0 km of shoreline is hardened (0%)*					
Presence of Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	2.16%, 95.81 *ha*			
*** Coastal corridor is 4.1% developed, including transportation (183.25). ** Road density is high: 867.1/km²*					

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 17 - Shoreline Types in AU 10



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 10:
Shoreline Biodiversity Features

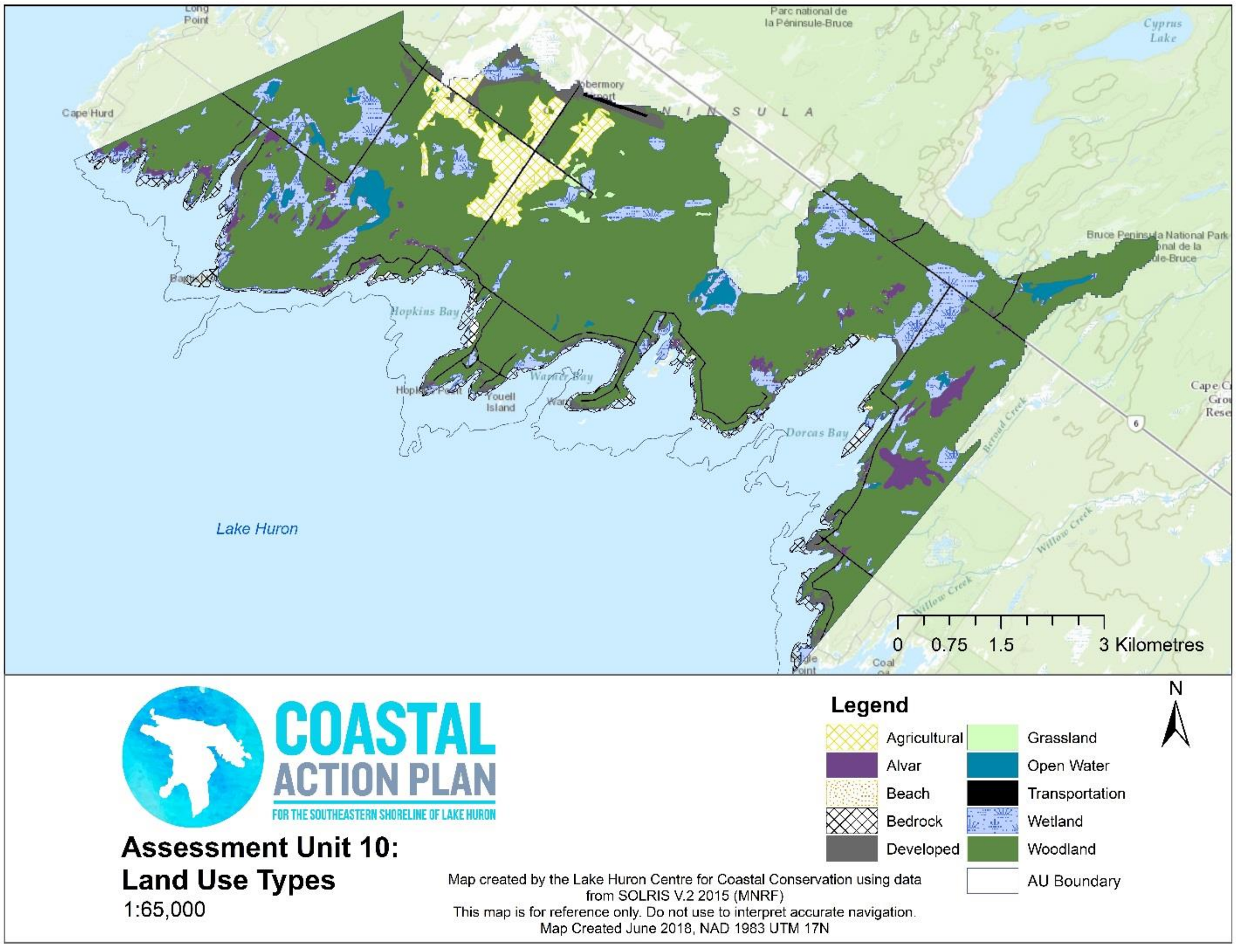
1:76,000

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.

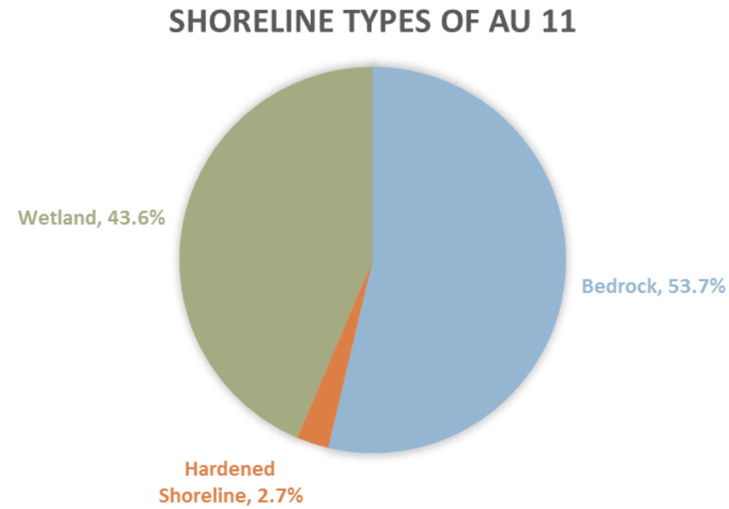
Bedrock shoreline.

Heavy development by cottage communities.

Coastal woodlands dominate landscape.

SHORELINE COMPOSITION IN ASSESSMENT UNIT 11

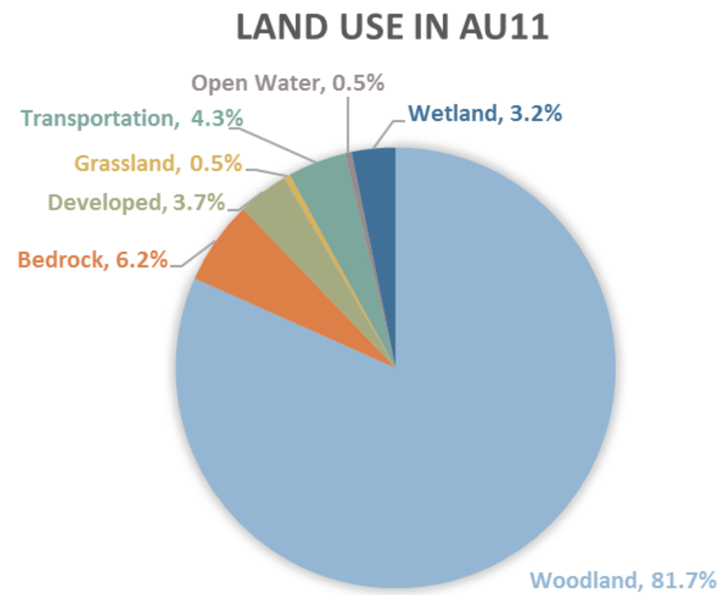
Total km	Bedrock	Hardened Shoreline	Island	Wetland
45.14	24.25	1.21	3.41	19.68
% coverage:	53.7%	2.7%	7.6%	43.6%



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

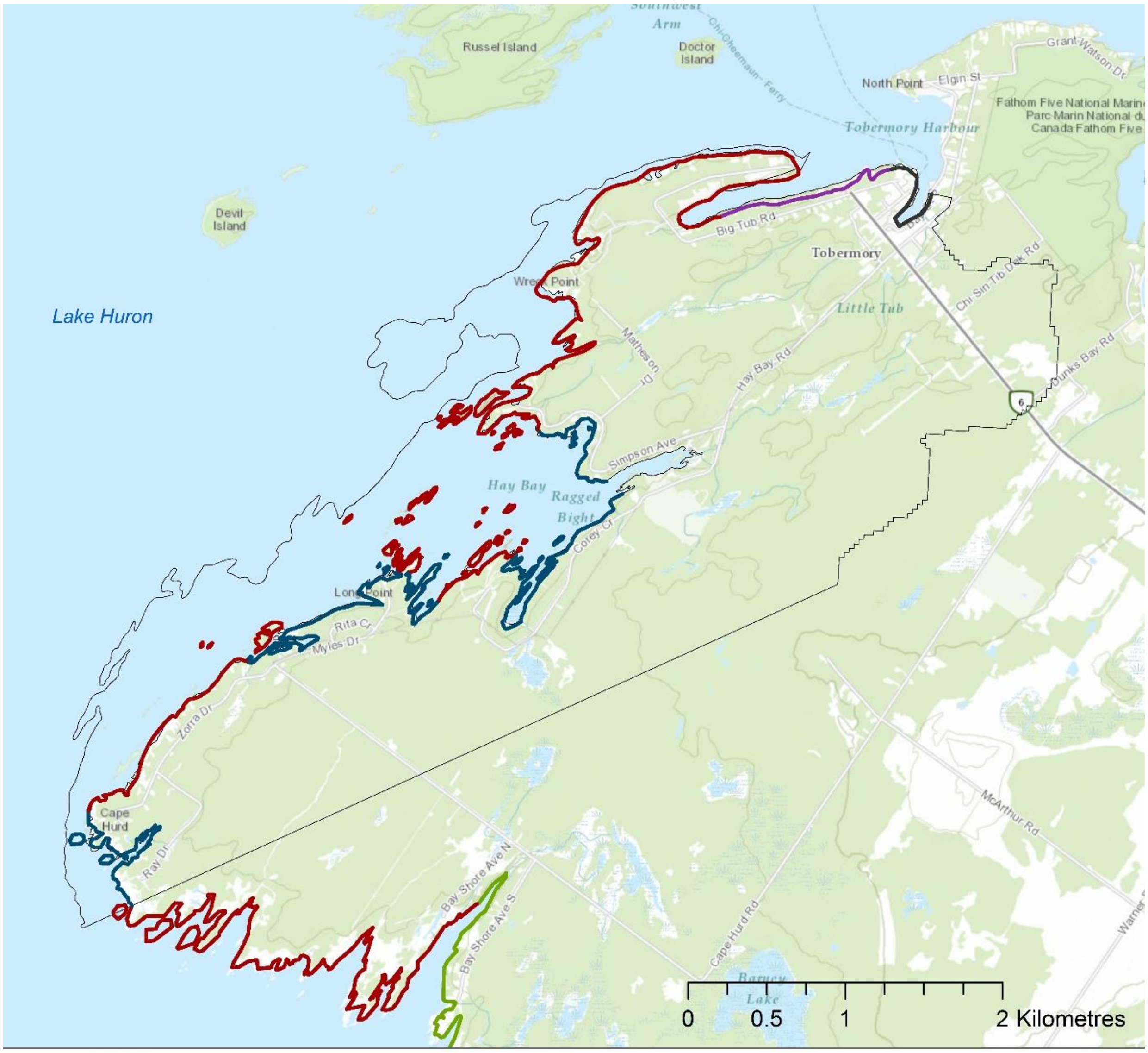
Ecosystem Health Analysis

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within the AU	<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 8%, with 0% agriculture, leaving 92% natural land cover. ** Woodland cover is 81.6% 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. 0 detected hardened structures in water or parallel hardening structures. 1.21 km of shoreline is hardened (2.7%)*					
Presence of Detritus	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 development (%)	>26%	11-25%	1-10%	0%
	Road density (m/km²)	>2000m /km²	700-1,999 m/ km²	100-690 m/ km²	<100 m/ km²
	Presence of transportation corridor (%, ha)	4.26%, 47.28 ha			
*** Coastal corridor is 8% developed, including transportation (88.65 ha). ** Road density is high: 1,938.57/km²*					

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

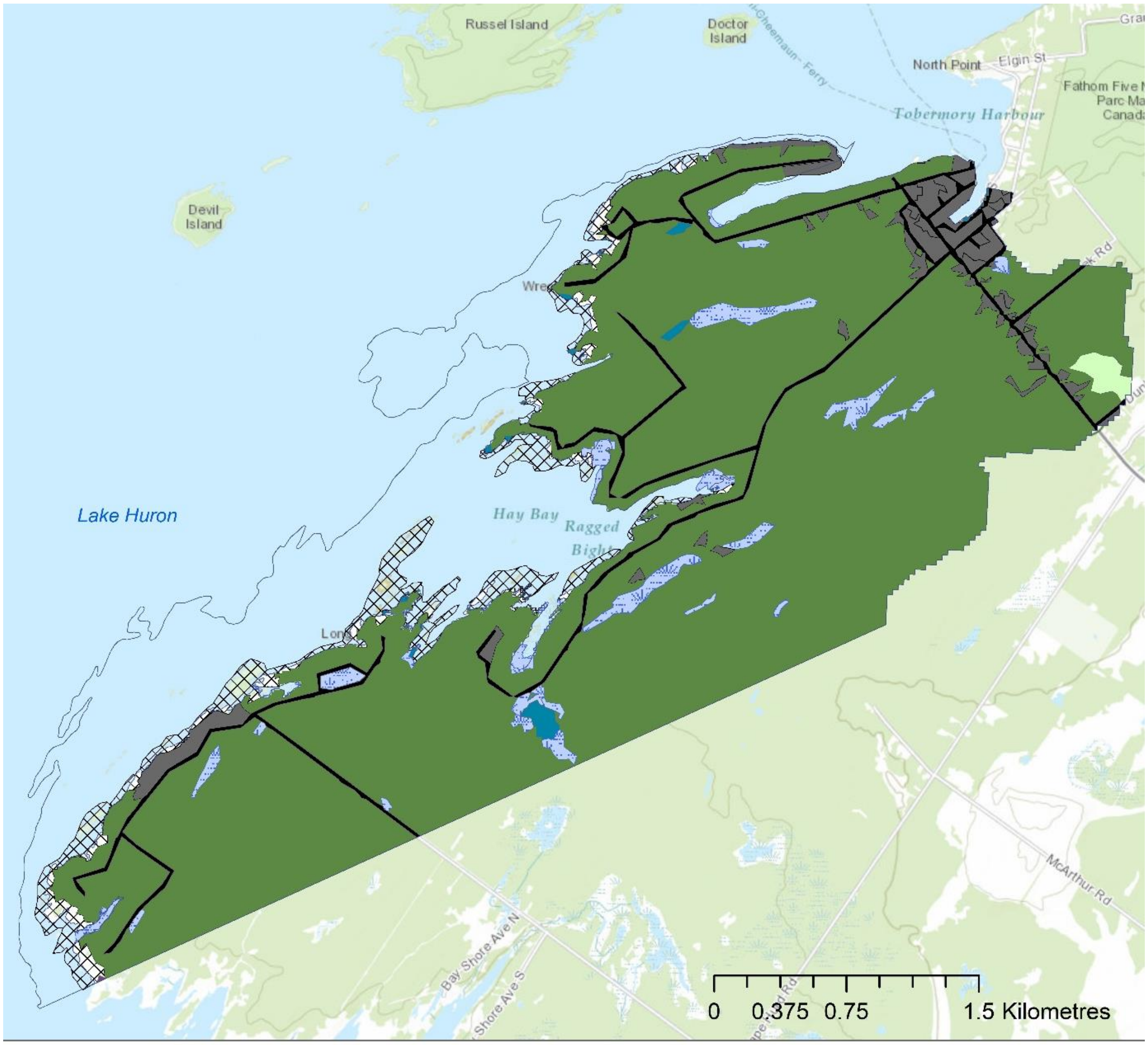
1:35,000

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



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

- Agriculture
- Alvar
- Bedrock
- Developed
- Grassland
- Open Water
- Transportation
- Wetland
- Woodland
- AU Boundary

N

CHAPTER 7: COASTAL MANAGEMENT

Lake Huron's southeastern shoreline crosses a continuously changing landscape with 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 pose a challenge when managing the southeastern shores cohesively. Cooperation among individuals, grass-roots organizations, local governance, and regional governance will enable collaboration 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 fragile coastal ecosystems is key to creating a sustainable, resilient coast. Holistically approaching coastal management encompassing social, economic, and environmental aspects will guarantee thriving communities, resilient to threats, while remaining malleable enough to foster thriving futures for healthy coastal communities.

All levels of land management (Figure 83), working together to maximize resources, taking advantage of opportunities, and continuing to work towards long-term goals, will create healthy, sustainable, and resilient places for the environment and communities to live symbiotically.

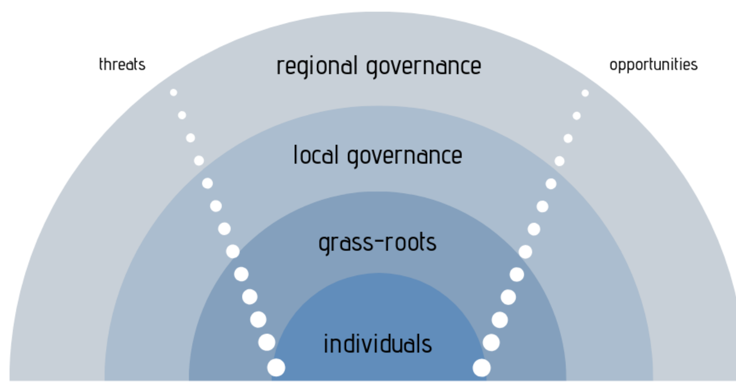


Figure 82 - Levels of land management

7.1 ECOSYSTEM-BASED 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, human 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 principle holds true for natural fluctuations in coastal habitats, in socio-economic states of coastal 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 coastal ecosystems 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 monitoring. In a society entrenched in short-term plans, governance, and ideals based on the political party du jour, or what funding is available to complete projects, adaptive management is a viable option to manage environmental impacts. "The challenge is not how to prevent human-induced change, but rather deciding how much change will be allowed to occur, where, and the actions needed to control it" (Stankey et al., 1985).

Managing improvements to environmental health and coastal community vitality should not occur by segregating them into two silos, but rather amalgamating them into a holistic system. Disregarding political boundaries and jurisdictions when conservation, restoration, and development projects are needed, using collaboration is the most effective way to fully complete these types of programs across the coastal corridor. Collaboration and communication are only starting to become commonplace in the current system. Consistency in education, incentives, management, regulation, and enforcement styles across jurisdictions will form a united front to tackle systemic issues and will mutually benefit all habitats in the coastal corridor. Consistency will also improve awareness of the threats and stressors to local ecosystems, and the bylaws, regulations, and requirements to preserve and improve the ecological integrity of coastal ecosystems among residents and communities. Holistic coastal management approaches employ four scales of land management (Figure 83);

(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.).

The CAP recommends ecosystem-based actions and adaptive management 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 involve 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 essential in preserving and enhancing coastal ecosystems. If landowners and land managers within the coastal corridor conserve and protect coastal ecosystems, many of these habitats would be safe from the myriad of stressors caused by threats.

Monitoring the state of ecosystem health and comparing changes to the history of data is a key aspect of ecosystem conservation and management. As discussed in Chapter 4, standardized Best Management Practice Guides, with resources such as dune vulnerability checklists, will allow landowners and grass-roots groups to frequently and consistently monitor the state of their coastal 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 the 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 initiating impromptu shoreline clean-ups and educate neighbours causing irreversible damage to their shoreline properties.

LOCAL GOVERNANCE

Land managers across the coastal corridor form a 'quilt' of jurisdictions, overlapping and working together towards ecological sustainability and resilience. As discussed in Chapters 4 and 5, there needs to be more consistency and continuity of regulation and bylaws managed by CA's and municipalities.

Table 42 - 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 armour stone 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

Cohesive bylaws, regulations, and goals, can reduce confusion among landowners, create a united front for shoreline management and appropriate uses of shoreline, as well as protecting coastal ecosystems straddling multiple jurisdictions. Table 42 is a review of the municipal bylaws related to beach or shoreline ecosystem protection, but only a few provide specifics for coastal ecosystem protection above and beyond permitted actions on recreational beach areas. Table 42 exemplifies inconsistencies in regulations and bylaws present across the shoreline, similar results showing a lack of consistency exist in upper-tier bylaws and CA regulation. An overarching “shoreline preservation bylaw” could encompass many existing bylaws into one place, including appropriate beach usage, dune protection, shoreline tree protection, gully protection, etc. A Green Bylaws Toolkit has been prepared by the Environmental Law Clinic that 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 ecosystems overlapping multiple jurisdictional boundaries is essential to maintain the ecological integrity of coastal habitats. Education and awareness are the first steps in creating a coast of eco-aware citizens. Local governance must share their work and educate communities and industries about the threats affecting coastal health. Raising awareness through education will improve the choices made by individuals and businesses mitigating threats caused by ignorance of the consequences. Improving the enforcement of development setbacks, buildings and developments, manure applications and other practices within buffer zones of watercourses will aid in the conservation and protection of soil, water, and air quality within the coastal corridor. Improving consistency in the enforcement of these offences, and implementing harsher consequences for infractions would also increase the respect for regulations and bylaws. Halting incompatible management techniques done by local governance themselves including mechanical beach grooming will improve the conservation of shoreline resources.

REGIONAL GOVERNANCE

Lake Huron’s southeastern shores contain many areas protected institutions such as Provincial or National Parks, Environmental NGO ownership, or Nature Reserves. Protecting areas of the coast will encourage ecological integrity preservation of the contained ecosystems. However, these ‘patches’ of protected areas are threatened by stressors outside their boarders. Increasing conservation and protection efforts around existing designated areas is crucial for the integrity of rare coastal ecosystems. Expanding protected areas, 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, land acquisitions do occur periodically through agencies such as Parks Canada, Nature Conservancy of Canada, CA’s, and Ontario Nature and are supported and recommended by this Plan. Areas that are prioritized 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 allow existing protected areas to be resilient to future changes. Regional governance can also play a crucial role in maintaining and enhancing 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 condone partnerships with resource extraction or development companies is of utmost importance. These plans, acts, and policies should be enhanced to further protect Great Lakes waters, rare coastal ecosystems, and support low impact development initiatives while phasing out or discontinuing unsustainable development practices.

Proposed changes to the Provincial Policy Statement, the Aggregate Resources Act and the Endangered Species Act are threatening to allow development and land-use change to wetlands and woodlands to promote aggregate resource harvesting. This action contradicts recommendations by scientific study and indicators set for climate protection, resiliency strategies, and ecological integrity. Partnerships between local and regional governance and grass-roots groups are needed to collaborate towards re-establishing these important acts as legislation that will protect the environment, not compromise it for short-term financial gain. The balancing act between needs of economy, community, industry and environmental protection for human health and ecological sustainability needs to be tipped back towards a focus on a balance instead of one for the other.

7.4 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 natural infrastructure presence, from preservation and restoration, to structures with nature and structures alone (Figure 84). Through this diagram, restoration is considered the next best option to preservation and can restore coastal processes to reinstate ecological integrity of coastal habitats.

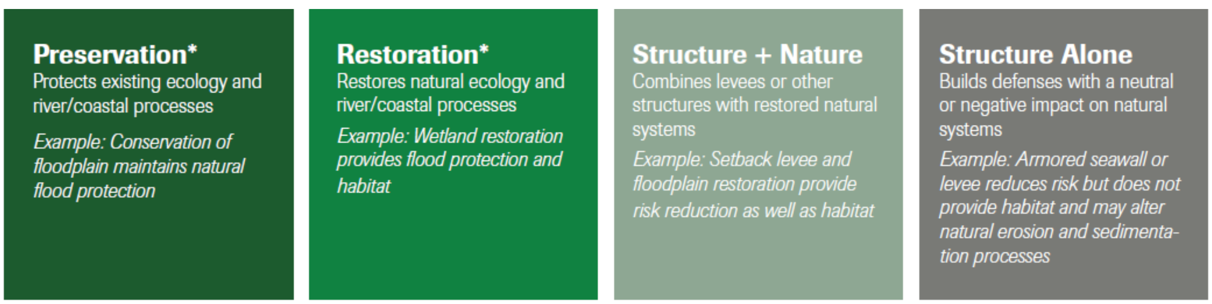


Figure 83 - Natural Infrastructure Methods (Downing, 2013, p.3)

Restoring coastal ecosystems is in form and functions is essential to ensuring ecological integrity, resiliency, and sustainability of these ecosystems. However, without repairing the 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). Holistic action and management are required to ensure investment effectiveness of restoration projects. For example, *Phragmites australis* are removed from a bay, but a creek entering the bay has *Phragmites* at its headwaters, there will always be a threat of reintroduction. Cooperation to effectively use time, resources, and effort will allow for diligence and efficiency in tackling restoration projects.

As discussed in previous chapters, structural protection approaches are extremely detrimental to coastal ecosystems on the southeastern shores. Therefore, non-structural and gray-green approaches outlined by the University of Michigan (2018) could be applied in place of existing derelict hardened shoreline structures through restoration projects. Natural infrastructure and gray-green infrastructure serve ecological functions and produce engineered outcomes for shoreline protection. Utilizing the ecosystem services of certain natural features is 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 used 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. This resiliency is going to be crucial 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, including:

(1) Land-use change (e.g. field to forest);
(2) Reinstating habitats which previously altered or destroyed (e.g. rebuilding dunes on sand beach);
(3) Removing human-made threats (e.g. structures, plastic pollution, and other NPS pollution inputs);
(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 habitats. Beach clean-ups have become a common annual event across Lake Huron's coast. Volunteerism in restoration events is on the rise (Chapter 4 & 5), owing to partnerships, cooperation, and community commitment for healthy shorelines. Encouraging continuations of these events through outreach, awareness, and societal change will 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 contributions of grants and donations to support 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 85).

Figure 84 - Brucedale Conservation Area, before and after Phragmites removal

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. The Pine River Watershed Initiative Network launched a reforestation campaign to lakeshore landowners within the Pine River Watershed to distribute free trees to landowners to increase forested habitat. Other groups like Communities in Bloom allow landowners to purchase trees for their properties, simultaneously raising money to keep their community beautiful through garden plantings within the local community.

Other shoreline restoration programs are available at cost or free through incentive programs such as the Green Ribbon Champion Program (GRC) which completes beach site visits on coastal properties and creates restoration plans for the property owner. GRC completes the restoration work, improving and restoring the ecological integrity of shorelines enabling coastal processes and ecosystem services to be reinstated. Encouraging restoration programs through municipal and corporate support allows grass-roots projects to succeed.

LOCAL GOVERNANCE

Prioritizing shoreline and coastal restoration treatments requires local governance to 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 for 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 from intensified climactic conditions and increased visitation and population. This will need to be done while maintaining sustainability with investments, time, and energy spent working on and managing aspects of the coast. An example identifying how much restoration is required within a local governance jurisdiction is provided in Case Study 3.

CASE STUDY 3: FOREST COVER RESTORATION IN WATERSHEDS

Improving forest cover can be done in rural or urban areas, to receive multiple restoration outputs of air quality, temperature regulation, water quality and water retention. Environment Canada recommends the guidelines in Table 43 for forest cover. A stable, low risk forest cover should be >50% of the watershed, a minimum risk is +40%, moderate risk being +30%, and high risk under 29%. Assessment Units 1 to 6 require action by local governance agencies to improve the forest cover within the coastal corridor (Table 43).

Table 43 - % 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 gives coastal communities a baseline to meet and exceed when planning urban and rural forestry projects, and the amount of program uptake they need to successfully improve this metric. Attaining these thresholds can be long-term programs, with high cost and time commitments. For example, Ausable Bayfield Conservation Authority analysed how much reforestation would be required to increase total tree cover by 1% across their watershed; this estimate determined that approximately 6,000 acres of land and approximately 4,200,000 tree seedings would be needed (ABCA, 2018). Based on current reforestation programs which plant between 50 and 100 acres of trees per year, it would take 60 years to complete a reforestation program of 1% of ABCA's watershed (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 runs 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 engages passionate and knowledgeable local entities to complete restoration projects in a way that makes sense for the area. The GLGCF provided $1.5 million in 2012 alone to fund restoration programs across the province with grants of up to $25,000. One of the grant recipients specifically completed beach and dune restoration in Grand Bend Ontario, within the southeastern coastal corridor (Ontario, 2012). Other government grants available by 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 seeking funding for restoration projects. Unfortunately, Provincial and Federal grants cannot fund all the projects that apply to the programs. However, the number of applicants these funding pools receive should be an indication to Provincial and Federal Government that increases to these grant programs are needed to support more initiatives across the coastal corridor and province. The need for consistency in the provision of grants, regardless of which political party is in power is needed to ensure continuity. Monitoring and restoration projects are also essential to coastal stewardship programs mitigating threats and stressors along the southeastern shores.

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 4.

CASE STUDY 4: PARKING LOT RESTORATION AT SINGING SANDS

Dorcas Bay on the southeastern shores of the Bruce Peninsula holds a rare relic sand beach and a coastal fen wetland called Singing Sands. This visitor area has 3.2 kms of trails, allowing visitors to travel across boardwalks in the fen, into dense forest areas containing mosses, lichens, and rare floral elements, ending on exposed bedrock outcrops and alvars. This area contains a high diversity of orchids, carnivorous plants such as the Pitcher Plant, and rare wetland flora such as Sundews that are specially adapted to live in fens adjacent to bedrock outcrops, as found at Singing Sands. This area attracts visitors for its shallow, gentle sand beach and hiking trails. For decades, this location has been owned and operated by Parks Canada through Bruce Peninsula National Park. Historically, park planning did not consider threats caused by parking lots and high levels of visitation to such sensitive coastal habitats. Therefore, a parking lot running parallel to the beach, seperating the beach from the fen was constructed (Figure 85). Positioning the parking lot this way reduced water flow between the two coastal habitat types, and put compounding stressors on both environments during the busy peak summer season. The increased visitation focused on enjoying the beach area for recreation; however, with the increase came exponential amounts of litter, erosion, vegetation trampling, and 'nutrient' inputs. In 2017, restoration efforts were undertaken to relocate the parking lot off the relic dune and restore the coastal fen environment by installing a more efficient boardwalk.

Figure 85 - Before and after restoration at Singing Sands, Bruce Peninsula National Park

The restoration work undertaken creatively rectified issues of capacity from an infrastructure perspective while also restoring and protecting the coastal fen and relic dune and swale, reconnecting the beach and fen. This work also allowed for enhanced protection around a cold-water stream entering Dorcas Bay which use to be abutted by parking lot. Redesigning the boardwalk also provided enhanced opportunities for movement and recreation throughout the fen by installing educational interpretive panels, a viewing tower, and high railings to keep visitors from entering the fen and potentially trampling sensitive vegetation (Figure 85).

Using creative thinking by moving the parking lot offsite to a location across the road also allowed for increased capacity without further impacting the sensitive ecosystems of Singing Sands. Utilizing the pre-disturbed environment of the front half of the old 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.

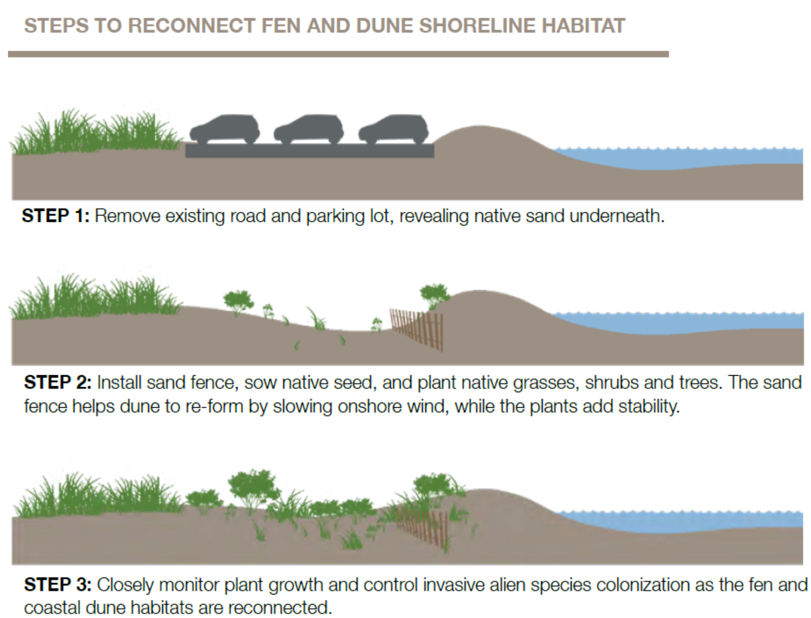


Figure 86 - Dune and fen restoration at Singing Sands (BPNP, 2018)

This case study provides an example of balancing a restoration project aimed at improving ecological integrity and protecting sensitive ecosystems, with enhancing infrastructure upgrades required to accommodate increased visitation of the area. This case study shows that best management practices for habitat restoration, in this example coastal fens and relic beaches, can transcend grass-roots, local governance, and regional governance scopes. Projects of this nature become demonstration sites for local governance and grass-roots organizations to emulate in their own communities. The same principals were used to restore this property that would be recommended to a landowner property 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 87). Similar recommendations and work can be completed by all levels of land management, from the private landowner, to the federal government.

7.4 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 the detriment to coastal ecosystems caused by these increases, initiatives to adaptively manage communities and land-use to foster resiliency and sustainability include: (1) intensify development instead of sprawling; (2) utilizing Low Impact Development strategies; (3) plan infrastructure upgrades to incorporate natural infrastructure or eco options (e.g. using ecological services instead of human-made counterparts).

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 closer to natural landscapes or in greener urban areas improve the mental health of residents, including less perceived stress and better diurnal cortisol responses (more effective sleep) (Kuhn et al., 2017). Communities in the coastal corridor live adjacent to much 'green' space, and '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% lower death rate for kidney disease, a 34% lower death rate for respiratory disease and a 13% lower death rate for cancer. Women also reported a 30% 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).

Therefore, increasing natural surroundings in coastal communities will improve the health and wellbeing of 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 and 'eco-tourism' experience opportunities including fishing, cultural engagement, kayaking, wildlife viewing, and forest bathing enhance the diversity of existing tourism opportunities in coastal communities, shifting focuses from beach day-use and camping, to a set of opportunities that can occur during shoulder seasons, expanding economic gains (Coastal First Nations, 2017a). Increasing tourism opportunities through 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. Cooperation, collaboration, and partnerships are the key to community development and bridging the gap between land-use and ecological integrity.

GRASS-ROOTS

Community development and land-use stressors can be reduced at the grass-roots level, including installing green low impact infrastructure, increasing natural cover, and using water catchment and filtration methods to reduce runoff. Increasing urban tree cover is one method to improve community development through grass-roots initiatives 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 the Province of Ontario’s 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). Improving forest cover in watersheds is an important recommendation to improving coastal woodland habitat.

Figure 87 - Low Impact Development example of a Rain Garden in London Ontario (City of London, 2019)

Low impact design (LID), also known as water sensitive urban design, and sustainable urban drainage systems, are natural infrastructure systems used to reduce water quantity and improve water quality entering watercourses and adjacent ecosystems. Typical LID infrastructure includes rain gardens, swales, constructed wetlands, pervious pavements, and rainwater catchment cisterns. Using LID principles, homeowners, community groups, and businesses can create more resilient, sustainable landscapes in rural and urban areas. Implementing LID 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). Some simple techniques and methods grass-roots groups and individuals can use to apply best management practices to community development and land-use include:

- Reducing impermeable pavements, 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);
- Naturalized landscaping (e.g. replace non-native garden species with native, drought tolerant, pollinator encouraging species; increasing tree canopy cover on property).

Case Study 5 provides an example of LID practices being employed in the coastal corridor of Lake, echoing the simple LID methods described. These projects and programs provide an example for more opportunities and areas across the coast that can use similar practices to provide increased resiliency and sustainability measures.

CASE STUDY 5: CAPTURING WATER THROUGH INCENTIVES

Grass-roots groups within shoreline watersheds are taking action to make rainwater catchment devices more accessible to landowners through incentive programs. Through rainwater catchment devices and infrastructure, these community stewards are reducing water runoff, conserving water through reduced reliance on municipal and well water, thereby also saving money on utility bills. Bayfield River Valley Trails Association have been selling rain barrels to landowners in Bayfield at a cost of $55.00 CAD which has had successful

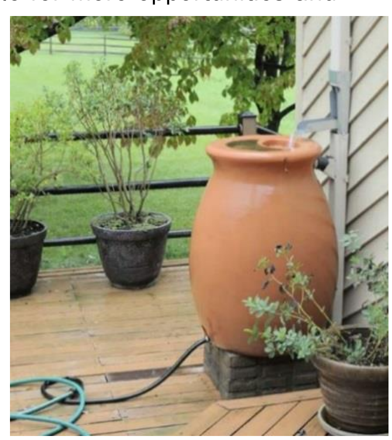


Figure 88 - Rain Barrel (CVC, 2015)

uptake (ABCA, 2019). Rain gardens are another simple, cost effective method for capturing water from precipitation or runoff.

"*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 are easily installed by individuals or grass-roots organizations. In recent examples across the coastal corridor, rain gardens have cost $1,000 to $3,000 CAD, with grants available up to $500 CAD provided by local governance projects (e.g. Huron County Clean Water Project, and the Municipality of Bluewater's Blue Flag initiative) (ABCA, 2018a). Collaboration and cooperation, sharing resources and time to complete these projects increases efficiency, tailors' projects to the community, and increases awareness about the threats and stressors impacting coastal ecosystems and management strategies to mitigate these stressors. This example of incentives initiating partnerships between landowners, home owners, grass-roots groups and local governance illustrates the potential for simple, cost efficient methods to improve resiliency and sustainability, while reducing stressors to coastal ecosystems.

Figure 89 - Rain Garden in Bayfield Ontario (ABCA 2018)

LOCAL GOVERNANCE

Communities across the coastal corridor have been established for over 150 years, with complications around maintenance and expansion being revisited often. Traditional hardened development and intensified land-use are commonplace in these communities. However, opportunities and alternative management practices are beginning to gain popularity for cost reduction, improvement of aesthetics, and ecological enhancements. A ranking of hardening and modifications impacting ecological integrity done by Stankey et al., (1984) groups 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 across the shoreline into these five categories will increase awareness of how much work needs to be done to re-naturalize ecosystems adjacent to coastal communities. Once baseline conditions are understood, 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 end-of-life replacement of infrastructure could incorporate simple and cost-effective adjustments from traditional techniques to ecologically sustainable options such as dark sky lighting for streetlights, permeable pavements on walkways and in city centers, rain gardens in boulevards or condensing urban and community road networks, making more pedestrian and cyclist friendly areas. There is a strong correlation between the increase of impervious surfaces to the increased needs for water-removal infrastructure. Using LID principles to achieve enhanced community resiliency to harsher storms and shifting seasonal climates will benefit the community by reducing future repair costs to existing infrastructure. Low impact development incorporates principles 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).

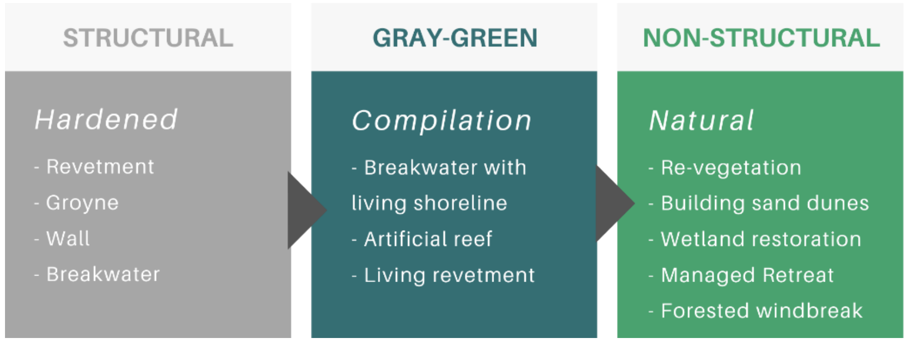


Figure 90 - Shoreline stabilization and protection approaches (Adapted from, Allan, Callewaert & Olsen, 2018)

Municipalities, First Nations, Métis and CA's manage a diverse set of landscapes, with assorted associated stressors and threats, but are common among one another across the coastal corridor of Lake Huron. Stressors associated with built infrastructure can be rectified by local governance using three approaches to development and land-use planning: gray-green infrastructure, non-structural, and structural approaches (Allan, Callewaert & Olsen, 2018; Figure 91). The influence and prevalence of human-built, hardened structures within the coastal corridor will adjust the prescription for how to make environmentally sensitive improvements that consider aesthetics, cost, and conservation. Figure 91 outlines approaches to shoreline stabilization and infrastructure preservation tactics tailored to Great Lakes ecosystems.

Under ideal circumstances, restoration of shorelines progresses from structural hardened approaches to non-structural approaches, relying on gray-green infrastructure in occasional applications. Individual and grass-root initiatives are successful but results are more profound when done holistically and with continuity, which includes publicly owned shoreline areas. As shown in Figure 92, with the enhanced knowledge of coastal processes and threats of more extreme storms and precipitation events, existing coastal infrastructure such as roads and parking lots adjacent to the shoreline were longer appropriate and were 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 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.

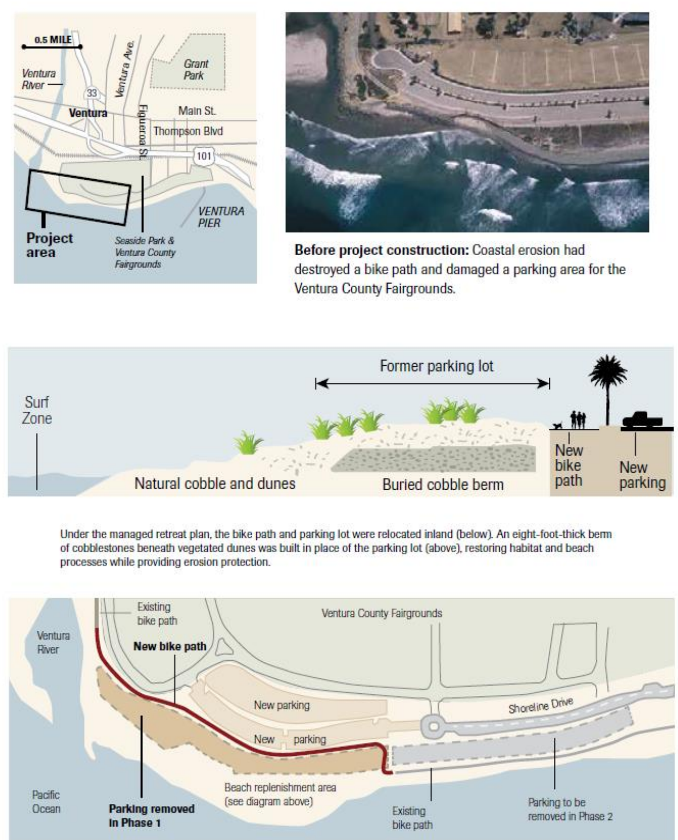


Figure 91 - Example of managed retreat in Surfers Point, Ventura California. Like North Shore Road in Port Elgin (Downing, 2013, p.17)

Urban areas often suffer from increased runoff and evapotranspiration rates caused by the inability of precipitation to permeate the ground through impermeable pavements. In some cases, the difference in amount of runoff in natural areas versus urban areas can be considerable, as evidenced in stormwater outflow quantities (Figure 93). Low Impact Development (LID) is a practice to reduce costs and impacts associated with traditional hardened infrastructure by utilizing 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 LID principles are inexpensive to incorporate into new communities and simple 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. Vegetated filter strips or eco-retention areas like wetlands in new developments can be preserved when planning a development, as well as using permeable pavements on roads and walkways to reduce water-influx on bordering natural ecosystems.

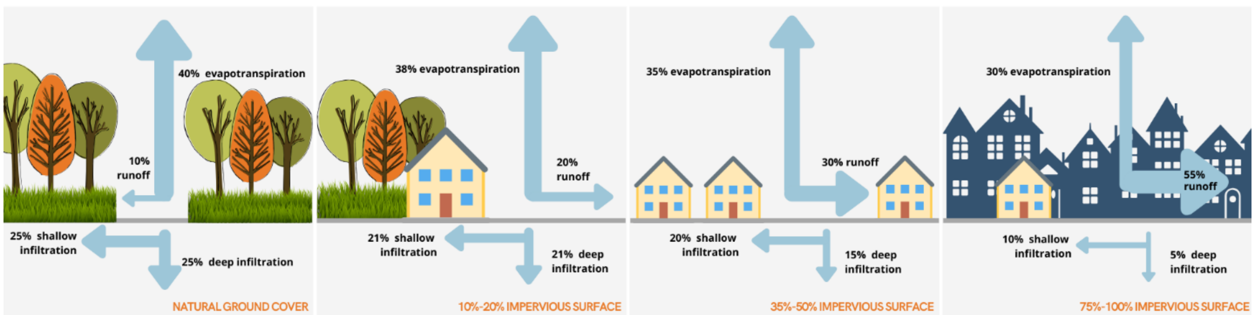


Figure 92 - Water movement comparison in natural and urban areas (Adapted from CVC, 2010).

Local governance agencies can easily access LID training courses through Credit Valley Conservation, remotely and in-person training. Opportunities for improving credentials of local planning departments include becoming certified in the *Sediment and Erosion Control,* or the *National Green Infrastructure Certification Program* (CVC, 2019). Requiring planning staff to be trained in LID principles, or take training courses through professional development goals 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, and areas of highest risk (e.g. development affecting sensitive coastal ecosystems like dunes) will empower local governance to prioritize projects. Case Study 6 described a location along the southeastern shores with effective infrastructure directly alongside areas which could use improvement using LID principles to reduce water quality concerns and restore coastal habitats and the ecological integrity of the shoreline.

CASE STUDY 6: 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 cater to high summer visitation rates. Although considerations were made to efficiently invest in infrastructure that would withstand many seasons of use, some inappropriate or misguided techniques have been used (e.g. parking lot material), where alternative infrastructure could be used.

In this example, positive and negative land management practices exist on one site, illustrating that consistency is rare across the shoreline and within individual recreation areas. Figure 94 shows the presence of a vegetated mature dune and buffer strip (Point 2), 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. Vegetation traps 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 m away (Point 1), there is no vegetation present to catch or filter pollutants, sand can blow 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.

This site is challenging due to the asphalt parking lot intended 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 m wide. Some heavily used areas (Point 1, Figure 94), are common within shoreline recreation areas, where the dune has been flattened by foot traffic, vegetation removed or trampled, and slope of beach reduced.

Figure 93 - Natural buffers and impermeable pavements in Sarnia

There are two improvements that could be made in this example to reduce stressors; (1) retrofit parking area to permeable pavement at 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 (Figure 94). "*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 asphalt surfaces with permeable pavements such as gravel grids or interlocking pavers will allow water to seep through cracks (Figure 95) to reduce runoff, improve nearshore water quality, and have a higher cultural aesthetic feel than intensified expansive concrete.

Figure 94 - Permeable interlocking concrete pavement (building.ca)

Permeable pavements and pavers are in use all over Ontario and are compatible with snow plows, making them perfect for extended seasonal visitation in winter. Permeable surfaces like gravel grids are being used at the Singing Sands visitor parking lot, and other forms of permeable surfaces, such as interlocking pavement, 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 (Figure 96). This boulevard could be retrofitted into a swale to catch runoff water, provide pollinator habitat, and with trees introduced, increase shade to reduce the heat island effect.

Positive features of this day use area include limited excess light pollution (no street lights), and the wide mature dune buffer between beach and parking lot. Other stressors to this area include the metal groynes, and uncertain invasive species treatment methods. Another positive feature of this location is the partnerships formed to improve dune habitat. Natures Way, the Sarnia Air Cadets, and other local groups have had 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 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.

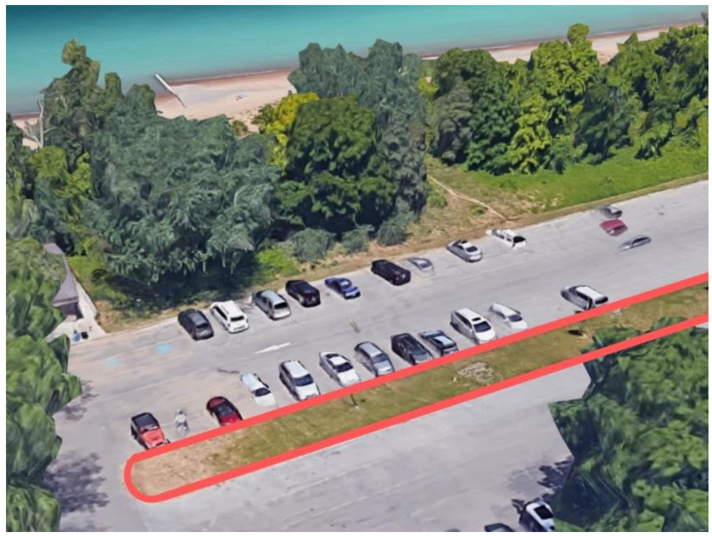


Figure 95 - Area available for bioretention swale opportunity at Canatara Beach and Park (Google Maps)

REGIONAL GOVERNANCE

Regional inputs to community development and land-use planning may take the longest to implement, but benefit communities by creating standards for development and planning that demand resiliency and sustainability measures be adopted for coastal and inland communities. Contributing methods by regional governance include:

- Amendments to the Ontario Building Code Act, Planning Act, Public Transportation and Highway Improvement Act, etc. requiring LID practices in new development and infrastructure upgrade projects.
- Demonstration areas of resilient and healthy coastal communities through funded projects and multi-level partnerships in high-use areas to restore or protect ecological services provided by coastal habitats.

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*" (County of Huron, 2015a, p.23). These documents and regulations are important to ensure positive change occurs, but should not be used in isolation of promoting and funding coastal grass-roots groups and local governance to complete resiliency projects that fit best for their community.

In other parts of the world, installation of LID technology is commonplace and widely accepted for the associated cost savings and environmental services provided. For example, in Victoria Australia, where freshwater is a limited resource, rainwater catchment is commonplace at the regional scale. The City of Melbourne has built and manages several systems to capture and treat stormwater to reduce urban flooding, improve water quality of nearby waterways, reduce cost of freshwater, and enhance liveability of coastal citizens in Melbourne (City of Melbourne, 2019). Applying LID practices on regional level infrastructure will take time as infrastructure life-spans end and replacement becomes necessary, contributing to a long-term coastal resiliency plan. Upgrading 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, and repurposing existing gardens into rainwater catchment or bioretention areas.

7.5 EDUCATION, ACCOUNTABILITY, AND PARTNERSHIPS

Increased public awareness about coastal processes, sensitivity of coastal habitats, and initiatives to reduce stressors are needed across all levels of governance. Educational resources, presentations, and community events were requested by the public and partners during the LHCCC 2017 Online Questionnaire and through the 2017 to 2019 Coastal Community Workshops. The main concern of respondents and attendees is the issue that public events are 'preaching to the converted', and environmental groups need to increase awareness through other avenues to convey messages to those not typically drawn to environmental events, workshops or information. Four methods of education and outreach were requested by attendees and respondents; (1) short informational videos; (2) social media posts; (3) workshops and; (4) presentations to community groups. These methods are the most practical and diverse set of communication and education tools. These four methods of increasing awareness and educating the coastal community are effective 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 advertising 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. Collaboration among a diverse set of groups will produce multiple outcomes, one of which should always be communication and outreach.

Other forms of 'organic' education and outreach through developing societal norms are possible as the awareness of impacts increase. For example, 2018 was 'the year of the plastic straw', where social media and news coverage became inundated with information about plastic pollution in the world's oceans and the effects it has on wildlife and water quality. Raised awareness of threats posed by single-use plastic encouraged alternatives and single-use plastic by-laws and bans, where businesses and cities pledge to go single-use plastic free in the next decade.

Figure 96 - Plastic straw reduction tips

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. “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.

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. Reminders that all environmental groups are aiming at similar targets, sharing successes and ways 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 +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 create a vibrant local community and a 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 the ecological 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 7: LOCAL BUSINESS TAKING ACTION

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 98 shows Caitlin, owner of Cait’s Café unpacking their first shipment of paper straws in April 2018.

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 iced drinks, we do charge $0.10 if they want a straw with 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 the 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.

Figure 97 - Caitlin Vail of Cait's Cafe unpacking paper straws

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) relies 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 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" (County of Huron, 2006). This guide is a tool for 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 (County of Huron, 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 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, control flooding and erosion, provide fish and wildlife habitat, reduce aquatic invasive species establishment, 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 8, 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 8: 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 1980s, this boardwalk is up for replacement, with several options being proposed by the awarded consulting firm. The new 3 m 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 metre, whereas concrete would cost $90.00 CAD, both with an anticipated lifespan of 15 to 20 years (Jackson, 2019).

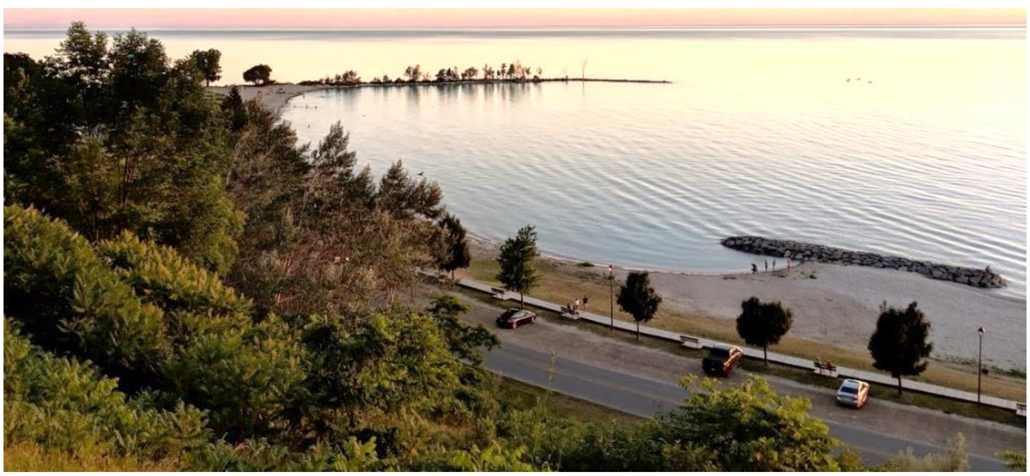


Figure 98 - Rotary Cove in Goderich, showing the wooden boardwalk running parallel to the shoreline

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). 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 the waterfront as pristine and natural as possible. We are not Toronto or 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 ecological 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. Partnerships between grass-roots, regional and local governance make plans like this 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

Supporting documents and relevant scientific plans and studies which have developed indicators and thresholds for comparing existing ecosystem conditions to ideal targets have been reviewed and compiled throughout the CAP. Using a methodology described by Lawrence (1995), recommendations for actions are made to adopt and implement strategies to meet targets and thresholds. Assessment Units were used as a basis for planning and evaluation, including threats to the coastal ecosystems, enabling mechanisms for cooperation and coordination across jurisdictions (Lawrence, 1995). The recommendations provide a strategic, long-term perspective, including planning for climate uncertainty with proactive and flexible approaches, and considering threats involved in land-use development. This is the context when setting action items and needs for implementing recommendations (Lawrence, 1995).

As identified recently by the International Joint Commission (2019), three levels of management are necessary to adequately manage coastal property: (1) Educate and raise awareness about the issue; (2) Incentivise change toward mitigating stressors and threats; (3) Enforce compliance to regulation and bylaws. These levels are incorporated into the following recommendations. Successful implementation of the recommendations will require broad support from grass-roots groups, local and regional governance, to complete this plan based on the fabric of public and private land ownership and the diversity of stakeholders managing land within the coastal corridor. Recommendations are intended to evolve throughout time and have been produced using scientific data and information that acknowledge the significance of coastal ecosystems and the importance of the ecosystem services they provide. Ensuring systems of evaluation, assessment, and monitoring are in place now, and in the future will enable proactive manage strategies within the coastal corridor. Education, public awareness and communication are included in the needs to fulfill each recommendation (Lawrence, 1995).

This Summary of Recommendations is provided under 6 main headings and in no order of preference.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
1.0 COMMUNITY DEVELOPMENT AND LAND-USE PLANNING			
1.1 Increased population	– Proactive protection and threat mitigation of increased population. – Proactive protection and threat mitigation of increased visitation and tourism.	Target: Consistent, bold bylaws, regulation, and stewardship protocols in existence across the southeastern shores by 2023. – All protective measures including a collaborative effort to have consistency among bylaws, regulations, and stewardship protocols to mitigate threats from increased human presence.	Evaluation: All local governance embracing a collaborative effort to have consistency before the target date will be successful. Short-term: Increase awareness among local governance and local coastal individuals about the threats that will occur if thresholds are not met. Mid-term: Create a budget line in annual local governance to enforce and monitor violations to these new bylaws. Mid-term: Create a budget line in annual local governance, as well as collaborating with grass-roots organizations to produce educative material to inform landowners and individuals about the increased bylaws and regulations, and provide incentive to adopt BMPs. Mid-term: Collaboration between grass-roots groups, industry leading scientists on coastal thresholds and recommendations to provide recommendations to municipalities about bylaw updates and scope. Long-term: Communication between all lower-tier and upper-tier local governance to create by-laws that are consistent and enforceable in their respective AUs and coastal ecosystems.
1.2 Permeable pavements	– Infrastructure upgrades to hardened surfaces should use permeable alternative and water infiltration structures.	Target: A reduction in impermeable surfaces in each assessment unit by 25% by 2029. – All municipal infrastructure upgrades regarding pavement (walkways, roads, parking lots, paths and trails), will strive to be permeable to ensure proper groundwater recharge and reduction of excessive runoff. – All new residential developments must use permeable pavements for roads, sidewalks, pathways, and parking lots. – Educate and encourage private landowners to install permeable pavements.	Evaluation: GIS data assessing area of impermeable pavement and permeable pavement to quantitatively track progress towards target. Continued annual monitoring needed. Short-term: Education and awareness brought to products, and maintenance procedures of permeable pavements. Mid-term: Incentive programs to encourage adoption of permeable pavements by residential, commercial, and industrial landowners. Long-term: Regulation and by-law requiring permeable pavements in urban and community areas (e.g. cottage community subdivisions and small rural towns and hamlets).
1.3 Dark sky lighting	– Upgrade municipal lighting to dark sky certified fixtures to protect night lifecycles of flora and fauna. – Encourage business and residential lighting in the coastal corridor to adopt dark sky compliant fixtures.	Target: 100% dark sky compliant fixtures in municipal and residential settings in the coastal corridor by 2029. – 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. – All new builds both residential, commercial, and industrial must design in dark sky compliant lighting as per the Ontario Building Code. – Lighting needs to be shielded to face downward and have a warmth rating of 3,000k or less.	Evaluation: GIS Data and aerial analysis of skyglow within each assessment unit to quantitatively track progress towards target. Continued annual monitoring needed. Short-term: Educate and raise awareness among governance staff and public individuals about the importance of dark skies and the stressors caused by light pollution. Support agencies and groups currently providing programs in this area (e.g. BPBA). Mid-term: Work with Provincial energy programs to incentivise low-energy (LED) lighting that is dark sky compliant through rebate programs. Long-term: Work with the Ontario Building Code to ensure all outdoor lighting is dark sky compliant to reduce skyglow.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
1.4 Stormwater sinks	– Infrastructure upgrades should incorporate structures to allow stormwater infiltration (e.g. bioswales, rain gardens, and pollinator habitat).	Target: 50% of infrastructure in coastal communities will strive to incorporate and implement stormwater retention devices by 2029. – All infrastructure upgrades starting in 2020 in the coastal corridor will commit to incorporating LID design to reduce stormwater runoff and pressure on municipal stormwater systems.	Evaluation: GIS data depicting municipal and private built-infrastructure such as roads, parking lots, and boulevards will take baseline data from 2019, and annually review % of infrastructure that has been upgraded to include stormwater LID BMPS with the target to be met in 2029. Short-term: Education of public land managers such as planning departments and public works departments, as well as council and mayors, raising awareness of products/designs available and maintenance procedures associated. Support to programs currently in existence will be done. Educate and raise awareness about the importance of stormwater retention on private lands including farm lots, residential properties etc. Mid-term: Regional incentive programs for municipalities, community associations and private businesses and landowners to build and maintenance stormwater sinks. Long-term: By-laws and regulation put in place to enforce stormwater retention on the landscape using LID structures and BMPs.
1.5 Harbours, marinas, and river mouths	– Infrastructure upgrades to harbours and marinas should incorporate targets from topic Area's, 1.1, 1.2, 1.3.	– Conforming to targets set in Topic Area's 1.1, 1.2, 1.3.	Short-term: A forum or AGM for marina operators on Lake Huron to unite members and share information would aid in providing consistent training and education to operators and patrons. Partnerships with NGO-groups (e.g. Ontario Chapter of the Canadian Power and Sail Squadron, Green Marine, Blue Flag Program). Short-term: Educate and raise awareness among marina operators about BMP's and products available to maintain marinas and harbours in a resilient, sustainable way.
	– Monitor and control aquatic and terrestrial invasive species in and around harbours.	Target: All marinas establish invasive species monitoring and treatment programs by 2023. Target: A reduction in invasive species presence in marinas by 50% by 2029.	Evaluation: Marinas monitor and GIS map all populations of non-native and invasive species annually, and report these populations to established reporting agencies such as Ontario's Invading Species Awareness Program. Mid-term: Training and education provided to marina operators and the boating community to identify, report, and control invasive species populations. Partnerships with municipalities and conservation authorities to tackle larger populations or more difficult species. Mid-term: A budget line in marina maintenance for the treatment and removal of invasive species.
	– Cease dredging activities, with alternative mooring options established for periods of low lake level.	Target: Cease dredging activities in all harbours, marinas, and private property by 2023 (with allowance only made for major shipping ports e.g. Goderich). – Using floating docks and re-naturalizing shorelines in and around harbours, marinas, and river mouths.	Evaluation: Based on orthophotography identification using SWOOP data or Google aerial imagery, an inventory of dredged sites will be inventoried, with every update of the South Western Ontario Orthophotography Project (SWOOP) every 4 years (2020,2024, 2028… etc.). Ensuring sites are naturally restored and reporting sites being dredged will ensure accountability and enforcement. This orthophoto analysis would occur through agencies currently regulating nearshore waters. Short-term: Educate private landowners, private marina operators, and public marina operators about the threats and stressors caused by

Topic Area	Action Item	Target, Indicator or Threshold	Needs
			dredging, and provide information for alternatives during low-lake levels to ensure recreation and use for boating is maintained. Mid-term: Regionally provided incentives for marina management to purchase alternative docking structures for use during low lake level periods. Long-term: Provincial and federal legislation restricting dredging of nearshore waters, enforceable by entities currently managing actions occurring in nearshore waters (e.g. MNRF, MECP, ECCC). As well as local by-laws restricting or eliminating dredging activities in their jurisdictions.
	– Marinas on the southeastern shores certify as a green marina to improve environmental stewardship, sustainability and resiliency.	Target: All marinas and harbours become certified as a green marina or blue flag marina by 2023. – Complete a yearly environmental performance review through a certification process such as Green Marine or Blue Flag.	Evaluation: All marinas become certified green marinas or blue flag marinas by 2023. Accountable through partnerships and AGM organized for Lake Huron marinas. Short-term: Increase education and awareness of these programs through knowledge sharing and partnership communication. Mid-term: A budget line from municipalities or public marina group to ensure these programs are followed and given enough attention for the application of improvements. Mid-term: Incentive to participate in these programs including media and promotion of these marinas as green (increasing visitation or tourism to area). Potential partnerships with regional tourism organizations, and counties. Mid-term: Marina and harbours become certified by Green Marine or Blue Flag Marina programs for reduction of environmental footprint.
1.6 Hardened shorelines	– Increase the amount of natural shoreline across the southeastern shores.	Target: <10% of shoreline hardened, maximum per AU reduction by 2029. Target: <1 structure every 6km maximum per AU reduction by 2029. – Awareness that shoreline hardening structures is an option of LAST resort.	Evaluation: GIS data, including municipal layers and provincial data to inventory areas of hardened shoreline, reducing hardening structures and km of hardened shorelines comparing baseline data from 2020 to annual or bi-annual evaluations. Short-term: Landowner education and awareness programs describing stressors caused by hardened shorelines. Short-term: foster collaboration within communities to increase willingness to remove structures where possible. Short-term: Incentive programs that re-naturalize shorelines for landowners and remove hardening structures (e.g. Green Ribbon Champion by LHCCC). Long-term: By-law or regulation created, along with update to nearshore waters regulation to support the removal of shoreline hardening structures, requiring the restoration of the shoreline to natural shoreline type when structure reaches end of life. No rehabilitation of structure is recommended.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
1.7 Transportation corridors	– Reduce application of salt in transportation corridors to protect water quality in adjacent coastal ecosystems.	Target: Reduce current general road salting practices by 50% by 2021. Reduce all road salting practices adjacent to high-sensitivity ecosystems by 2021. – Reduce or eliminate road salt applications adjacent to high-sensitivity ecosystems including rivers, wetlands, alvars, etc.	Evaluation: review of road salting practices done by public works departments and MTO in frequency and application rates on roads and paths adjacent to high-sensitivity ecosystems as of the 2019-2020 season. Rectify these applications for the 2020-2021 season. Short-term: Raised awareness and education of alternative ice treatment and prevention products by municipalities and agencies applying products to roads during winter months. Mid-term: Contracts with companies that create alternative ice treatment products or sand to roads instead of salt.
	– Promote vegetative cover along and over roadways to reduce heat island effects, thermal pollution and water in areas with high density of roads.	Target: Increase vegetative road cover in dense transportation corridor areas with a speed limit of 60km/h to 80% coverage, and areas with a speed limit of 80km/h to 30% coverage by 2029. Thresholds: Road density thresholds exceeding 14m/ha cause negative impacts to water quality of wetlands and inland waters.	Evaluation: GIS data and orthophoto analysis of vegetation cover in transportation corridors taken as a baseline in SWOOP's 2020 imagery compared on a 4 year reoccurring basis, increasing vegetation cover (or potential mature canopy cover) to target levels. Short-term: Raise awareness of importance of shaded roadways to reduce thermal pollution and the ability of tree cover to up-take stormwater among road managers and environmental NGO's and tree planting program administrators. Mid-term: Tree planting programs currently in existence through CA's or grass-roots organizations, partnering with roadway and transportation corridor managers (e.g. MTO, municipalities, counties) to implement tree planting initiatives in target areas. Mid-term: Create a budget item for road maintenance, community development, and public works to plant trees over the next 10 years to increase canopy cover over applicable roads to target levels. Mid-term: Support windbreak tree plantings to improve soil health on adjacent property (by reducing wind erosion and providing runoff buffer from roadway) through existing planting programs, encouraging municipalities to provide incentives, and partnering with regional governance on planting programs.
	– Incorporate LID principles along roadways and within transportation corridors throughout the coastal corridor.	Target: Install LID principles in transportation corridors (on roads, boulevards, sidewalks, etc.), during 100% of all new roadway projects and infrastructure upgrades. – During infrastructure upgrades, install eco-passages, reduce road density where possible, and divert stormwater into natural catchment structures.	Short-term: Improve the awareness of Low impact design strategies to planners and land managers. Short-term: Encourage land managers which have installed LID strategies to share their experience and knowledge about these structures to other land managers, enabling easier application of successful design strategies in the coastal corridor. Mid-term: Design LID BMP's directly into new developments and roadways, and retrofit existing areas with LID strategies during infrastructure upgrades.
	– Monitor population extents and control the spread of invasive species	Target: All land management agencies have an established invasive species monitoring and control program by 2023. Target: Reduce presence of Phragmites, Spotted Knapweed, and other aggressive invasive species by 50% by 2029.	Evaluation: GIS data to be used to map and monitor abundance and population extent of roadside noxious weeds and invasive species. Short-term: Land managers partner and share data with existing provincial and regional programs (e.g. Ontario Invading Species Awareness Program).

Topic Area	Action Item	Target, Indicator or Threshold	Needs
			Short-term: Grass-roots and local agencies can secure funding through provincial and federal programs for invasive species control as well as by allotting a budget-line item for control and monitoring. Short-term: Partnerships between Ministry of Transportation Ontario, Municipalities, Townships, and privately-owned road managers to complete monitoring and treatment of invasive species populations throughout coastal corridor.
1.8 Beach Grooming	– Cease and prevent mechanical beach grooming on sand beach and dune habitats.	Target: No sand beach or dune on the southeastern shores will be regularly mechanically groomed. – Replace mechanical beach grooming routines with hand grooming methods. – A "groomer" may be used once-per-year at the beginning of the season after ice melt to remove storm debris including plastic and immense washups of woodchips.	Evaluation: Annual review of beach grooming and beach maintenance procedures done by private communities and public land managers to show no mechanical beach grooming. Short-term: Reallocation of beach grooming budget from beach groomer/algae harvester operation, 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. Paying staff a living wage (A living wage in Huron County is defined as $17.55 as of 2019 by the United Way), and accounting for an average $20,000/year beach grooming budget for staff time would average approximately 983 hours of human labour costs for hand-grooming available per year, (approximately 61 hours/week if peak season is between May-August, available within that budget). Mid-term: Encourage the Blue Flag Beach program to incorporate a removal of mechanical beach grooming and an addition of hand grooming into their certification criteria.
1.9 Societal consumerism-single use plastic	– Create a corridor of blue communities cognizant of impacts caused by single use plastic with strategies in place to reduce waste.	Target: All major communities in the coastal corridor to become blue communities by 2029. – A reduction of single-use plastic consumption in coastal communities through retail, restaurants, and business, to reduce potential for these items to escape waste streams and enter natural ecosystems, creating potential for ingestion, entanglement and pollution of coastal ecosystems.	Evaluation: Number of communities which carry the blue community designation will determine if the target has been met. Short-term: Increase education and awareness of the stressors caused by packaging, and single use plastic products, through partnerships with action committees and community groups. Short-term: Continue to have annual beach clean-ups across the shoreline and in different ecosystems to raise awareness about the stressors caused by plastic pollution and improve ecological integrity of ecosystems. These are done by grass-roots groups and reported through the existing group "The Great Canadian Shoreline Clean-up". Short-term: Partnerships between existing Blue Communities or communities with environmental action committees (e.g. Bayfield, Goderich) and aspiring communities to transfer knowledge and experience to support one another through the process.

2.0 RESTORATION OF COASTAL ECOSYSTEMS

Topic Area	Action Item	Target, Indicator or Threshold	Needs
2.1 **Sand beaches and dunes, and cobble beaches**	– Restore and increase dune habitat across the coastal corridor.	Target: All high-energy sand beaches and shorelines have dunes restored to them using restoration practices, by 2029. This may engage other recommendations, including removal of shoreline protection devices and structures. Threshold: 8 to 10 m wide dunes existent on all sand beaches not considered relic at low water level (<176.43m, IGLD85). – Prevent vehicles from driving on beaches using barriers, education and enforcement. – Prevent parking on beach areas in certain communities (e.g. Sauble Beach) which still allow the practice.	Evaluation: Use orthophotography and site visit data to map existing dunes (2020) and compare annually to new restored dune area, as well as using site visit qualitative information to determine if dunes are healthy, to determine whether the target has been met. Short-term: Education and increased awareness for private landowners, visitors to Lake Huron and businesses along shorelines about the importance of building and maintaining dunes and the services they provide. Mid-term: Incentive programs for individuals requiring resources to complete dune restorations (e.g. Green Ribbon Champion, LHCCC). Mid-term: Enforcement for infractions of dune destruction through embellishment in current bylaws or new bylaws surrounding shoreline protection. Enforcement coming from Municipality and County level governance. Mid-term: Municipal bylaws preventing motorized vehicles on all beach and dune ecosystems to be embellished, reinstated, or added to shoreline protection bylaws. Mid-term: Amendment to the Provincial Policy Statement reflecting a regulation to preventing motorized vehicle use or parking on sand beaches on the southeastern shores.
2.2 **Bluffs and gullies**	– Improve the health and resiliency of bluffs and gully habitat through vegetated buffers and setbacks.	Target: Restoration of bluff and gully slopes, re-naturalizing the area allowing for proper ecosystem function, while balancing the needs of coastal communities (e.g. removal of auxiliary structures from bluff and gully faces including staircases, boats, etc.). Threshold: Minimum of 100 m wide vegetated buffer at top of slope of gullies and bluffs adopted by 2029. Threshold: Minimum of 30 m wide development restriction buffer zone to protect slope from load stress (Conservation Authority Regulation dictation for setback distances may state wider zone of setback is required) adopted by 2029.	Evaluation: GIS data is available signifying bluff and gully hazard zones through conservation authority regulation. Tracking vegetation cover, number of residential structures and auxiliary structures and the area they consume are tracked and monitored over time. Maps of these setbacks are available on CA websites through online mapping software. Long-term: Cooperate and collaborate among municipalities, conservation authorities, LHCCC, and cottage community associations to transition communities on bluffs and gullies to meet target conditions.
	– Increase awareness of the value of bluff erosion.	Target: Raised awareness about coastal processes surrounding bluff and gully erosion and the importance of eroded sediment for other ecosystem health.	Short-term: Distribute information in the form of BMP guides, videos, and communication products to communities living on bluff and gully habitats, including shoreline management techniques to employ during times of high and low lake level. Long-term: Partner with municipalities, conservation authorities, LHCCC, and cottage community associations to share resources and expertise to produce and deliver communication products to educate residents about hazards, and fragility of bluff and gully ecosystems.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
2.3 Wetlands	– Increase and improve wetland cover in AUs to exceed minimum thresholds.	Target: Wetland cover should be at minimum, 6% of every sub-watershed and 10% of every major watershed entering Lake Huron by 2029.	Evaluation: GIS mapping will be able to monitor wetland cover change over time, with minimum thresholds set in the target. Short-term: Continue to encourage wetland restoration and creation through existing programs (e.g. through CA's), by raising awareness of programs and associated incentive programs. Mid-term: Secure funding from regional partners to continue to offer wetland restoration programs locally. Mid-term: Work with regional partners (e.g. NCC) to secure tracts of coastal wetland to protect ecosystems and their respective buffer zones.
	– Monitor and control population extent of invasive species in coastal wetlands.	Target: Map all populations of invasive species in coastal wetland environments by 2025. Target: All local land managers (e.g. municipalities, and CA's) establish invasive species monitoring and treatment programs by 2023. Target: A reduction in invasive species presence in coastal wetlands by 50% by 2029. Target: Map remove and control all populations of *Phragmites australis subsp. Australis* from all coastal wetlands directly on Lake Huron's shoreline by 2025. Target: Map, remove, and control all populations of *Phragmites australis* from all coastal wetlands within the coastal corridor by 2029. Target: Map and begin management on all other invasive species, with annual monitoring programs to track population extents.	Evaluation: GIS mapping files available through local and regional agencies (e.g. CA's, MNRF, etc.) will show extent of coastal wetlands. Through this GIS layer and site visits that have occurred, will map or specify presence and population of invasive species. This will provide a baseline to work towards to remove IS to meet targets. Short-term: information on presence and population extent of invasive species can be accessed and shared among partners (e.g. Ontario's Invading Species Awareness Program). Mid-term: Budget items required by regional and local land management agencies to map, remove and control all populations of invasive species in Lake Huron's wetlands. Short-term: Increased education and awareness campaigns are required to continue to encourage the early detection of invasive species in Ontario. Mid-term: Incentivize local and grass-roots action towards invasive species control, including voluntary programs and services to remove invasives on privately owned land. Short-term: Support existing citizen science reporting programs for invasive species including the Ontario Invading Species Awareness Program through partnership, promotion, and data sharing and services.
	– Protect and restore existing wetland habitats, while increasing wetland cover by AU.	Target: Protection of all coastal wetlands through bylaws and CA regulation and restoration of historical wetland areas. Threshold: 6% of sub-watersheds and 10% of major watershed should be wetland cover.	Short-term: Incentive programs for building wetlands on privately owned land by continuing existing programs present in local and regional agencies (e.g. Wetland restoration program through ABCA). Short-term: Coordinate partnerships to maximize funding towards larger restoration projects.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
	– Increased patrol and enforcement of violations to coastal wetland protection outlined in regulation and legislation.	Target: Increase protection status of unevaluated, evaluated but not significant, locally significant, and provincially significant coastal wetlands to meet provincially significant wetland protection designation through municipal bylaw, Official Plan, Conservation Authority Act and Provincial Policy Statement.	Evaluation: Increasing buffer zones around all coastal wetlands to match or exceed provincially significant wetland boundaries will protect the ecological integrity of these sensitive ecosystems. Short-term: Protect current coastal wetlands by enforcing existing regulation, bylaw, and acts. Mid-term: Incentivize wetland preservation through property tax incentives (through local and regional programs and land management). Mid-term: Support positive development projects that create infrastructure at wetland areas which reduces cumulative impacts to wetlands (e.g. boardwalks, viewing platforms) through grants, incentive programs, or partnerships between multiple agencies to fund LID infrastructure around wetlands.
2.4 Woodlands	– Increase woodland cover in each coastal AUs.	Target: Current 2019 woodlands protected and enhanced in size and quality to support the ecological services they provided. Threshold: All AU have a minimum of 30% forest cover, with goals to increase to 50% forest cover by 2029.	Evaluation: Forest cover can be monitored through GIS data sets through County planning department, CA planning, and provincial SOLRIS data sets. Monitoring changes to forest cover through annual updates from CA and grass-roots tree planting programs, or when SWOOP data becomes refreshed every 4 years to re-delineate woodland boundaries and interior habitat can monitor improvements to forest cover. Short-term: Increase awareness of the importance of interior forest habitat through communication products, outreach efforts to private landowners, and general community groups. Short-term: Continue to encourage forest restoration and creation through existing programs (e.g. through CA's), by raising awareness of programs and associated incentive programs. Mid-term: Secure funding from regional partners to continue to offer forest restoration programs locally (e.g. 50 million tree program). Mid-term: Work with regional partners (e.g. NCC) to secure tracts of coastal woodland to protect habitat and respective buffer zones. Mid-term: Review and update tree preservation bylaws to reflect shoreline tree protection regulations (e.g. Shoreline tree preservation bylaw, Township of ACW).
	– Improve connectivity between woodland habitat patches to increase ecological integrity and ecosystem services.	Target: Identify priority isolated woodland areas and fragmented habitats requiring movement corridors to reduce fragmentation by 50% by 2029. Threshold: 50% of all woodlands in the coastal corridor connected with supporting habitats by 2029.	Evaluation: Using GIS data, identification of isolated forest areas and small wooded areas can be tracked annually to determine what percent of woodland patches are isolated and require corridors. Mid-term: Strategies are required and collaboration between local, regional and grass-roots organizations to link these ecosystems for flow of species (e.g. if a forest is isolated around tilled land, strategies between local governance and individual landowners could be made through collaboration to link this ecosystem to others close-by through restoration projects).

Topic Area	Action Item	Target, Indicator or Threshold	Needs
	– Increase woodland interior habitat and establish recommended buffer zones around woodland habitat.	Target: Apply development restrictions within 120 m of wooded habitat enforced through bylaw, CA regulation and county Official Plan through amendments to existing plans by 2022. Threshold: All AU have a minimum of 2, 200 ha interior forest patch, with goals to increase to 5, by 2029. Threshold: All AU have wildlife corridors a minimum of 50 to 100m wide between forest patches.	Evaluation: Monitoring quantity of woodland interior habitats through GIS data and the quantitative and qualitative change of these annually or during SWOOP data updates every 4 years. Short-term: Increase education and awareness of the importance of interior forest habitat for species of flora and fauna, using communication products such as video, media, and print products. Partnerships and collaboration on this effort will maximize limited resources and provide consistent messaging.
2.5 River mouths and connecting watercourses	– Protect and restore buffer zones around watercourses and river mouths to improve water quality.	Target: All watercourses with mouths at Lake Huron's southeastern shores would meet or exceed science-based thresholds for health of watercourse habitat and to improve water quality entering Lake Huron's nearshore waters by 2029. Threshold: A 30 m vegetated buffer established on either side of warm and cold-water watercourses through all land-use practices. Threshold: 75% of entire stream length must be naturally vegetated and have canopy cover.	Evaluation: Through GIS data and orthophoto analysis, determination of stream cover of each mapped watercourse can be done as to 2019 cover, with updates provided at each 4 year SWOOP update to compare progress made, along with data from restoration projects done by landowners. Short-term: Programs existing that support re-naturalization and restoration of buffer zones around watercourses, including cattle exclusion fencing and reforestation should be supported by regional and provincial agencies. Short-term: Educating and raising awareness of the importance of vegetating watercourses, keeping cattle and pasture herds out of watercourses, and preventing creek dredging is needed. Mid-term: Incentive programs through restoration projects and vegetation planting subsidies to establish and protect buffers around watercourses would increase participation.
	– Increased patrol and enforcement of violations of regulations and legislation to river mouths and connecting watercourses.	Target: Bylaw, CA regulation, county Official Plans, and Provincial documentation should reflect the necessity for buffer zones around watercourses and vegetation cover over creek waters.	Mid-term: Support the continuity of bylaws across the coastal corridor using collaboration and communication to ensure consistency in policy and regulation.
2.6 Islands & nearshore waters	– Protect nearshore, lakebed, and island habitats in nearshore zone through best management applications.	Target: Method of transportation to islands during times of low lake level which reduces impact to lake bed, adopted in 2023. Target: Reduce development footprint on islands in southeastern shores nearshore zone	Evaluation: No increase in development and transportation footprint after 2020. Short-term: Work with communities living on, and adjacent mainland communities to derive a lower-impact transportation route to islands off the southeastern shores to reduce impact to lakebed during times of low water levels. Short-term: Work with communities on islands to reduce or maintain their development footprint, while providing enhanced habitat opportunity for migratory birds, bats, and fish. Short-term: Education and outreach are required to collaborate effectively with these communities.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
3.0 EVALUATION, ASSESSMENT, AND MONITORING			
3.1 Ecological monitoring of coastal ecosystems	– Create or update standardized monitoring toolkits for each coastal habitat.	Target: Create or update monitoring tool kits for each ecosystem type, palatable for individual landowners, and grass roots groups to complete from a citizen science-based perspective.	Evaluation: When monitoring tool kits are created and available widely to all AUs, the target has been met. Short-term: Monitoring toolkits available for free, to landowners, community associations, and grass roots groups, to enable citizen science monitoring across the coastal corridor to track finite changes to ecological integrity and catch changes early on (e.g. Coast Watchers, LHCCC).
	– Secure long-term funding for monitoring and evaluation projects managed by local and grass-root groups.	Target: Existing provincially and federally managed funding pools improved to support long-term projects (5 to 10 years). As well as expanding the amount of funding and resources available through these programs to support more projects across the coastal corridor. – "What Gets Measured, Gets Managed".	Evaluation: When funding pools are improved through collaboration and communication, the target is met. Short-term: Communication between groups using funding pools for monitoring programs and provincial and federal funding pools for conservation need to be improved to communicate the needs for long-term projects. An initial meeting is needed, as well as an advisory committee (from pool of funding recipients) which can communicate the need for long-term funding quickly to decision makers. Communication that monitoring and completing BMP stewardship activities is as critical, if not more so than other budget line items that are protected and increased year-after-year. Mid-term: Resources such as long-term funding for project management, development of toolkit and minor equipment required to create these toolkits. Collaboration between agencies to share resources to enable this action is necessary. Long-term: Funding for long-term projects needs to be protected against changes in provincial and federal government.
3.2 Collaboration with Academia for monitoring	– Collaboration with academic partners to collect and analyze monitoring data from coastal habitats regarding indicators and thresholds.	Target: Enable academia to participate in the background research, assessment, and monitoring required to derive appropriate indicators and thresholds for the coastal corridor	Evaluation: Determining whether this target is being met can directly be compared to how many reports are being produced and published by the academic community partnering with grass-roots and local groups on the southeastern shores. Short-term: use collaboration techniques to enable Masters or Doctoral research projects into specific indicators for each ecosystem on Lake Huron's southeastern shores. Employ collaboration efforts between regional, local, and grass-roots organizations to assist with the facilitation of this research.
3.3 Assessment units as a basis for planning and monitoring	– Pool data across land managers within assessment units to compare present condition, thresholds, and indicators, to past conditions.	Target: Unite partners within each AU to collaborate, communicate, and share resources during mutually beneficial projects and programs	Short-term: Communication and awareness of all grass-roots, local, and regional agencies within each assessment unit. Mid-term: Education and awareness increased to private landowners and individuals about the programs, regulations, and bylaws in their area, who to contact for what purposes, and how to access information.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
3.4 Plan for uncertainty with flexible, proactive, long-term strategies	– Commitment to monitor indicators, and meet thresholds among all agencies and individuals.	Target: Continuous communication and collaboration among stakeholders to partner on projects to monitor indicators and meet scientifically derived thresholds to ensure the health of coastal ecosystems.	Short-term: Open data and data sharing is needed among agencies and organizations. The communication and sharing of data will allow for knowledge of data gaps and provide goals for monitoring and data collection. Sharing data and keeping resources accessible among agencies will reduce duplication and increase accuracy with larger data sets. Short-term: Open communication about project status, needs, and successes/ failures along the way to greater AU partner community. Could be done through regular communication, or through presentations to partners through groups such as Healthy Lake Huron, Watershed Steering Committees or Lake Huron conferences (e.g. Is the Coast Clear Biannual Conference). Mid-term: Funding pools available for projects that require long-term monitoring, action, and flexible scope. Funding for grass-roots and local groups through regional, Provincial and Federal funding pools, as well as private and corporate sponsorships are extremely important for long-term monitoring and education projects.
3.5 Beyond the minimum standard	– Encourage a 'culture' among land managers and landowners in the coastal corridor to exceed minimum standards.	Target: Revisit indicators and thresholds to determine if they are being met. If they are already met, setting higher standards to mitigate increasing impacts from climate change and store carbon.	Evaluation: All local governance agencies (municipalities, townships and counties) have the list of thresholds, and have clear strategies to exceed these recommended thresholds. Short-term: Coastal scientists work with members of each AU to determine their standing in comparison to the indicators proposed. Mid-term: Determine strategies to exceed the minimum recommended thresholds to increase resiliency and reduce potential for damage and impacts to coastal health.
4.0 EDUCATION, PUBLIC AWARENESS, AND COMMUNICATION			
4.1 Political and public commitment	– Communicate targets and thresholds to promote public and partner accountability.	Target: Sharing information about the goals and status of how projects are meeting thresholds in each AU and across the coastal corridor keep land managers and individuals accountable for progress made.	Evaluation: Representatives from local governance can communicate progress made at the annual gatherings for shoreline groups, including the Annual Lake Huron Municipal Forum. Seeing progress made by other members of shoreline organizations can inspire and promote action in other areas along the southeastern shores. Short-term: Communicating positive actions made toward coastal stewardship is rewarding for areas of the coastline which have shoreline residents that value from healthy coastal environments, as well as can be a draw for tourists hoping to visit eco friendly communities.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
4.2 Diverse methods of outreach	– Create a diverse portfolio of outreach materials to appeal to different audiences and knowledge levels through multi-media, presentations, and print materials.	Target: A coast of eco-aware, healthy citizens eager to promote sustainability and resiliency of their communities and coastal environments.	Short-term: communicating through social media regularly to educate about coastal ecosystems and the rare unique species that call this area home; as well as the threats and stressors faced by these habitats. Short-term: communicating through multi-media platforms, such as video, podcasts, webinars, and traditional written outlets to show the uniqueness of the southeastern shores and raising awareness of the projects being done along the coast. Short-term: partnering with local business to encourage awareness of coastal issues through consumerism and changed trends in lifestyle choices. Short-term: continuing outreach and engagement through workshops, speaker series, conferences, clean-up days and presentations to community groups to engage individuals in a hands-on, fun way. Short-term: Resources and funding are required to prepare material for communication and to put on events. Collaboration between all groups to fulfill this target and share resources for mutually beneficial results is essential. Support from industry and regional partners is extremely important to supporting these initiatives.
4.3 Best management practice guides	– Create or update Best Management Practice guides for shoreline stewardship across the coastal corridor.	Target: Each municipality or township should have their own BMP guide tailored to their specific shoreline. – Two guides have recently been updated: (Township of Huron-Kinloss, Municipality of Kincardine), and other municipalities can follow suit.	Evaluation: All municipalities and townships across the shoreline that have a BMP updated within the past 5 years will meet the target threshold. If all AUs have a BMP guide, then target will be met. Short-term: Funding and resources are required, and partnerships necessary to complete BMP guides. Collaboration among agencies to provide resources to create a BMP guide will allow co-ownership and consistent information provided to landowners and businesses about how best to manage their coastal ecosystems.
4.4 Expectation management	– Collaborate with agencies promoting the coastal corridor, to mitigate the expectations of visitors.	Target: Regional tourism organizations and local tourism promotion companies have a united front to mitigate expectation of visitors and tourists to coastal ecosystems by the 2021 season.	Evaluation: Using surveys of tourists and visitors, a baseline can be established for the level of knowledge tourists and visitors had about the area and the sensitive ecosystems and stewardship practices are promoted in the area, comparing it to a bi-annual version to monitor whether expectations are becoming more realistic and whether visitors are aware of the stewardship practices needed to be employed when visiting the coastal corridor, (first season starting 2021). Short-term: Communicate the need for expectation management to advertising and promotion groups to incorporate this information in their strategies.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
	– Increase awareness of coastal ecosystem processes among real estate agencies.	Target: When properties in the coastal corridor are sold, information is communicated to the new homeowner or landowners about what to expect in that area in regards to coastal threats, coastal ecosystem health and requirements, and details like erosion rates and BMP strategies, by 2023.	Evaluation: If packages about the AU are provided to new landowners who operate through real estate agencies, the target has been met. Short-term: Communication with real estate agencies in the coastal corridor about the importance of reiterating this information to potential buyers. Mid-term: Packages unique to each AU need to be prepared and available digitally and in hard copy to real estate agencies Short-term: Partnerships between grass-roots groups, local and regional governance to provide funding for the preparation of these guide packages is required.
5.0 MECHANISMS FOR COOPERATION AND COLLABORATION			
5.1 Support annual communication events and products	– Hold annual and biannual events to improve collaboration and information sharing.	Target: Hold events open and accessible to all members of the Lake Huron coastal community to share information, build relationships, foster communication and collaboration, and provide opportunity for experience and engagement with scientific information about the coastal ecosystems on the southeastern shores. – Include invitation and participation by local and regional governance, grass-roots groups, First Nations and Métis, and individuals. – Most of the coastal corridor is privately owned, therefore ensuring cooperation and collaboration among individual landowners and other groups is essential to completing conservation stewardship initiatives.	Evaluation: Supporting existing annual or bi-annual events, increasing attendance from partner organizations and public individuals and members of the community. Mid-term: Continue to hold events which unite shoreline grass-roots, local, and regional governance bodies to share information and raise awareness within the greater coastal community (e.g. Is the Coast Clear Lake Huron Conference, LHCCC; The State of Lake Huron Conference; Lake Huron Municipal Forum, LHCCC). Mid-term: Funding and resources are needed to put on large, valuable community events. Partnerships and collaboration are needed to ensure these events can occur at low cost to attendees to make events accessible for all. Short-term: Holding public events in coastal communities across the coast is important to raising awareness about the sensitive ecosystems and threats and stressors. Through these events, cooperation and collaboration occur among neighbors, and within communities to unite behind the science towards common goals. Investing resources in presentations and community events is important to ensuring community groups have accurate information and resources available to complete stewardship projects. Short-term: Need communication strategies, and partnership opportunities through projects.
5.2 Increase data sharing among coastal groups and agencies	– Encourage knowledge and data sharing between grass-roots, local, and regional governance groups.	Target: Open data sharing among all groups within AUs to facilitate knowledge sharing and partnership on projects. – Understanding gaps in data sets allow for improvements in consistency and completion of data across the coastal corridor.	Short-term: Begin a bi-annual data sharing program to facilitate knowledge sharing, and partnership with projects to meet ecological targets and thresholds (GIS data information and restoration/ stewardship metrics). Short-term: Raise awareness between environmental agencies about the importance of sharing data, and reasoning why collaboration is important to meeting common goals.

Topic Area	Action Item	Target, Indicator or Threshold	Needs
6.0 GOVERNANCE, REGULATION AND INCENTIVES			
6.1 Incentive programs	– Increase regional and local governance giving/ receiving funding for incentive programs managed by grass-roots groups to complete restoration projects and stewardship initiatives.	Target: Incentive programs be enhanced and expanded by 30% to provide opportunity for more projects across the coastal corridor by 2023.	Evaluation: If incentive programs provided by local and regional governance meet the target, then this action item is successful. Short-term: Grass-roots groups work with local governance agencies to describe the types of incentive programs are most needed in the coastal corridor, with 3 to 5 year lifespans on funding for programs supporting incentive programs (i.e. dune restoration work, tree planting, wetland creation).
		Target: An increase of 30% of current Provincial and Federal funding from 2019 levels allocated to local governance groups to disperse to grass-roots agencies, or go directly towards grass-roots groups for incentive programs by 2029.	Short-term: Communicate with Provincial and Federal Agencies the importance and necessity for long-term funding pools to ensure monitoring programs and restoration initiatives can be continued. Short-term: Allocation of funds from regional governance into grass-roots and local groups will create more boots-on-the-ground projects to be completed, provide opportunity for local jobs, employing people in rural communities, and enable measurable action benefitting communities occurs where the need is greatest: in small coastal communities.
6.2 Consistency in regulation, bylaw, and policy	– Consistency in bylaws, upper and lower tier Official Plans for shoreline management.	Target: Consistent bylaws, and wording in official plans implemented by 2022. – Examples include: shoreline protection bylaw (Appendix D), shoreline tree preservation bylaw. – Clearer, more specific targets, positions and recommendations are needed in these documents to provide less opportunity for confusion and interpretation.	Evaluation: When there is consistency in shoreline protection and restoration bylaws, the target has been met. Short-term: Work with local governance to update bylaws and local regulation to ensure consistency across neighbouring jurisdictions to reduce confusion and improve protection of shoreline ecosystems.

<u>**Definitions:**</u>

Target: The specific goal to be met to achieve the action item.

Threshold: The defining amount of change needed to meet the target and achieve the action item.

Evaluation: How it will be determined whether the targets and thresholds have been met.

Short-Term: Easily, or somewhat easily adopted, and can be completed between 6 months and a year from the starting date.

Mid-Term: Somewhat easily to adopt, with an approximate completion time of 1 to 3 years from the starting date.

Long-Term: More coordination and partnerships needed to complete these goals, making them time consuming. Approximate completion time of 3 to 5 years.

CHAPTER 9: CONCLUSIONS

Through the development of the Coastal Action Plan, public support from coastal communities along the southeastern shores 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.

Intentions to review the proposed actions in 3 to 5 years to see how land managers and individuals have translated the recommendations 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 the CAP. The key aspects governing whether this plan is successful at eliciting change is pronounced in the actions completed through the recommendations. A baseline assessment of coastal ecosystems, stressors that affect them, and opportunities that exist for improvement provoke action to improve the heath of the coastal corridor. Through the completion of projects guided by recommendations, a feedback loop of monitoring, evaluation, and reporting is required through the principles of adaptive management. As Peter Drucker, writer of Management Practices states, "what gets measured gets managed". Measuring positive and negative changes 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 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. Engaging grass-roots, local, and regional governance in the recommend actions of the 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 the 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 Lake Huron 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 to create opportunities to support these recommendations in the Plan. The 2016 to 2019 Coastal Action Plan for the Southeastern Shores of Lake Huron 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, and the Ministry of Environment, Conservation and Parks.

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APPENDICIES

APPENDIX A: ECOSYSTEMS BY ASSESSMENT UNIT

AREA OF COASTAL ECOSYSTEM PER ASSESSMENT UNIT (ha)

AU	Total area	Sand Beach	Dune	Bluff	Gully	Cobble Shoreline	Wetland	Woodland	River mouth	Alvar / Bedrock
1	8,582.31	58.30	0	29.91	230.69	3.54	477.79	976.43	8	0
2	8,939.55	182.18	340.68	172.20	165.84	2.22	1,119.96	1,409.64	9	0
3	7,297.41	103.34	0	166.75	888.39	0	287.74	706.30	3	0
4	8,681.95	78.11	0	0	477.76	4.97	456.81	1,066.94	2	0
5	10,865.82	12.36	9.89	0	0	2.35	2,938.45	2,556.43	5	0
6	11,931.26	99.48	0.68	0	67.60	14.99	1,978.80	5,355.12	2	55.29
7	8,339.08	140.44	0	0	0	0	1,798.87	5,079.24	0	71.37
8	5,567.19	1.09	0	0	0	0	658.80	3,603.64	2	10.66
9	10,108.32	0	0	0	0	0	1,119.07	7,723.00	0	86.27
10	4,417.38	1.32	0	0	0	0	434.52	3,237.13	0	101.72
11	1,107.56	0	0	0	0	0	35.56	904.31	0	0.48

*** GIS analysis based on partner data layers and SOLRIS Provincial Data*

LENGTH OF SHORELINE COASTAL ECOSYSTEMS (km)

AU	Total length	Sand beach & Dunes	Mixed Sediment	Bluffs	Cobble Beach	Bedrock	Hardened Shoreline	Island	Wetland
1	81.20	4.14	44.07	0	0	0	13.29	0.34	19.70
2	120.85	55.46	43.21	4.31	1.15	0	15.04	0	1.34
3	63.94	9.42	42.34	2.41	0	0	9.77	0	0
4	39.76	13.92	20.39	0	2.20	0	2.30	0	0.96
5	53.31	1.77	0	0	15.07	0	10.94	0	25.53
6	82.91	11.37	12.11	0	12.85	4.79	15.30	0	26.51
7	191.43	0	0	0	0	98.97	4.55	87.00	87.91
8	84.61	0	0	0	2.75	56.34	0.00	24.75	25.52
9	126.36	0	0	0	9.25	82.70	0.00	5.24	34.42
10	75.79	0	0	0	3.05	65.48	0.00	1.31	7.26
11	45.14	0	0	0	0	24.25	1.21	3.41	19.68

*** GIS analysis based on partner data layers, Ontario Shoreline Segmentation data layer (ECCC) and SOLRIS Provincial Data*

APPENDIX B: 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 and 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-Colborne-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 C: GLOSSARY OF TERMS

Feature	Definition	Sources
Alvar	*"Natural communities of humid and sub-humid climates, in areas of glaciated horizontal limestone/dolomite (dolostone) bedrock pavement with a discontinuous thin soil mantle. Alvars are characterized by distinctive flora and fauna with less than 60% tree cover, maintained by associated geologic, hydrologic, and other landscape processes".*	Reschke et al., 1999
Assessment Unit	*A portion of the coastal corridor on the southeastern shores, derived using littoral zone methodology developed by Environment and Climate Change Canada. This area represents the extent of sediment transportation along the shoreline from Sarnia to Tobermory. These units represent each area of analysis.*	
Beach	*"An accumulation of loose sediments at the edge of a body of water shaped and formed in response to wave action… The three common beach types include sand, shingle or cobble ridge".*	DFO, 1996 (p.6)
Bluff	*A steep vertical exposure comprised of a combination of clay, sand, shale, bedrock, or limestone. These areas are prone to erosion due to their direct interaction with changing lake levels.*	(LHCCC, 2013)
Breakwater	*"Offshore structures made of large boulders or cement blocks used to protect anchorages or harbor entrances from wave energy".*	UoH, 2014
Coastal Wetland	*"Lands seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface; 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).
Cobble Beach	*An area of the coast dominated by a substrate of various sized cobble, pebble, shingle, or boulder stones with direct interaction with wave and wind influences of Lake Huron.*	(Liipere, S., 2014)
Dynamic beach	*The dynamic beach hazard limit includes the flooding hazard limit plus a dynamic beach allowance. "Dynamic Beach: the sum of the 100-year flood level, 15-m wave uprush limit and an additional 30 m allowance for the dynamic nature of beach movements".*	OMMAH (2017); Davidson-Arnott & Mulligan (2016).
Erosion	*The movement of weathered rocks, sediment and minerals from one location to another through wind or water influences.*	UoH, 2014
Gully	*An erosional feature cut into a bluff, typically "V- Shaped" when young, "U- Shaped" with age. Formed through natural and anthropogenic influence, are typically caused by erosion of a water tributary feeding perpendicularly into Lake Huron.*	(LHCCC, 2013)
Grass-roots	*Small organizations focused on a local area or specific place including a town, a cottage*	
Groyne	*"A rigid structure often built perpendicular to the shoreline that interrupts water flow and movement of sediment"*	UoH, 2014
Healthy Beach	*A beach with ecological function retained: sand transportation in the littoral zone; significant 'top sand' (no 'wet beach'); presence of a mature dune system with dune grass and/ one or more restoration measure in place (sand fencing, boardwalk, staircase over dune).*	(LHCCC, 2008)

Island	*"Any land mass (natural or anthropogenic) surrounded by an aquatic ecosystem. An 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.
Jetty	*"A rigid structure built in pairs perpendicular to the shoreline to stabilize inlet channels".*	UoH, 2014
Light Pollution	*The alteration of night natural lighting levels caused by anthropogenic sources of light.*	Falchi et al., 2016
Limits of Acceptable Change	*"The variation that is considered acceptable in 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.)
Local governance	*Organizations or groups focused on a specific local area, including Conservation Authorities, Municipalities, Townships, Counties, and Provincial and National Parks.*	
Major Watercourse	*A linear water feature equal to or greater than 20m wide. Appears black, blue, grey or different shades of brown on IRS imagery.*	(County of Huron, 2010)
Microplastics	*Plastic pre- or post- consumer particles ranging from 1 nanometre to <5mm in size.*	NOAA, Oceanwise.org
Minor Watercourse	*A linear water feature less than 20m wide. Appears black, blue, grey or different shades of brown on IRS imagery.*	(County of Huron, 2010)
NPS Pollution	*"Non-Point Source Pollution" is pollution resulting from many sources which combine to create a concentrated pollution source (e.g. light pollution, thermal pollution).*	
Regional Governance	*Organizations or agencies representing governance of a large, regional area, including the Ministry of Natural Resources and Forestry, Environment and Climate Change Canada, The Province of Ontario, the Government of Canada, Ministry of Environment, Conservation, and Parks.*	
Rip Rap	*"Loose collections of large rock or cement blocks placed along a shoreline".*	UoH, 2014
Sand Beach	*An area of the coast dominated by a substrate of sand that is dynamically altered through wave movements and wind action.*	(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.*	(LHCCC, 2008)
Sea Wall	*A rigid wall structure made of cement or metal placed parallel to a shoreline.*	UoH, 2014
Unhealthy Beach	*A beach compromised by anthropogenic factors including: beach raking (removal of top-sand); dune destruction via foot traffic or vehicle influence; invasive species present; over-visitation by humans; obvious nutrient enrichment problems (e.g. beach closures and algae blooms); pollution via litter and 'wash-up' that establishes itself in the sediment.*	(LHCCC, 2008)
Woodland	*An area dominated by treed vegetation with the canopy cover exceeding 60%. Woodlands consist of coniferous, deciduous or a mix of trees. Coastal Woodlands can appear on different sediment types and along different slopes.*	

APPENDIX D: 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:

a. 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;
b. Minimize the destruction of trees;
c. Sustain a healthy natural environment by maintaining and improving the ecosystem services provided by trees;
d. Protect significant and sensitive natural areas;
e. Contribute to human health and quality of life through the maintenance of tree cover;
f. Maintain water quality;
g. Reduce airborne pollution;
h. Maintain and enhance natural habitat;
i. Prevent soil erosion and water runoff;
j. Protect, promote and enhance the aesthetic values of land;
k. Protect fish habitat as defined in the Fisheries Act, Revised Statute of Canada 1985; and
l. 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 E: 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.

APPENDIX F: WETLAND BUFFER ZONES

Information from *How Much Habitat Is Enough* by Environment and Climate Change Canada (2013).

Table 3. Selected Critical Function Zone Data for Wetlands

Species	Extent of Critical Function Zone from Wetland Edge	Reference	Notes
	Reptiles		
Midland Painted Turtle	Maximum 600 m, mean 60 m; range 1 to 164 m; mean 90 m, range 1 to 621 m	Semlitsch and Bodie 2003	Review of three studies
	1 to 620 m, mean 90 m for nesting	Christens and Bider 1987	
Spotted Turtle	85 m for nesting, 54 m for dormancy	Joyal et al. 2001	Distances are mean plus standard deviation
	75 to 312 m for nesting; dormancy up to 412 m	Milam and Melvin 2001	
	Maximum 150 m; range 3 to 265 m; range 60 to 250 m	Semlitsch and Bodie 2003	Review of three studies
Blanding's Turtle	380 m for nesting, 18 m for basking and 114 m for dormancy	Joyal et al. 2001	Distances are mean plus standard deviation
	Mean 815 m, range 650 to 900 m; mean 135 m, range 2 to 1115 m; mean 168 m	Semlitsch and Bodie 2003	Review of three studies
Spiny Softshell	Mean 3 m; range 2 to 3 m; mean 0.3 m; mean 5 m	Semlitsch and Bodie 2003	Review of four studies; latter two studies single individuals
Snapping Turtle	Mean 94 m, range 38 to 141 m; mean 37 m, range 1 to 183 m; mode 25 m, maximum 100 m; mean 27 m, range 1 to 89 m	Semlitsch and Bodie 2003	Review of four studies
Wood Turtle	Mean 27 m, range 0 to 500 m; maximum 600 m; mean 60 m, maximum 200 m	Semlitsch and Bodie 2003	Review of four studies
Northern Map Turtle	Mean 2 m, range 2 to 3 m	Semlitsch and Bodie 2003	Review of one study
Eastern Musk Turtle	Mean 7 m, range 3 to 11 m	Semlitsch and Bodie 2003	Review of one study
Northern Watersnake	No adjacent lands area recommended	Attum et al. 2007	Species fairly sedentary and generally does not require upland habitat
	Maximum 6 m	Semlitsch and Bodie 2003	Review of one study
	Frogs		
Western Chorus Frog	Maximum 213 m, mean 75 m	Semlitsch and Bodie 2003	Review of one study
Wood Frog	Post-breeding movements ranged from 102 m to 340 m, median 169 m	Baldwin et al. 2006a	Recommends conservation of network connected habitats
	30 m inadequate to support viable populations	Harper et al. 2008	Did not test beyond 30 m
	11 to 35 m partially mitigates timber harvest impacts	Perkins and Hunter 2006	Study is in forested landscape where the non-buffered area is logged
	40% of individuals wintered further than 100 m from breeding pond	Regosin et al. 2003	Recommends maintenance of suitable terrestrial habitat beyond 100 m
Green Frog	Mean 36 ± 25 m for foraging	Lamoureux et al. 2002	
	Mean 137 m, maximum 457 m; mean 121 m, maximum 360 m; mean 485 m , range 321 to 570 m	Semlitsch and Bodie 2003	Review of three studies
Bullfrog	Mean 406 m	Semlitsch and Bodie 2003	Review of one study

Appendix F: Continued…

Salamanders			
Spotted Salamander	Mean maximum 106 m	Veysey et al. 2009	Salamanders used clear-cut areas to some degree
	30 m inadequate to support viable populations	Harper et al. 2008	Did not test beyond 30 m
	60% of individuals wintered further than 100 m from breeding pond	Regosin et al. 2003	Recommend maintenance of suitable terrestrial habitat beyond 100 m
	Mean 67 m, range 26 to 108 m; mean 103 m, range 15 to 200 m, mean 64 m, range 0 to 125 m, mean 150 m, range 6 to 220 m; mean 192 m, range 157 to 249 m, mean 118 m, range 15 to 210 m	Semlitsch and Bodie 2003	Review of six studies
	Range 3 to 219 m, mean 112.8 m for overwintering	Faccio 2003	Recommended "life zone" to encompass 95% of population was 175 m
Ambystoma salamanders	Mean 125 m for adults, 70 m for juveniles	Semlitsch 1998	Recommended "life zone" to encompass 90% of population was 164 m
Jefferson Salamander	Range 3 to 219 m, mean 112.8 m for overwintering	Faccio 2003	Recommended "life zone" to encompass 95% of population was 175 m
	Mean 39 m, range 22 to 108 m; mean 92 m, range 15 to 231 m; mean 252 m, range 20 to 625 m; mean 250 m	Semlitsch and Bodie 2003	Review of four studies
Blue-spotted Salamander	52% of individuals wintered more than 100 m from breeding pond	Regosin et al. 2003	Recommend maintenance of suitable terrestrial habitat beyond 100 m
Eastern Newt	No distances given	Roe and Grayson 2008	Newts are wide-ranging and active in the terrestrial habitat
	No distances given	Rinehart et al. 2009	Proximity to developed land cover essentially precluded newt occupancy
Nesting Waterfowl			
Various species in Ontario	0 to more than 400 m; 90% were within 200 m. About 20% of nests were inside or within 25 m of wetlands	Henshaw and Leadbeater 1998	Based on data from 102 nests at coastal marshes over two years. May be applicable where suitable waterfowl nesting habitat is present.
Dragonflies and Damselflies			
Various species	Dragonflies, especially Halloween Pennant, found 10 to 160 m from wetland edge	Bried and Ervin 2006	Study in Mississippi. There was a different sex balance at different distances.
	Bogs with natural habitat around them had a higher dragonfly and damselfly abundance than those with peat mining in adjacent lands	Bonifait and Villard 2010	Study in bogs in New Brunswick

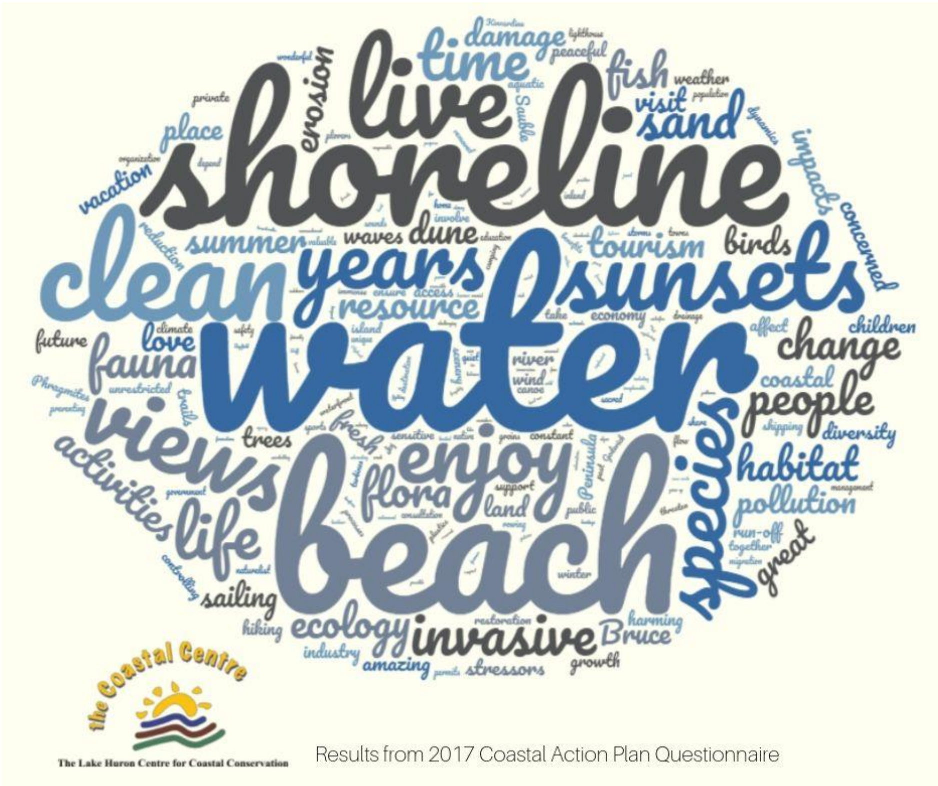
Appendix F: Continued…

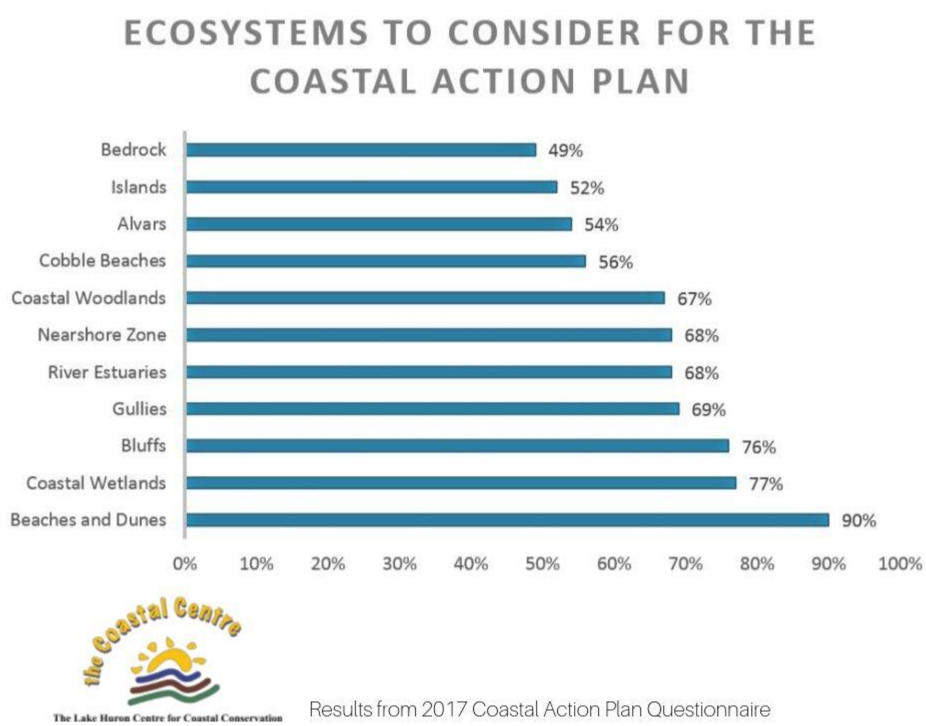
Table 4. Examples of Recommended Protection Zones or Buffers to Wetlands

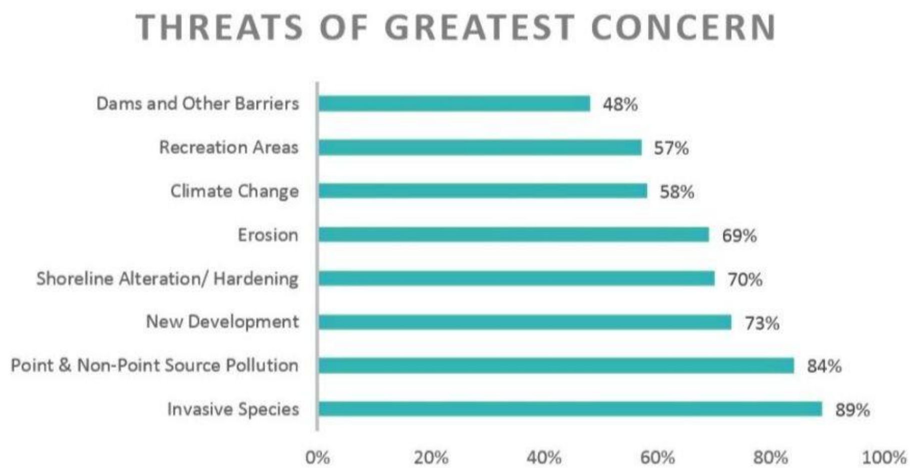
Stressor	Suggested Extent of Protective Zone	Reference	Notes
Sediment	6 m	Hook 2003	High attenuation rate regardless of slope (0 to 20%)
	10 to 60 m	Skagen et al. 2008	Range based on literature review
Herbicide drift from agricultural lands	Strip at edge of cultivated fields (data indicate > 6 to 9 m)	Boutin and Jobin 1998	Cites other studies suggesting 5 to 10 m
Non-point source agricultural pollutants	16.3 m grass/woody strip (riparian)	Lee et al. 2003	Removed > 97% of sediment, narrower (7 m) grass provided some benefits
Residential stormwater	15 m; 23 to 30 m on slopes greater than 12%	Woodard and Rock 1995	Groundcover type also very important
Human disturbance, landscaping (e.g., wood piles, composting)	19 to 38 m	Matlack 1993	Fencing may achieve same results in less width
Nitrate	16 to 104 m	Basnyat et al. 1999	Objective was > 90% nitrate removal
Human disturbance by watercraft	More than 80 m	Rodgers and Schwikert 2002	Based on a flush distances* of approximately 45 to 80 m for Great Lakes species (no waterfowl)
Human disturbance, recreation-related (e.g., camping, hacked trees)	67 to 130 m	Matlack 1993	
Human disturbance (on nesting Great Blue Herons)	100 m	Erwin 1989; Rodgers and Smith 1995	Flush distance* was 32 m ± 5.5 m; 40 m added to mitigate antagonistic behaviour
Urban cats	190 m	Haspel and Calhoon 1991	Measured distance predation rates on wildlife extended into adjacent natural area

* Flush distance = proximity of disturbance that will cause bird to leave nest

APPENDIX G: QUESTIONNAIRE RESULTS

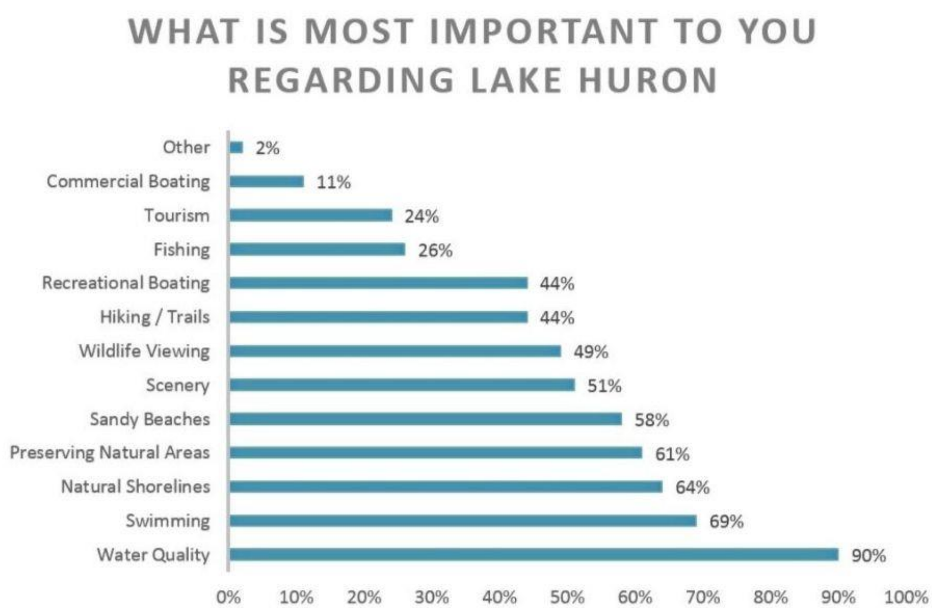






The Lake Huron Centre for Coastal Conservation

Results from 2017 Coastal Action Plan Questionnaire



The Lake Huron Centre for Coastal Conservation

Results from 2017 Coastal Action Plan Questionnaire