Examining the ecosystem service and social well-being contributions of beach grass (*Ammophila breviligulata*) and the implications for integrated coastal planning along the southeastern shoreline of Lake Huron, Canada

by

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Author's declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Beach grass (*Ammophila breviligulata*) is a key component in maintaining the stability of the prominent beach-dune ecosystems of the Lake Huron shoreline, with benefits to dependent species (e.g., piping plover) and those living along or visiting the shoreline (e.g., through the maintenance of public and private infrastructure for beach-front restaurants, cottages). The capacity of beach-dune ecosystems to respond favorably to climate change conditions also depend on the maintenance of intact beach grass populations. However, the human-environment interactions that determine how people perceive and respond to beach grass are poorly understood, despite the importance of beach grass to the southeastern shoreline of Lake Huron (and throughout the Great Lakes basin).

The goal of my research is to enhance opportunities for integrated coastal planning along the southeastern shoreline of Lake Huron by assessing the underlying drivers of change with regard to beach grass, and understanding how coastal resource users (e.g., property owners) perceive the benefits beach grasses provide (i.e., ecosystem services). The objectives of this research are: (1) examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors; (2) understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass; (3) identify ecosystem services related to beach/dune grasses of value to property owners and visitors along the shoreline; (4) establish how beach grass changes are linked to the well-being (e.g., material, subjective and relational) from the perspective of property owners and shoreline visitors; and (5) generate insights to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron. Several methods of data collection and analysis were used in this research, including a review of the literature, a structured survey that was completed online and on the phone by participants (n=123), and semi-structured interviews with key informants (n=4) (e.g., conservation authority and non-governmental organization representatives). The structured survey was limited to property owners and beach visitors of the southeastern shoreline of Lake Huron and was designed to identify how people perceive and understand ecosystem services related to beach grass with which they are familiar, how they perceive and interact with beach grass and the implications for their own well-being (i.e., material, relational or subjective), and to gain insights on how to better manage beach grass along the southeastern shoreline of Lake Huron. The semi-structured interviews conducted with key informants offered additional context in terms of understanding beach grass changes and shoreline management issues reported in the survey data, initiatives in place to address these issues, and what types of management and conservation initiatives are needed to better address these issues and improve the social well-being of shoreline community members.

Several key findings emerge from this research. First, human-caused drivers of change greatly impact regulating, supporting, and cultural beach grass ecosystem services which impact all dimensions of social well-being in both positive and negative manners. Second, human actions that support or hinder the conservation and protection of beach grass are primarily driven by the importance placed on regulating and cultural ecosystem services as well as their knowledge of them. Third, mitigative measures of convenience, education, targeting other values and social influence have been found to affect the knowledge and importance of beach grass ecosystem services, and thus impact social well-being. Shoreline community members, such as many of the survey respondents, play an important role in the conservation and management of beach grass along the Lake Huron shoreline, and therefore, are a driving force in the creation of their own well-being.

The results of this research will serve to enhance coastal action planning by demonstrating how including impacts of beach grass change on social well-being (e.g., material or subjective benefits) and the drivers behind the human-environment of the shoreline can facilitate the improvement of the safety and well-being of the Lake Huron shoreline communities.

Acknowledgements

This thesis would not have been possible without the ability to use and live on lands that had been stolen from the Haudenosaunee, Neutral, Anishinaabek peoples. I recognize this privilege and the atrocities that colonialism has brought to these people in the past and the injustices that have subjected them to current marginalization. I also recognize the land treaties with the Crown, wherein these peoples agreed to share part of their land with people from all around the world. Therefore, I would like to acknowledge the unique and enduring relationship that exists between the peoples and their traditional territories. The University of Waterloo is situated on the Haldimand Tract, which includes ten kilometers on either side of the Grand River. This is the traditional land of the Haudenosaunee, Neutral, and Anishinaabek peoples. I had the privilege of calling this land my home for the duration of my pursuit of my degree of Master in Environmental Studies, as well as using it to acquire the knowledge and skills needed to obtain this degree and thrive in my academic community. Much of the field research for this thesis took place on the Saukiing Anishnaabekiing, the traditional territory of the Saugeen Ojibway Nation. The Saukiing Anishnaabekiing encompasses much of the Bruce Peninsula, and extends down south of Goderich and east of Collingwood. Here, I had the privilege of being able to visit and learn about the Lake Huron shoreline and interact with its Indigenous and non-Indigenous inhabitants.

I would like to thank the Lake Huron Centre for Coastal Conservation for supporting my research, both creatively and financially by introducing me to the beauties and complexities of the Lake Huron shoreline and through the awarding of the Geoffrey Peach Scholarship. I also would like to thank all the cottage owner associations and organizations that aided me in the data collection for this research, as well as all the participants that graciously gave up their valuable time to contribute my research and the continuous improvement and protection of the Lake Huron shoreline and its precious natural resources.

Finally, this thesis would also not have been possible without the ongoing and unconditional support of my closest friends, Ruth, Julie, Sarah-Louise and Harleen, and my parents. To my supervisor, Derek Armitage, thank you for your ongoing support throughout my journey here at the University of Waterloo. You have taught me so much and have always come through when I needed guidance. Thank you to Mark Andrachuk and Simon Courtenay for contributing your expertise to this thesis and giving up much of your valuable time to help me in pursuit of my Master in Environmental Studies degree.

Dedication

I would like to dedicate this thesis to all those who are blessed (or cursed) with a compassion for nature and a passion to save it from the grips of unsustainable human societies. I also dedicate this thesis to beautiful Lake Huron and the environmental stewards that work tirelessly to protect it, its resources and biodiversity. Working on this project has allowed me to see the beauty and greatness of Lake Huron and has motivated me more than ever to ensure that it is protected.

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List of acronyms

ABCA	Ausable-Bayfield Conservation Authority
BSRA	Bluewater Shoreline Residents' Association
CA	Conservation Authority
CAP	Coastal Action Plan of the Southeastern Shoreline of Lake Huron
CBM	Community-Based Management
CICA	Centre-Ipperwash Community Association
ES	Ecosystem Service
GLB	Great Lakes Basin
GSCA	Grey Sauble Conservation Authority
ICM	Integrated Coastal Management
IPCC	The United Nations Intergovernmental Panel on Climate Change
LHCCC	Lake Huron Centre for Coastal Conservation
MA	Millennium Ecosystem Assessment
MMAH	Ministry of Municipal Affairs and Housing
MVCA	Maitland Valley Conservation Authority
MWB	Material Well-Being
NGO	Non-governmental organization
NVCA	Nottawasaga Valley Conservation Authority
ONMR	Ontario Ministry of Natural Resources
PACA	Port Albert Citizens' Association
PCBA	Point Clark Beach Association
PFBHA	Port Franks Beach Homeowners' Association
PPS	Provincial Policy Statement
RWB	Relational Well-Being
SCOI	Saugeen Cottagers' Organization Incorporated
SCRCA	St. Clair Region Conservation Authority
SVCA	Saugeen Valley Conservation Authority
SWB	Subjective Well-Being
TSS	Town of Saugeen Shores
USA	United States of America
WEBs	Well-Being Ecosystem Service Bundles

WeD	Economic and Social Research Council's Well-being in Developing Countries research group

Chapter 1 – Introduction

Beach-dune systems are important for the stability of the Lake Huron shoreline by providing social, environmental, and economic benefits, however they are extremely vulnerable to natural and anthropogenic impacts (Peach, 2016). If they are lost or removed, then the resilience of the whole coastal ecosystem is compromised, the shoreline can become unstable which drastically affects shoreline community members and beach users, other ecosystems, and infrastructures (Beatley, 2009; Peach, 2006). Humans are fully dependent on the quality of the environment, thus, maintaining beach-dune ecosystems, is beneficial for social well-being because it is beneficial for the ecosystem as a whole (Leopold, 1942). Climate change will potentially continue to alter these crucial ecosystems for the foreseeable future, but their capacity to respond favourably will depend on their degree of natural function retention. In most cases, this means that minimally altered/disturbed beach-dune ecosystems will have the resiliency to cope with the challenges that climate change brings, and the degree of resiliency declines as disturbance increases (Peach, 2016).

The protection of beach-dune ecosystems along the Lake Huron shoreline is therefore becoming increasingly important. In order to do this, human actions and behaviours toward beach grass (*Ammophila breviligulata*), the primary fabric of the crucial beach-dune ecosystems of the shoreline, need to be conducive to its growth and maintenance; this is referred to as environmental stewardship. Understanding the complex drivers behind human behaviour toward beach grass is central for the implementation of effective conservation measures of beach grass in the face of climate change. To do this, I propose using a framework that serves to connect the various benefits provided by beach grass to social well-being in order to understand how human impacts on beach grass can impact social well-being.

Ecosystem services (ESs) are the benefits that humans receive from the environment. ESs act as a tool for the economic valuation of the environment, and as a more general way to understand how people think about the environment (Steinman et al., 2017; Turner & Daily, 2008). Social well-being, in terms of environmental resources, is defined as the ability of an individual's resource pool, materially, relationally or subjectively, to overcome the obstacles and challenges that they face (Britton & Coulthard, 2013; Dodge, Daly, Huyton, & Sanders, 2012). Linking the ES discourse with social well-being, for the management of the Lake Huron shoreline will not only capture the dependence of social well-being on ecosystem health, but will also shed light on the dynamic and complex nature of human-environment interactions and drivers of human behaviour and actions toward beach grass (Tengberg et al., 2012; Turner & Daily, 2008). Understanding these interactions is crucial for coastal resource management because it demonstrates how potential decisions can affect social well-being by altering or restoring ecosystems (Daily et al., 2009).

The Coastal Action Plan for the Southeastern Shoreline of Lake Huron (CAP) is a regionally-focused management plan being developed by the Lake Huron Centre for Coastal Conservation (LHCCC) to enhance the use and protection of the shoreline from Sarnia to Tobermory. This plan aims to develop environmental management strategies tailored to the valuable natural features and species of the area, and the threats and stressors that impact the Lake Huron shoreline (LHCCC, 2016). The CAP also aims to involve the resource users directly in ecosystem conservation by guiding them toward best-management initiatives that are relevant to them (LHCCC, 2016). This will ideally lead to a user-focused coastal action plan that will directly benefit the well-being of the resource users simply because they are the ones facilitating the improvement in quality of the coastal ecosystem services on which they rely (LHCCC, 2016).

1.1 Research goals and objectives

The shoreline of Lake Huron faces many direct and indirect anthropogenic impacts. Some impacts are related to the loss of beach grass. The goal of my research is to enhance opportunities for integrated coastal planning along the southeastern shoreline of Lake Huron by assessing the underlying drivers of change with regard to beach grass, and understanding how coastal resource users (e.g., property owners) perceive the value of the ecosystem services beach grasses provide. My specific research objectives are as follows:

1. Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors.
2. Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.
3. Identify beach grass ecosystem services of value by property owners and visitors along the shoreline
4. Establish how beach grass changes are linked to social well-being from the perspective of property owners and shoreline visitors.
5. Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.

By identifying the key benefits of beach grass (beach grass ESs) that property owners and shoreline visitors value, they can be appropriately 'valued' (in monetary and non-monetary terms) and prioritized by decision-makers (Bolund & Hunhammar, 1999). Understanding the ecological and social causes of beach grass change can allow for better resource management. Evaluating the impacts of beach grass change on social well-being (e.g., material or subjective benefits) will shed light on the dynamic and complex nature of the human-environment interactions that are impacting the Lake Huron shoreline (Tengberg et al., 2012). With that, current coastal planning efforts can be enhanced such that they facilitate the improvement of the safety and well-being of the Lake Huron shoreline communities.

1.2 Geographic context

My research examines the Lake Huron shoreline that extends from Sarnia, at the southern tip of Lake Huron, to Tobermory, at the top of the Bruce peninsula. This will be henceforth referred to as the southeastern shoreline of Lake Huron (**Figure 1.4**). However, the main focus of my work within this shoreline are those with sandy beaches and beach grass (see **Figure 1.4**).

1.2.1 Great Lakes

Lake Superior, Lake Huron, Lake Michigan, Lake St. Clair, Lake Eerie and Lake Ontario comprise the water system referred to as the Great Lakes. The Great Lakes were formed at the end of the last glaciation, about 10 000 years ago (Egan, 2017). They are massive glacial lakes, formed by immense glaciers that eroded and carved the land as they travelled over it. This created large depressions in the ground. The rapid melting of the glaciers combatted the force of isostatic uplift, filling the depression with a huge supply of freshwater (Egan, 2017; Pollard, 2014). They are not mere lakes but are true marvels of the world, with gleaming, bright blue water, stretching farther than the eyes can see. No one standing at the shore of any of the lakes would consider that this expanse of interconnected water systems, spread out over 250,000 square kilometres, is merely a lake (Egan, 2017). More than anything, the Great Lakes, are a large, slow flowing river, extending from the headwaters of Lake Superior, 200 metres above sea level, down Niagara Falls, into Lake Ontario and finally exiting at Gulf of the St-Lawrence River and into the ocean. This steady flow can be compared to a series of gigantic water-filled buckets, with each one flowing into the one beneath it (Egan, 2017). The Great Lakes contain a significantly large portion of the world's freshwater, a coveted resource. Of all the water on the planet, only 3% is freshwater, most of which is locked up in ice caps or deep underground and not readily available for human use. Only 20% of freshwater on Earth is surface water, and one fifth of it can be found in the Great Lakes (Egan, 2017).

Figure 1.1 *Taken in Grand Bend, Ontario, and does not even begin to capture the true expanse of the waters of Lake Huron. Photograph: Charlotte Hings.*

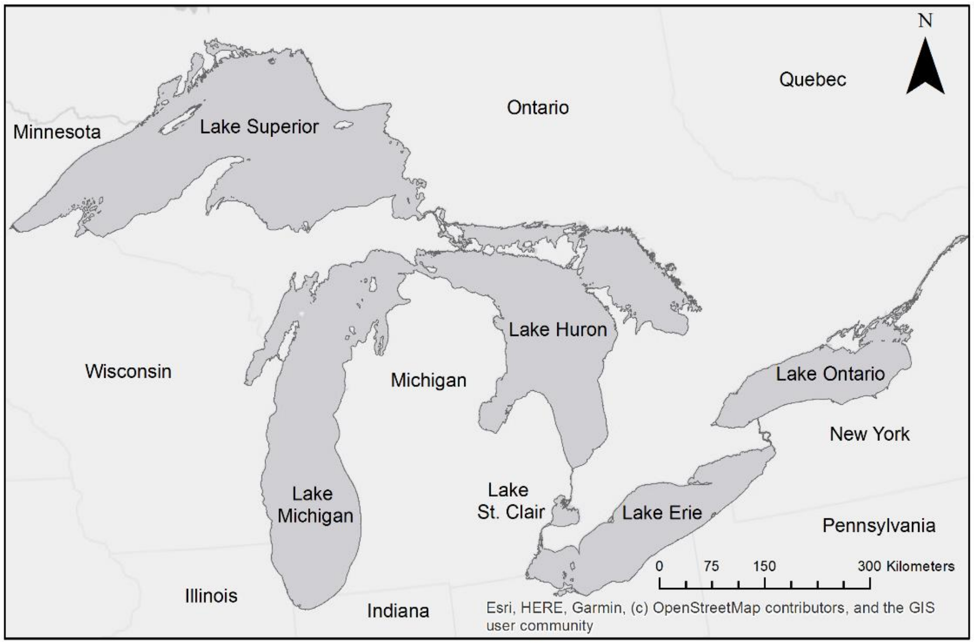

Figure 1.2 *Map of the Great Lakes (Detroit District U.S. Army Corps of Engineers and Water Issues Division of Environment Canada, 2009).*

Each lake shares territory with the United States (USA), except for Lake Michigan, which is entirely located in the state of Michigan (USA). This creates complications when trying to navigate governance challenges concerning multiple lakes, as both countries need to constantly communicate their plans and intensions and collaborate when taking action to avoid contradictions and redundancies (Caldwell, 1988).

1.2.2 Lake Huron

Lake Huron is located in the middle of the Great Lakes water system and receives water flowing in from Lake Superior and Lake Michigan (Egan, 2017). The eastern most area of the lake is referred to as Georgian Bay, and it is shaped like a small pocket within the lake. Lake Huron has a depth of approximately 230 metres at its deepest point (Egan, 2017; Environment Canada, Environmental Protection Agency, & Great Lakes National Program, 1995), and holds 3,550 cubic kilometres of water on average (D. Wilcox, Thompson, Booth, & Nicholas, 2007). Lake Huron is home to 115 species of fish, including at least 16 non-native species that have made Lake Huron their home. These species, as well as impacts of other invasive species, such as the Sea Lamprey (*Petromyzon marinus*), have caused shifts in the Lake Huron food web over several decades, leading to seven species of native fish being extirpated from Lake Huron (Nawrocki, 2015).

In addition to its rich aquatic biodiversity, the entire shoreline of Lake Huron is extremely diverse in its topography, allowing for many different ecological niches to host a wide range of aquatic, land, and avian species. **Figure 1.3** depicts the various topographic categories of the Lake Huron shoreline.

Lake Huron fisheries represented an important economic sector for both Canada and the USA throughout much of the 20th century (Clark et al., 2016; Environment Canada et al., 1995). Chinook Salmon and Lake Whitefish represented large portions of the Lake Huron fisheries' economies, however, the importance of the fishing industry has declined significantly since the beginning of the 21st century due to low fish stocks, invasive species (alewives, sea lamprey) and decreased fishing effort (Clark et al., 2016; Egan, 2017; Johnson, He, & Fielder, 2015).

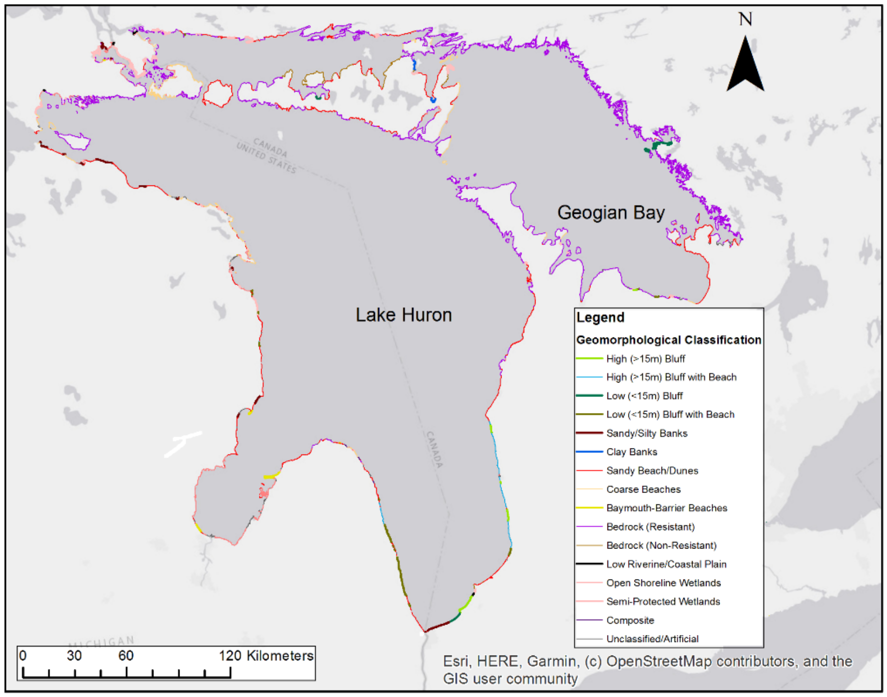

Figure 1.3 *Lake Huron shoreline topography (Detroit District U.S. Army Corps of Engineers and Water Issues Division of Environment Canada, 2009; Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2013).*

1.2.3 Southeastern shoreline

The southeastern shoreline of Lake Huron represents the stretch of shoreline area that is the focus for my research on the ESs and social well-being dimensions of beach grass. This stretch of shoreline itself is also diverse in topography, allowing for rich aquatic, terrestrial and floral biodiversity, as well as a large variety of recreational, touristic and economic activities. **Figure 1.4** depicts these various topographies, their locations, and their coverage percentages. For this thesis, the southeastern shoreline was chosen as the general area for field research, and participant scoping, however, given the diverse topography of this area, and that the central focus of this thesis related to beach-dune ecosystems, only portions of the shoreline containing these topographical features were of use to this research. Therefore, the field sites where data was gathered for this thesis are depicted in Chapter 3 (**Figure 3.1**).

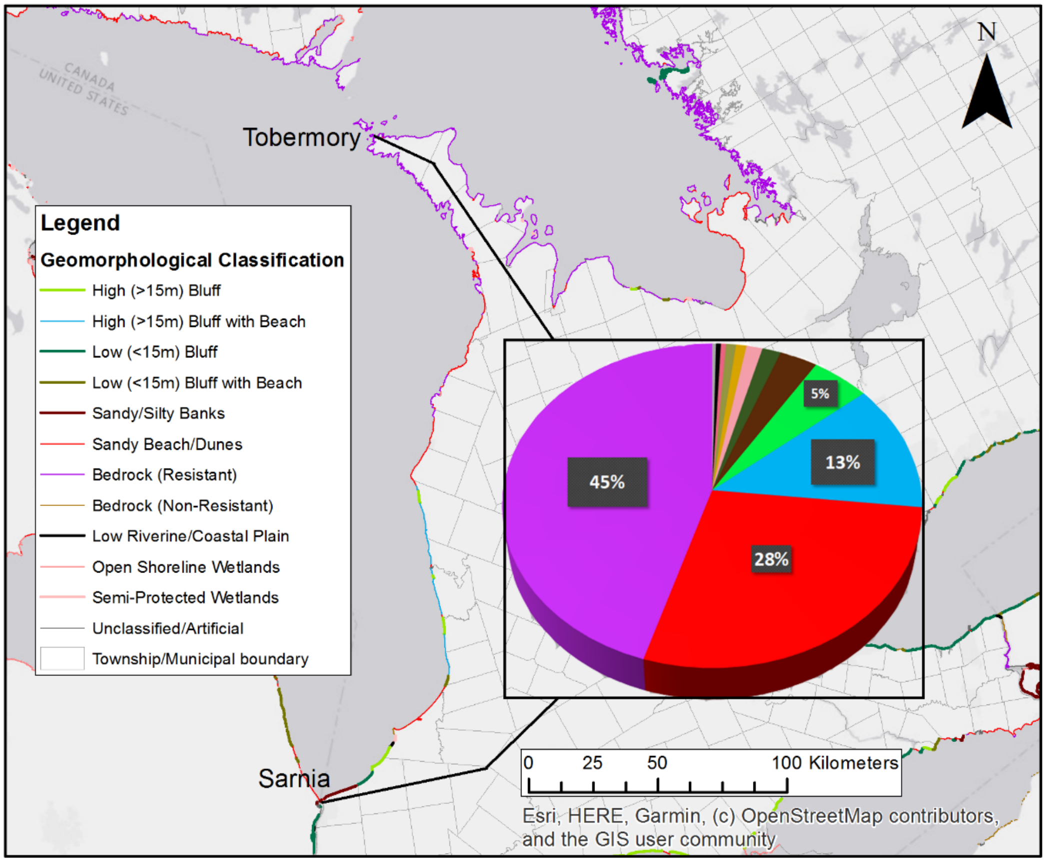

Figure 1.4 *The southeastern shoreline of Lake Huron, stretching from Sarnia to Tobermory (Detroit District U.S. Army Corps of Engineers and Water Issues Division of Environment Canada, 2009).*

1.2.4 Beach grass and the changing Lake Huron shoreline

The Great Lakes' dune systems are of national significance. Beach-dune shorelines are the most diverse ecosystem in the Great Lakes Basin (GLB) and are also the most vulnerable to human pressures (LHCCC, n.d.-a). Only 2% of the Lake Huron shoreline contains these fragile beach-dune ecosystems, despite their immense importance to the stability of the shoreline (Cann, 2018). This is primarily due to the large amount of development and recreational activities that have occurred along the shoreline that are eroding, damaging and destroying these dunes and their important vegetative cover (Cann, 2018; Peach, 2006). The dunes along the Lake Huron shoreline formed over 6000 years ago as a result of glacial subsidence (Peach, 2006). Most of them are relict sand deposits and have no active input sources, but are quickly eroding due to anthropogenic impacts (Kuchma, 2014). Municipal and provincial policies recognize erosion as a natural process, and use this as reasoning for zoning laws (ABCA, 2019b; GSCA, 2013; Ministry of Municipal Affairs and Housing, 2014; MVCA, 2016; SCRCA, 2013; SVCA, 2018), however the erosion rates these dunes are facing are larger than they should naturally be and can be lowered by mitigating human impacts and preserving the natural vegetation of the dunes (Kuchma, 2014; Peach, 2016).

Beach grass (*Ammophila breviligulata*) is a grass native the Lake Huron sand dunes and is extremely important for maintaining the resilience of these beach-dune ecosystems as well as the whole coastal ecosystem of Lake Huron (LHCCC, n.d.-a). Its growth and persistence along the shoreline help maintain sand dunes because its roots hold the sand below them in place year-round (Baldwin & Maun, 1983). Sand dunes are extremely important components of the Great Lakes coastal ecosystem because they act as buffers against wave and water damage from storms and they protect the land from flooding (Mathew, Davidson-Arnott, & Ollerhead, 2010; McLaughlin & Cooper, 2010; Sallenger, 2000). They allow the creation of more complex plant communities nearby because they protect and shield those areas from strong winds and floods (Chadwick & Dalke, 1965; Emery & Rudgers, 2010). Since the dunes are built and supported by plants, particularly beach grass, the resilience of the dunes depends highly on the presence of this grass. If the grass is lost or removed, then the shoreline can become unstable, and this affects the people, other ecosystems and infrastructures (Clarke, 1994; Davenport & Davenport, 2006; Donnelly, 2018; Doody, 2013; Featherstone, Anderson, & Moran, 2005).

Nearly all communities of the GLB are already experiencing local impacts of global climate change, and are expected to need to adapt to future climatic changes. Among many other changes, warming air and water temperatures have been recorded throughout the GLB, which have led to changes in winter ice cover, water flow timing, flooding and storm frequency and intensity, and lake water level fluctuations (Donnelly, 2018; Peach, 2016). The longer free-ice conditions in winter can potentially lead to higher wave energy, and thus, higher erosion levels along the shoreline. Additionally, increased flooding and storm frequency and intensity are also expected to increase wave energy and erosion. Specifically, the shoreline of Huron County is expected to experience diminished sand reserves because of these changes (Davidson-Arnott, 2016). Lake level fluctuations play an important role in human activities, coastal processes and nearshore ecosystems, which will therefore impact the development and maintenance of beaches, dunes, and wetlands (D. Wilcox et al., 2007).

The protection and maintenance of sand dunes fundamentally affects the quality of the beaches along the shoreline. On a larger scale, the capacity of beach-dune ecosystems to respond favourably to climate change conditions will depend on the retention of their natural functions, in other words, their level of disturbance and the establishment of beach grass populations (Peach, 2016). Beaches and dunes that have little to no human-related disturbances are inherently more resilient to the impacts of climate change, making their preservation even more important to the safety and well-being of the Great Lakes coastal communities (Peach, 2016). In order to better understand how to maintain these fragile systems, this research project will examine the relationship between ESs related to beach grass and social well-being in order to understand the fundamental human-environment interactions that are shaping the Lake Huron shoreline and provide recommendations for a community-based management approach that will support socio-ecological and cultural sustainability of the coastal ecosystem.

1.3 Research design

My research employed a case study-based approach of the southeastern shoreline of Lake Huron, along with several methods of data collection and analysis. The case study that is the focus of my research is the defined southeastern shoreline of Lake Huron. In the context of my case study-based research, I employed both quantitative and qualitative methods to create an explanatory sequential research design. Inductive and deductive approaches to qualitative data analysis (e.g., coding themes in interviews) were also used. An inductive approach served to complement the deductive approach by accommodating the new information that arose throughout the research process, as well as to build a framework in which uncertainties could be analyzed. Three methods of data collection and analysis were used in my research, including a review of literature, structured surveys, and semi-structured interviews. Further details on my research methodology and methods are provided in Chapter 4.

1.4 Thesis structure

This thesis offers an empirical assessment of the how humans along the southeastern shoreline of Lake Huron interact with their local environment, and how these interactions impact their social well-being. Chapter 1 has introduced the problem context for this thesis, presented the objectives of this research , and briefly summarized the local context upon which this thesis is based. In Chapter 2, I review the literature and offer a conceptual framework to guide my research, focusing in particular on key concepts such as ecosystem services, social wellbeing and coastal planning. In Chapter 3, I present a more detailed account of the case-study context, outline the specific governance challenges facing the southeastern shoreline of Lake Huron, and highlight opportunities for improvement in relation to the objectives of this thesis. In Chapter 4, I outline the methodical approach and data collection and analysis methods used to conduct this research. Chapters 5, 6 and 7 serve as the context to present the main results of my research, specifically in relation to the first four objectives of my research. In Chapter 8, I summarize the key insights of my research and discuss the implications for coastal planning along the southeastern shoreline of Lake Huron, objective 5 of my research. In Chapter 9, I offer a brief conclusion of my research to summarize my key findings and opportunities for practical solutions on the ground.

Chapter 2 – Review of the Literature

In this chapter, I synthesize the relevant histories, definitions and applications of the central concepts of this research, and with reference to my research objectives: 1) integrated coastal planning and management (Section 2.1); 2) ecosystem services (Section 2.2); and 3) social well-being (Section 2.3). I also review the literature to determine the specific ESs that beach grass provides, serving as a foundation for the relevant survey questions (Section 2.4) Finally, I conclude by discussing how these concepts can be linked for the management of the unique challenges facing the Lake Huron shoreline through the introduction of my conceptual framework for this research (Section 2.5).

2.1 Integrated coastal planning for the Lake Huron shoreline

Integrated coastal planning and management (ICM) is a unified approach to address human activity to protect natural coastal resources, while also protecting humans from coastal hazards and achieving cooperatively-formed objectives (Beatley, Brower, & Schwab, 2002; Ehler, 2003). This involves the collaboration of all levels of government, from federal, to local, and even down to the individual resource users and community members to protect, enhance, and conserve the coastal zone for the current and future generations. The need for ICM is based on the vast effects of human pressures on coastal resources, public policy enhancing these effects, and lack of cultural sustainability and sustainable development within the coastal zone (Beatley et al., 2002). In order to understand how Lake Huron can move toward a more integrated management approach, the spatial zone in which to apply integrated management must be defined (Section 2.1.1), the challenges and opportunities of integrated management must be outlined (Section 2.1.2), the anthropogenic and environmental pressures impacting this zone must be understood (Section 2.1.3), and finally, the pathway for sustainable coastal development must be paved by all stakeholders in the coastal zone (Section 2.1.4).

2.1.1 Defining the coastal zone

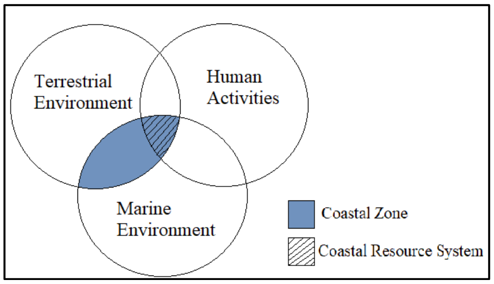

Figure 2.1 *Defining the coastal zone and the coastal resource system, which is where ICM takes place, adapted from Thia-Eng (1993).*

Defining the coastal zone is important in because this boundary determines the limits within which certain rules and requirements apply. Due to the diversity and dynamism of coastal areas, any attempt to define an inland limit for the coastal zone is likely to be inadequate from an ecological perspective. In general, the coastal zone refers to where the land, the sea and their respective ecosystems meet, overlap and interact, as depicted in **Figure 2.1** (Cullinan, Food Agriculture Organization of the United Nations, & Service Development Law, 2006; Thia-Eng, 1993). The coastal zone is a dynamic interface, where land, water and atmosphere interact to create an area that is extremely vulnerable to human and other external influences, and must be governed as such (Beatley et al., 2002). The USA's Coastal Zone Management Act defines the inland boundary of the coastal zone only to the extent necessary to control the area of shorelands whose use has direct effects on adjacent coastal waters (Cullinan et al., 2006). The dynamic and unique environmental qualities of the coastal zone mean that it is home to a great number and variety of living organisms, most of which tend to be adapted to live exclusively in the coastal zone (Cullinan et al., 2006). The interfaces of large freshwater bodies and terrestrial environments exhibit similar properties to the marine coastal zone. The shorelines of the Great Lakes are thus often considered to be the "fourth seacoast" of Canada (and the USA) (Beatley et al., 2002; Egan, 2017).

When considering how to manage such an area, it must be taken into consideration that coastal zones face the impacts of human actions that occur inland, indicating that the coastal zone should actually encompass the entire watershed that drains into the coastal waters (Beatley et al., 2002). In the case of the Lake Huron southeastern shoreline, this would thus encapsulate the five watersheds that are each governed by a unique Conservation Authority (CA) (see **Figure 2.2**). Therefore, the coastal zone for the Lake Huron southeastern shoreline would thus be most easily delineated by the administrative boundaries of the St. Clair Region Conservation Authority (SCRCA), Ausable-Bayfield Conservation Authority (ABCA), Maitland Valley Conservation Authority (MVCA), Saugeen Valley Conservation Authority (SVCA), Grey Sauble Conservation Authority (GSCA), and the north boundary of the GSCA to Tobermory (see **Figure 2.2**).

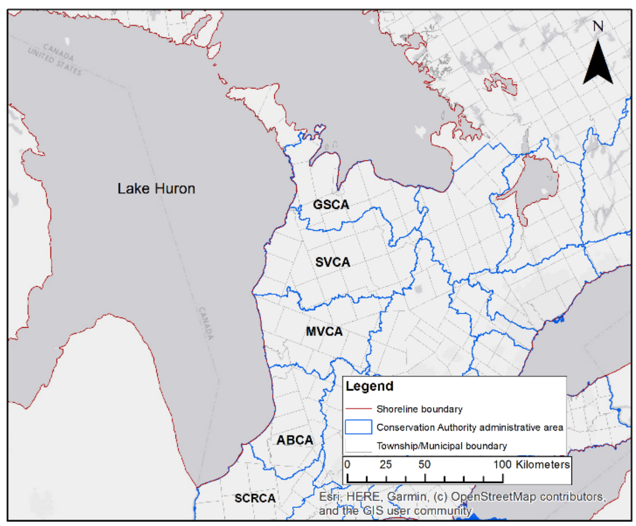

Figure 2.2 *Conservation Authority administrative areas (Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2013, 2019a, 2019b).*

2.1.2 Challenges and opportunities of ICM

The conflicting interests and competing demands of the various levels of authority within the coastal zone can make sectoral management of the Lake Huron coastal zone challenging (Section 2.1.2.1). Having an integrated approach to the management of the shoreline can serve to align these interests and demands (Section 2.1.2.2), while also taking into consideration those of external actors (e.g., resource users), as well as resources and drivers (e.g., human-environment interactions) (Section 2.1.2.3).

2.1.2.1 Inter-institutional coordination

ICM is a political process involving a number of key actors, interest groups and government agencies. These different stakeholders bring different perspectives on coastal management to the table, meaning that decisions are often the result of the interplay of these perspectives. The stakeholders include all people who have some relationship with the shoreline (Beatley et al., 2002). In the case of the Lake Huron shoreline, it would include major interest groups that seek to influence or are influenced by the allocation of coastal resources, such as provincial governmental organizations (Ontario Ministry of Natural Resources (OMNR) and CAs), non-governmental organizations (LHCCC and all cottager associations), local governmental organizations (counties and municipalities), people who, spend time at the coast for recreational or business purposes, and eat fish and seafood from coastal fisheries (resource users), and most importantly, shoreline biodiversity and future generations (the values of which must be accounted for by influential stakeholders) (Beatley et al., 2002; Lawrence, 1997).

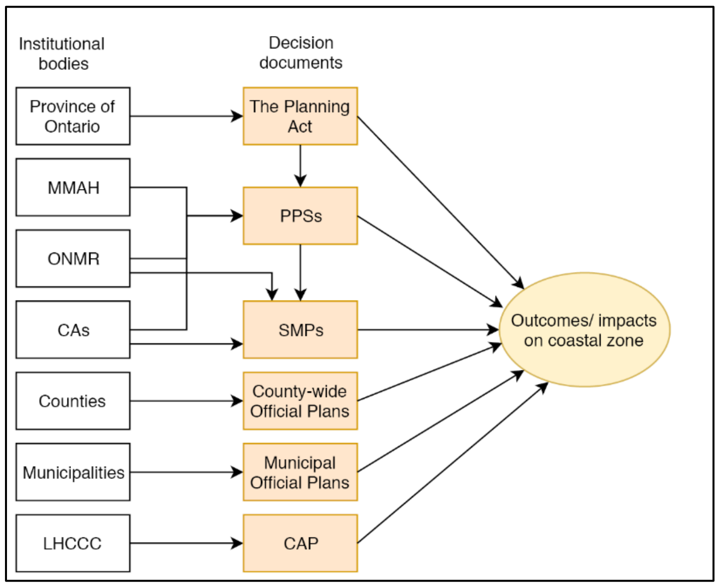

Figure 2.3 *Sectoral management of the Lake Huron shoreline (Lawrence, 1997; LHCCC, 2016; Ministry of Municipal Affairs and Housing, 2019)*

Currently, sectoral management of the coastal zone is causing discontinuities in management as different stakeholders can lack coordination in their management processes. Each stakeholder produces their own documentation in reference to the governing and land use of the shoreline. The provincial government of Ontario is in charge of creating and updating the Planning Act, which is "provincial legislation that sets out the ground rules for land use planning in Ontario. It describes how land uses may be controlled, and who may control them (Ministry of Municipal Affairs and Housing, 2019)". Under the Planning Act, the Ministry of Municipal Affairs and Housing (MMAH) update their Provincial Policy Statements (PPS) when necessary. This is a document that applies province-wide with the goal of recognizing and addressing "the complex inter-relationships among environmental, economic and social factors in land use planning (Ministry of Municipal Affairs and Housing, 2014)". In the context of the Great Lakes shorelines, this document governs where new structures and developments can be built relative to flooding hazards, dynamic beach hazards and acts as the general land use planning guide for the shoreline area (Ministry of Municipal Affairs and Housing, 2014). The province of Ontario is divided into various governing districts by the ONMR as depicted in **Figure 2.4**. These districts, along with the CAs contained within them (**Figure 2.2**), are the designated implementing agencies for the Great Lakes Shoreline Management Plans (SMPs) (Lawrence, 1997). The goals of the SMPs are to "minimize risks to life, property damage and social disruption, and to encourage an integrated approach to shoreline management" and each CA has their own for their respective stretch of shoreline to which their SMP applies (ABCA, 2019b; GSCA, 2013; MVCA, 2016; SCRCA, 2011; SVCA, 2018). The Planning Act requires all counties and municipalities in Ontario to adopt an official plan, consistent with the current PPS. These official plans give direction for the physical, social and economic development within the county, while ensuring the long-term protection of the natural environment and the services it provides (County of Bruce, 2019; Huron County, 2015a). This sectoral management process is outlined in **Figure 2.3**.

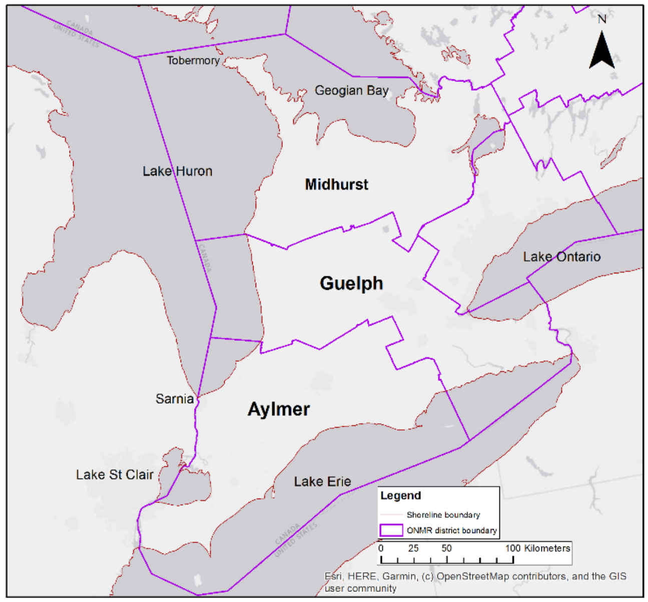

Figure 2.4 *OMNR districts in the southeast region that are along the Lake Huron southeastern shoreline (Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2008b, 2019b)*

All of these documents are produced in a somewhat coordinated manner under the Planning Act, but the coastal zone is a fragile environment faced with complex management and environmental issues that cannot be managed by one sector alone, nor can it be managed by separate sectors working independently, as the activity of one sector can impact that of another.

2.1.2.2 Toward integrated and cohesive decision-making

By improving the cooperation and coordination between government sectors, levels, and agencies, coastal management issues can be resolved more systematically and efficiently, thus, improving overall sustainability and environmental quality (Thia-Eng, 1993). Changing the composition of the management system in this way, also allows new ideas and perspectives to emerge, permitting new creative solutions that are unconstrained by sectoral

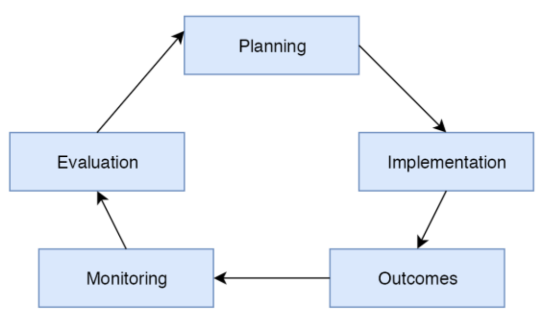

Figure 2.5 *The ICM policy-making cycle, adapted from Ehler (2003)*

management (Doppelt, n.d.). New goals, strategies, and implementation plans will be designed to tackle the issues from the source of the problem rather than dealing with their impacts. This aligns practices with sustainability (Doppelt, n.d.). Through the ICM policy cycle (**Figure 2.5**), each step is performed in an integrated and collaborative way, ensuring a cohesive decision-making process (Ehler, 2003).

2.1.2.3 Community-based management

Within the implementation of ICM, is community-based management (CBM) which entails the involvement of the people that live in and interact with the resource system, in the design, implementation, and monitoring phases of the policy-making cycle of ICM (Kearney, Berkes, Charles, Pinkerton, & Wiber, 2007). Here, community can be defined both geographically (e.g. Goderich residents), as well as socially (e.g. shoreline cottage owners). In order to promote sustainability and resilience, management of the resource system cannot follow a purely top-down approach, but must be composed of complex interactions among many actors from multiple sectors and scales (Patterson et al., 2015). The federal governments and organizations stemming from them cannot be the sole managerial bodies of a system. Civil society and scientific experts must also be included as significant components of the equation (Nakicenovic & Schulz, 2011). CBM emphasizes the role of the civil society in the creation of their own well-being, meaning that although the environment is undergoing many changes, adaptation and mitigation are not the only options for dealing with these effects (Kearney et al., 2007; Nakicenovic & Schulz, 2011).

ICM and CBM represent adaptive forms of governance as their planning capacities leave space for changes in external factors, allowing for adaptation to unpredicted change (e.g., climate change) (Ehler, 2003). Thus, when managing a particular complex socio-ecological system where knowledge of it is incomplete, adaptive governance is necessary (Dietz, Ostrom, & Stern, 2003). Adaptive governance requires local self-organization of resource users and collaboration with government agencies, and non-governmental organizations (NGOs) in order to adapt to changes within a socio-ecological system such that a desired regime is maintained (Brunner, Steelman, & Coe-Juell, 2005; Folke, Hahn, Olsson, & Norberg, 2005; Gunderson, 1999).

In many contexts, and especially in the context of Lake Huron, shoreline management has more to do with the management of the people than with the management of the hazards (Donnelly, 2018). To manage these people, CBM is crucial. Decisions need to be made as a collective and there must be measures in place that educate property owners about the fragility of the ecosystems that make up their waterfront properties (Donnelly, 2018).Therefore, CBM is important because the resources that local communities rely on for their well-being, are managed through the policies created by several different governmental sectors; and when utilizing these resources, all of these sectors have to be dealt with (Kearney et al., 2007). By involving civil society in the policy-making cycle, well-being, overall cohesiveness of the policy-making cycle, and the long-term health of the relevant human systems within coastal communities can all be simultaneously improved (Kearney et al., 2007). With this improvement comes the improvement of water quality, coastal zone resilience and sustainability, thus making CBM a fitting approach to move toward cultural sustainability and resilience within the coastal ecosystems of Lake Huron (Kearney et al., 2007). When participatory governance is rooted at the community level, at the level of fundamental human reality, then it is likely to be more effective and robust (Kearney et al., 2007).

The existing provincial and municipal policies in place regarding development along the shoreline are only directed at future developments (Huron County, 2015b; Ministry of Municipal Affairs and Housing, 2014). While this is also important, once the properties are built, there is limited guidance for property owners and visitors on how to manage their property such that coastal system resilience and shoreline integrity is maintained. Significant problems exist because of current development and recreational uses along the shoreline, namely, erosion of fragile beach-dune systems, which are a key coastal feature (to be discussed in the following chapter). This has sparked the need for Best Management Practices, which are methods outlined to property owners and visitors of the shoreline that ensure the protection of the shoreline, prevent undesirable anthropogenic effects and promote appropriate shoreline development and management (Kuchma, 2014). The lack of knowledge and education about coastal processes among property owners, beach visitors and community members is likely a key factor in the loss of these beach-dune ecosystems. The effectiveness of integrating more education and interactive measures pertaining to the socio-ecological benefits derived from the presence of beach grass along the shoreline into a CBM structure will be explored in this research project.

2.1.3 Key drivers of change

The underlying causes of coastal degradation are important to identify and understand so that the ICM policy framework can work to respond to these pressures (Cullinan et al., 2006). The interface of the terrestrial and aquatic environments is inherently resilient. It is a dynamic environment by definition and therefore, natural changes are expected. However, the presence of humans in large and dense populations within the coastal zone pushes the limits of the ability of the environment to withstand external damages to its integrity because people alter the natural dynamics of the system (Beatley et al., 2002).

Some important pressures on coastal ecosystems in general that also apply to the Lake Huron shoreline are (Beatley et al., 2002; Cullinan et al., 2006; Egan, 2017): 1) nutrient pollution, 2) physical alteration of the shoreline, 3) global climate change, and 4) invasive species. These specific pressures impacting the Lake Huron Shoreline environment will be discussed in detail in the following chapter.

2.1.4 Pathways to coastal sustainability

Despite the presence of human beings, a central cause of environmental problems in the coastal zone, eliminating human presence is not a realistic solution. The future of both the natural world and of humanity are so intertwined, therefore, it is crucial to pivot the central focus of coastal management programs to imbue a perspective of sustainability (Beatley et al., 2002; Brown & Garver, 2009). Sustainable costal communities are founded on the following interrelated concepts 1) the perception of stakeholders in the coastal zone must embody the philosophy of humankind as part of the system, not its master, 2) promote well-being of all those in the coastal zone, 3) enhance the valued ecosystem services of those in the coastal zone.

Sustainability concerns not only environmental and ecological systems, although these are the central focus, but also concerns social and economic systems (Beatley et al., 2002). The role of humans in influencing sustainability within the coastal zone cannot be overlooked. Interactions between humans and the environment in the coastal zone are driven by the perception of the resources within the coastal zone, as well as the environment as a whole (Beatley et al., 2002). An erroneous perception of the environment does not promote sustainability, as it does not reflect the correct functioning of the system. Schumacher (1974) explains the outcomes of this erroneous perception:

> *"Modern man does not experience himself as part of nature but as an outside force destined to dominate and conquer it. He even talks of a battle of nature, forgetting that if he won the battle, he would find himself on the losing side."*
>
> *–Ernst Friedrich Schumacher (1974)*

Schumacher (1974) also describes how this perception estranges humans from reality, and inclines them to treat anything that is not man-made as valueless, when in fact, the capital created by nature is far more valuable. This flawed perception influences environmentally destructive behaviour which is unsustainable because it threatens the quality of the resource base that has given life in the first place (Schumacher, 1974).

Perception is generally defined as "a process intervening between stimuli and responses (Garner, Hake, & Eriksen, 1956)". Within this context, someone's perception is formed through various converging operations, which are defined as "any set of experimental operations which eliminate alternative hypotheses and which can lead to a concept [(perception)] which is not uniquely identified with any of the original operations, but is defined by the results of all operations performed (Garner et al., 1956)". In other words, perception is formed through the interactions of an individual's life experiences and their personal relationships, which define what values/objects/resources are most important to them, and the knowledge they have gained throughout their life (**Figure 2.6**). Perception of any particular item is constantly changing as a person collects new life experiences, meets new people, gains more knowledge and develops new opinions.

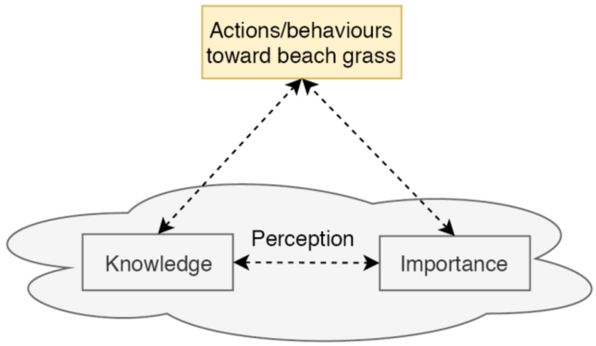

Figure 2.6 *The interacting forces of an individual's knowledge about a particular topic (beach grass used as the example), the importance of it to them, and what actions they choose to take toward that.*

When considering this definition of perception and the influences various dimensions of it have on human behaviour, the adoption of sustainable behaviours and actions becomes central to breaking the environmentally destructive cycle within the coastal zone (Beatley et al., 2002). This is because sustainable coastal communities adopt a perception of the environment that stays true to the functioning of the system: "Man, whether civilized or savage is a child of nature, he is not the master of nature. He must conform his actions to certain natural laws (Carter & Dale, 1974)". To influence the formation of a stewardship perception such as this one, greater knowledge, appreciation of, and respect for nature are essential (Beatley et al., 2002).

Adopting a CBM approach to coastal zone management of the Lake Huron shoreline supports public education because community-based organizations businesses, local governments, and schools can involve and educate people about the coastal environment in ways that government, by itself, cannot. These institutions have the power to connect directly with the resource users and provide education programs tailored to them (Beatley et al., 2002). To be able to do this, there are other pieces of the puzzle that must also be incorporated: 1) the coastal ecosystem services valued by this same group must be identified and protected, and 2) the aspects of the specific coastal zone that promote the social well-being of its inhabitants must be identified and reinforced. A greater understanding of these among coastal planners and resource users will build toward a greater appreciation and respect for these resources, and thus coastal sustainability.

Sustainable coastal communities seek to minimize destructive impact on natural systems, create highly livable and enduring spaces, and meet the needs of all groups in the community. Long-term human well-being is highly dependent on the well-being of the shared features of the community and interdependence of its members (Brown & Garver, 2009). In other words, human well-being is dependent on the quality of the environment in which they live. Through the lens of ESs for achieving sustainability in coastal communities, the following must be achieved (Beatley et al., 2002):

- Avoid consumption and destruction of ecologically sensitive lands (e.g. coastal wetlands, species habitat and areas rich in biodiversity)
- Be aesthetically pleasing and visually stimulating
- Develop integrative and holistic strategies that accomplish multiple goals
- Focus on coastal restoration as well as preservation
- Implementing restorative rather than destructive land use practices

These all support and enhance environmental quality, and by doing so, also support and enhance different dimensions of well-being, as will be discussed in Section 2.2 (*Ecosystem services*).

Finally, to promote sustainability, all human activity must be directed toward a positive long-term environmental impact, not just short-term gain, but must not ignore the needs of living people (Beatley et al., 2002). Through the lens of enhancing well-being for achieving sustainability in coastal communities, the following must be achieved (Beatley et al., 2002):

- Reduce the exposure of people and property to coastal hazards by keeping them out of flood zones, dynamic beach hazard zones, and high-erosion zones.
- Promote a sense of place, understanding, and appreciation of the biophysical context.
- Have a high degree of livability and their spaces uplift the human spirit.
- Enhance spaces for social and public interaction that help shape a sense of shared identity.
- Value participation of all community members.
- Provide opportunities for community members to be actively involved in their governance.

These all support and enhance different dimensions of well-being, as will be discussed in Section 2.3 (*Social well-being*).

2.2 Ecosystem services

Understanding the fundamental relationships among humans and nature is crucial (Costanza, 2018). Throughout human history, many belief systems have emerged that place human above, apart from or fundamentally different from the rest of nature (Brown & Garver, 2009; Costanza, 2018; Schumacher, 1974). Humans are not apart from nature, but are embedded in the natural world and have now become a powerful driving force upon which the planet's future is dependent (Costanza, 2018; Crutzen, 2006; Schumacher, 1974). Due to aspects of biology, capacity for complex language and collective learning, and high social skills, humans have become the Earth's apex predator and developed complex technological innovations that alter the Earth's systems at a global scale (Crutzen, 2006; Harari, 2016).

Many human civilizations have lost sight of the value of anything unquantifiable and non-anthropocentric such that the inherent value of nature that John Muir fought so hard to communicate, is rarely, if ever, recognized by decision-makers (Kingsnorth, 2017; M. Smith, 1998). Instead, the prominent ideology in nature conservation is that of Gifford Pinchot: how humans can benefit from natural resources, which views nature as a means to "progress" technology and the environment. In this perspective, to use resources sustainably is important, not because of their inherent value, but because of their contribution to continuous economic growth and use by humans (M. Smith, 1998). Theoretical and descriptive analyses of the human-environment interdependence can therefore do little to shift the global economy's valuation of nature, however, the concept of ESs is able to add a quantitative and monetary lens to nature, translating the value of nature into a language that economists and decision-makers understand (Costanza, 2018).

Ecosystem services, defined generally as the benefits that humans or society as a whole receive from the environment (Steinman et al., 2017), analyze, model, quantify and value the degree to which humans are connected with and benefit from the Earth's ecosystems (Costanza, 2018). This concept thus serves as a tool for the economic valuation of the environment (Turner & Daily, 2008). Costanza et al. (2014) estimated the monetary value of all ecosystems services on the planet to be between $164 trillion and $190 trillion (CAD) in 2011 (Costanza et al., 2014).

Despite the high degree of emphasis on economic criteria, ESs are not strictly confined to the material benefits of the environment. ESs comprise all functions or processes of the ecosystems that can have both material or non-material value to people (K. M. A. Chan, Guerry, et al., 2012). More specifically, an ES describes the way that a specific or general aspect of the environment is able to contribute overall to well-being by aiding in the meeting of a human need or want either directly or indirectly (Daniel et al., 2012). There are four main types of ESs: provisioning, supporting, regulating and cultural. Provisioning ESs are generally described as the contributions of the environment to meeting essential humans needs (e.g., water, air, biomass) and material well-being (Daniel et al., 2012; Steinman et al., 2017). Supporting ESs are the indirect benefits that humans derive from the environment (e.g., the process of photosynthesis that creates biomass). Supporting ESs are foundational to provisioning ESs, as they carry the benefits that stem from the basic ecosystem functions that allow a resource to be available for human consumption and present in high quality (Daniel et al., 2012; Steinman et al., 2017). Regulating ESs are the indirect benefits that are "obtained from the regulation of ecosystem processes" (e.g., water quality, air quality) (Beaumont et al., 2007). Cultural ESs are unique from the others in that, they are direct, non-material benefits that humans derive from the existence of a resource, the availability of a resource to future generations, and the option to use or enjoy a resource in the future (e.g., recreation, education) (Daniel et al., 2012; Millennium Ecosystem Assessment, 2005; Steinman et al., 2017).

2.2.1 *Critiques of ecosystem services*

There are limits with the ES concept. The concept is criticized for being anthropocentric in nature, promoting an exploitative human–nature relationship, and conflicting with biodiversity conservation objectives (Schröter et al., 2014).

By definition, the ES concept is anthropocentric, focusing on how nature serves humans. What is truly being criticized here by some is the exclusion of the intrinsic value of nature within ES classification and description (McCauley, 2006; Redford & Adams, 2009; Sagoff, 2002). This critique is rooted in the long-standing, unresolved environmental ethics debate about the motive for human action toward nature (Schröter et al., 2014). Muir advocated for the preservation of the environment because of the inherent value found within it. Pinchot advocated for the conservation of the environment because of the instrumental (benefits to humans) value found within natural resources (M. Smith, 1998). While the instrumental value drawn from nature is clear when examining provisioning and regulating ESs, when examining supporting and cultural ESs, the overlap of inherent value and instrumental value comes to light. For example, the aesthetic value of an ecosystem product requires it to be examined for its own purpose and natural beauty ("in and of itself") as well as being valued by a human (Krebs, 1999). In this thesis, the aesthetic value (cultural ES) and biodiversity maintenance value (supporting ES) of beach grass will be explored later in sections 2.4.1.3 and 2.4.1.4, and further in the results (Chapter 6). For these beach grass ESs, the reasons why people may value biodiversity, for instance, could be for its intrinsic value (i.e. because it exists) or because of the instrumental value they gain from it (K. M. A. Chan, Satterfield, & Goldstein, 2012; Reyers, Polasky, Tallis, Mooney, & Larigauderie, 2012). In this regard, the social well-being framework that will be presented in Section 2.3, contributes an opportunity to examine non-instrumental benefits through the consideration of relational and subjective dimensions of social well-being.

The exploitative human-nature relationship that is said to result from the implementation of the ES concept, is caused by the ties of ESs to economics, giving it a transactional nature leading to consumers focusing on the monetary values and being alienated from nature (Robertson, 2012). While the economics portion of ESs can do this, the inclusion of reciprocal feedbacks between humans and their environment (e.g. removal of beach grass causing high erosion and loss of beach area) serves to cause people to reflect on their dependence on Earth's ecosystems, offering a way to conceptualize humanity's relationship with nature beyond monetary gains (Borgström Hansson & Wackernagel, 1999; Folke et al., 2011; Raymond et al., 2013). Narrowing in on this aspect of the ES concept in this thesis, aims to bridge the gap between the modern, alienated consumer and nature (Schröter et al., 2014).

The ES concept is said to conflict with biological conservation objectives because it is thought that planning and executing conservation strategies based on ES provision might not be concerned with protection of biodiversity, and will thus divert attention and interest. This critique came about due to the questioning of the strength of the relationship between biodiversity and ESs (Schröter et al., 2014). The Millennium Ecosystem Assessment (MA) has acknowledged the overlap of biodiversity and ESs by including aspects of biodiversity within supporting, and cultural ES categories. In this way, the MA has become very successful in communicating with decision-makers for biodiversity and ES conservation initiatives, suggesting that they can be complementary (Millennium Ecosystem Assessment, 2005; Schröter et al., 2014). Additionally, Cardinale et al. (2012) outlines sufficient evidence of the direct influence of biodiversity on the quality and providing of certain provisioning and regulating ESs (Cardinale et al., 2012). This connection plays an important role in this thesis, as an important regulating ES, beach grass helps prevent erosion and build sand dunes that allow for the colonization of other grass species that provide further stability of the shoreline dunes. Therefore, this connection emphasizes that not only beach grass is needed to provide this regulating ES, it is also other grass species.

2.2.2 Integrating ecosystem services and social-well-being

As will be discussed in Section 2.3 (*Social well-being*), the MA (2005) was not able to establish a direct connection between ecosystem services and human well-being on a global scale (Millennium Ecosystem Assessment, 2005). However this type of relationship is frequently observed on smaller scales (Bolund & Hunhammar, 1999; Brondízio & Chowdhury, 2013; Brondizio & Moran, 2008; Doody, 2013; Ponting, 2007). For example, inhabitants of Easter Island in 800 A.D. did not realize or consider the impacts of their growing population and intense logging on their environment. Living on a secluded island, with minimal means of off-island transport, the inhabitants of Easter Island were faced with essentially finite resources. Their culture involved the erection of many large stone monuments (cultural ES) that could only be transported from one location to another by rolling them on logs which always came from freshly downed trees (provisioning ESs). Logging these trees at an unsustainable rate led to increased erosion (decline in regulating ES), infertile soils (decline in regulating and supporting ESs) and the eventual depletion of all trees on the island, and this was the main cause of the complete downfall of their society (Ponting, 2007). Societies such as those in Mesopotamia, Ancient Egypt, The Indus Valley and Ancient China followed patterns similar to Easter Island (Hings, 2016; Ponting, 2007).

On local scales, recreation and tourism (cultural ESs) contribute greatly to well-being through means such as physical exercise, aesthetic experiences, intellectual stimulation, and inspiration. But the reaping of these benefits depends on built infrastructure, accessibility, and most importantly, ecological conditions (Daniel et al., 2012; Thompson et al., 2009). As Doody (2013) observed, the building of infrastructure on coastlines and shorelines for the purposes of tourism, recreation and urbanization are the main causes of sand dune loss in several European countries over the past 50 years. This has had a negative effect on the integrity of the shorelines, leading to many structural and safety issues, causing these development sites to become abandoned and economically non-viable (Doody, 2013). Therefore, the lack of the consideration or mitigation of the ecological impacts of tourism and recreation destroyed these opportunities and the well-being they provided completely (Doody, 2013).

These examples describe clear connections between the quality of ecosystems services and human well-being and demonstrate a need for the integration of human well-being in decision-making and governance of societies. As will be discussed in Section 2.3 (*Social well-being*), social well-being captures the nuances of human-environment interactions, especially in terms of the impacts of human actions/behaviour toward to the environment. Therefore, an ES-well-being lens can help to identify the specific ESs that contribute to social well-being (well-being ecosystem service bundles or WEBs), and then the ecosystems that provide them can be appropriately valued by decision-makers (Bolund & Hunhammar, 1999). **Figure 2.7** illustrates this general process.

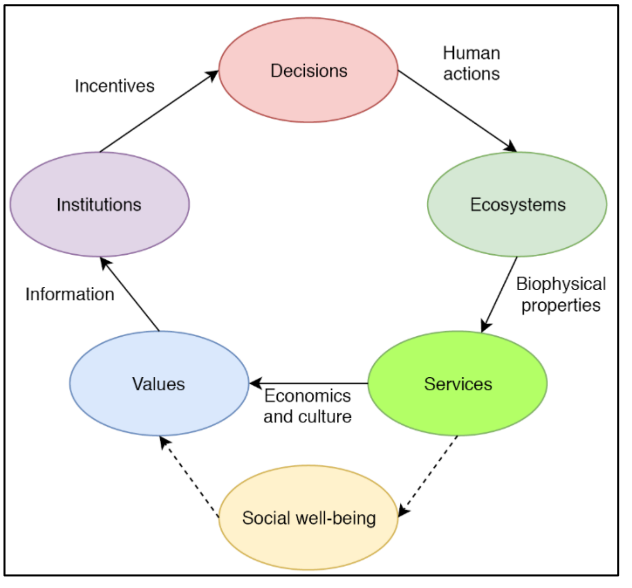

Figure 2.7 *How ESs and the social well-being they provide reflect the culture and values of a society and can be integrated into decision making, adapted from Daily et al. (2009).*

Economic valuation of the environment through the language of ESs is able to translate the specific changes in outputs of the environment to changes in social well-being in monetary or non-monetary terms. The value placed on a specific ES reflects the values of society and the way they view and understand the world around them (Daily et al., 2009). Designing institutions that are able to reflect these societal values in their environmental governance strategies is extremely important for building culturally sustainable societies. Once the monetary and non-monetary values associated with each ES are closer to being what is considered "right," then societal behavior and planning efforts can be focused toward the preservation and conservation of nature, as opposed to its exploitation and domination (Daily et al., 2009; Leopold, 1942). This is the paradigm that supports the sustaining and improving of social well-being simply because doing what is best for humans in the long-term is also doing what is best in the interest of the non-human components of the system simply because the two are so deeply interconnected (Leopold, 1942).

2.3 Social well-being

The MA encouraged an increase in the interest of governments, NGOs and academics to pursue well-being-driven initiatives, especially with respect to the examination of environmental change (White, 2009). The MA examined the parameters of basic material, health, social relations, security, and freedom in order to measure changes in human well-being with respect to changes in ecosystem services (Millennium Ecosystem Assessment, 2005). From here, many different interpretations of human well-being for development action have emerged. All of these conceptualizations, generally unite around common insights (White, 2009):

1. Well-being includes both subjective and objective dimensions.
2. Well-being has a moral dimension that holds people's values, dictating the different ways different people will interpret their own well-being.
3. Well-being is not a single state; it is fluid and constantly changing as life progresses.
4. Enhancing well-being involves working directly with people and communities and building a broader environment in which they can flourish.

Among these emergent conceptualizations is that of social well-being, or "3D well-being," developed by the Economic and Social Research Council's Well-being in Developing Countries research group (WeD) at the University of Bath, and based on five years of empirical research across four countries (White & Ellison, 2007). Social well-being has three dimensions, as described by White and Ellison (2007) – material, relational and subjective. Material well-being is defined by the physical, material resources that people have. This includes food, shelter, aspects of the physical environment, economic assets and income (Britton & Coulthard, 2013; White, 2009; White & Ellison, 2007). Relational well-being is what people do and the interactions that they have with each other. It involves power structures, identity, and the connections and difference between people (Britton & Coulthard, 2013; White, 2009; White & Ellison, 2007). For this, it is not solely the number of social interactions that determines someone's relational well-being, it is the quality of these interactions and how they contribute to a person's feeling of value and importance (Larson, 1993). Subjective well-being is people's own perceptions of how they feel and what their quality of life is (Britton & Coulthard, 2013; White, 2009; White & Ellison, 2007). Quality of life can include the conditions of the environment in which people live (including ecosystem health and quality) and attributes of people themselves (Pacione, 1982, 2003).

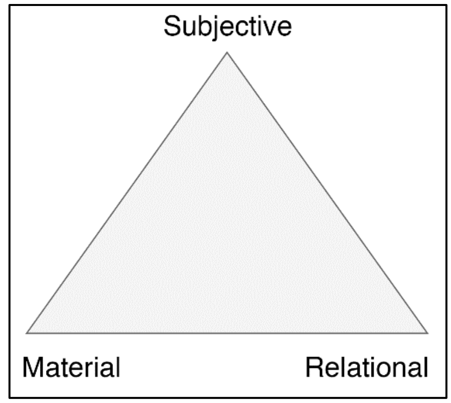

Figure 2.8 The WeD visual depiction of the interacting dimensions of social well-being (White & Ellison, 2007).

White and Ellison (2007) originally depicted the dimensions of social well-being as three interdependent articles (material, relational, and subjective) emerging from the interplay of objective (people's circumstances) and subjective (their perceptions) parameters (see **Figure 2.8**) (White & Ellison, 2007). I feel that this visual depiction of social well-being and its description in this way does not fully embrace the true complexity of the three independent articles. White and Ellison (2007) place subjective well-being at the apex of the triangle, indicating that material and relational well-being are products of values and culture (White & Ellison, 2007). Material and relational well-being are thus experienced in different ways by different people, meaning that they are also subjective. The perceptions that someone has about their quality of life shapes the way that they experience a certain level of material or relational well-being. Therefore, in a visual depiction, placing any one of these above the other undermines this crucial connection. Encapsulating material and relational well-being inside subjective well-being, as in **Figure 2.9**, more accurately captures the influence of each individual's subjective view of the world around them on their own situation.

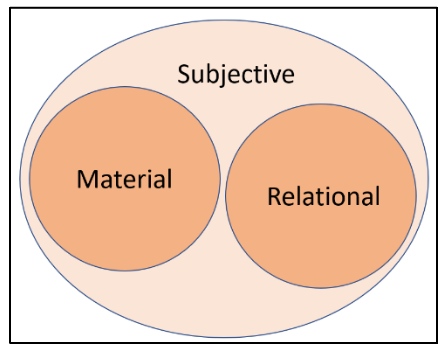

Figure 2.9 *The dimensions of social well-being visually depicting the influences of subjective well-being on the other dimensions (adapted from White and Ellison (2007)).*

Social well-being in society is shaped by many things including, living conditions, culture, social and political structures, economic status and the physical environment. Environmental challenges (e.g., flooding, erosion, biodiversity loss) can impact many areas of social well-being such as economic security, basic needs, human health and safety and the quality of social interactions (Larson, 1993). Early work in well-being research identified "environmental mastery" as a constituent of well-being (Ryff, 1989). "Environmental mastery" in this context can be described as humans acting as though they and nature are separate entities, and not part of the same system, which leads to people treating natural resources solely as commodities existing only for their use and benefit (Kosoy et al., 2012; Schumacher, 1974). This paints a pitiful portrait of humanity best described by Raworth (2017) and visually depicted by Cutts (2012) in **Figure 2.10**.

Figure 2.10 *Steve Cutts' animation examines man's poor relationship with the natural world, featuring the words of Kate Raworth describing what is referred to as the "rational economic man" (Cutts, 2012).*

This description of the "rational economic man" as a master of the environment was, at the time, said to have high levels of well-being because it was based on principles of infinite economic growth being equated to high levels of well-being. These principles, while relevant at the time of their conception, cannot be applied in the Anthropocene because the economies they have produced have grown so large that they have become degenerative and are damaging the living world on which human well-being fundamentally depends (Brown & Garver, 2009; Kosoy et al., 2012; Raworth, 2017).

"The Environmentalist's Paradox" is a term that was conceived when the MA (2005) failed to reveal a direct relationship between ecosystem services and human well-being as expected (Raudsepp-Hearne et al., 2010). The MA (2005) found that on a global scale, declines in ecosystem services, leads to improvements in human well-being (Millennium Ecosystem Assessment, 2005). In this assessment, human well-being was measured using parameters that, while accurate, are products of a degenerative economy, meaning that they do not fully capture well-being beyond what is derived from consumption of provisioning services and material goods (Millennium Ecosystem Assessment, 2005; Raudsepp-Hearne et al., 2010; Raworth, 2017). The impacts of excessive consumption of natural resources is also time-lagged, meaning that consumption is not felt directly or right away, leading to a misconception of the true relationship between well-being and environmental degradation when examined on an inadequate time scale (Raudsepp-Hearne et al., 2010).

The concept of social well-being therefore aims to move beyond the well-being gains by material goods, and its dimensions can more adequately capture the nuances of human-environment interactions, especially in terms of the impacts of human actions/behaviour toward to the environment. By understanding what these interactions are, the study of social well-being can contribute to a better understanding of the various reasons and conditions that affect people's feelings or behaviours. This can help identify specific problems that warrant special attention or societal action as well as specific standards against which actual conditions can be judged for effective policy formation (Pacione, 2003). By doing so, governance and policy decisions can be improved through the incorporation of motivations for positive behavioural change (Coulthard, Johnson, & McGregor, 2011). However, having a clear set of indicators of social well-being is necessary.

2.3.1 Social well-being indicators

With regard to my research, relevant indicators of social well-being are outlined in **Table 2.1**. These indicators provided a deductive foundation for data collection and analysis (chapters 5, 6 and 7), and were chosen for their relevance to the southeastern shoreline of Lake Huron as determined by existing literature.

Table 2.1 *Indicators of social well-being relating to beach grass that have emerged during this literature review.*

Dimension	**Indicators**	**Examples specific to beach grass**
Material	Current financial situation	Paying for beach grass or dune removal/restoration; paying for property damages caused by lack of beach grass/dunes; saving money from avoiding property damages due the presence of beach grass/dunes (MVCA, 2016; Peach, 2007; SVCA, 2018; Town of Saugeen Shores, 2013).
	Property value	The presence or lack of beach grass impacting property value in terms of preventing damages; impacting the aesthetic value of the property either positively or negatively (MVCA, 2016; Peach, 2007; SVCA, 2018; Town of Saugeen Shores, 2013).
	Enjoyment of the beach	The alteration of the nature of the beach due to loss of beach grass; maintenance of a healthy beach area due to the presence of beach grass; excessive erosion preventing beach access due to lack of beach grass; decreased erosion due to presence of beach grass and dune systems ; (Baldwin & Maun, 1983; Olson, 1958a; Peach, 2007; Van Dijk, 2004; Van Zwol, Andreae, & Carroll, 2012).
Relational	Sense of place	Beach grass as a component of local/regional identity; Beach grass as an important component of the maintenance of the shoreline’s natural and unique characteristics (Daniel et al., 2012; Schaller, 2014; Thoreau & Torrey, 1949).
	Feeling of community belonging	Activities related to beach grass that promote the feeling that one is contributing to the community and is part of something greater than oneself (Becker, 1997; Brown & Garver, 2009; Marks & Shah, 2004; Peach, 2007).
	Participation in community activities	Protection of beach grass as a motive for involvement in local restoration or cleanup events (Becker, 1997).

	Personal relationships	Conflicts or collaboration with neighbors to clear or restore beach grass; shared agreement or arguments with community members surrounding the elimination or restoration of beach grass (Brown & Garver, 2009).
Subjective	Overall happiness	The contribution of beach grass to other dimensions of well-being such as community belonging, access to nature, and making meaningful contributions to the community and the environment (Brown & Garver, 2009).
	Safety and security	Understanding the role that beach grass plays in maintaining the stability of the shoreline, mitigation of hazards, and improvement of water quality (A. Crowe & Milne, 2013; Edge & Hill, 2007; McLaughlin & Cooper, 2010; Peach, 2007; Sallenger, 2000; Town of Saugeen Shores, 2013; Whitman et al., 2014).

2.4 Beach grass ecosystem services and well-being

As defined earlier in Section 2.2, ESs are the benefits that humans or society as a whole receive from the environment (Steinman et al., 2017). This thesis will specifically examine the social well-being drawn from the presence of beach grass (*Ammophila breviligulata*) by Lake Huron shoreline communities, referred to here as beach grass ESs.

2.4.1.1 Provisioning ecosystem services

As previously defined, provisioning ESs are contributions to meeting essential humans needs and material well-being (Daniel et al., 2012; Steinman et al., 2017). In terms of essential human needs there are things such as food (Levy et al., 2005; Wood et al., 2005), water (Levy et al., 2005; Vorosmarty; et al., 2005), fuel and fibre (Sampson; et al., 2005), and shelter (Levy et al., 2005), none of which are provided by beach grass. In terms of contributing to material well-being, beach grass contributes by mitigating infrastructural damages due to coastal hazards and, therefore, improving material well-being through the maintenance of property value and the avoidance of repair expenses. However, these are more appropriately classified as the regulating ESs for beach grass.

2.4.1.2 Regulating ecosystem services

The main role of all the regulating beach grass ESs is maintaining the stability of the Lake Huron shoreline, and allowing the dynamic system to function within a normal range of variation. These are the services most taken for granted because they are functions of the natural systems and require little-to-no investment or human intervention to carry out their functions (Postel & Carpenter, 1997). Uncoincidentally, regulating ESs are the services most rapidly being lost due to coastal planning decisions that do not take their value into account (Postel & Carpenter, 1997). In some cases, the values of regulating ESs may not even be apparent until they are lost or destroyed (Postel & Carpenter, 1997).

These ESs are widely identified in academic literature (see **Table 2.2**). In general, studies that investigated weather and storm moderation tended to focus on the beach-dune environment more generally, as opposed to focusing specifically on the effects of beach grass. Impacts of beach grass on water quality have only recently been documented in the literature and are mostly focused in the Great Lakes shoreline environment.

Table 2.2 *Results of academic literature review describing the regulating ESs relating to beach grass and beach-dune systems.*

Regulating ES	Findings relating to ES	Source
Weather and storm moderation	Sea grass, responsible for building sand dunes close to the Ocean's coast, are able to provide a more consistent buffering against tsunamis.	(Cochard et al., 2008)
	Proposed a new scale to describe the impact of a storm on a given area of coast depending on its features. In this scale, areas with higher dunes were described as having a significantly lower storm impact.	(Sallenger, 2000)
	Various dune stabilizing vegetation was grown in an artificial dune medium and was found to have no difference in protection from storm surge and intense over wash than natural dune environments. These findings indicate that this artificial medium can be used to repair damaged dunes, and that the dune stabilizing vegetation plays an equally, if not more, crucial role in the stabilization of sand dunes than the dune medium.	(Makowski, Finkl, & Rusenko, 2013)
	When evaluating coastal vulnerability index in reference to ability to withstand intense storms and wave action, coastal characteristics were used as a parameter. Vegetated coastal areas indicated low vulnerability, whereas bare dunes and gravel ridges indicated high vulnerability.	(McLaughlin & Cooper, 2010)
	The Greenwich dunes have grown considerably in height and volume due to increased vegetation cover. They now appear to provide considerable protection against severe storms.	(Mathew et al., 2010)
Erosion prevention	Mature dunes along the Lake Huron shoreline, characterized by high *A. breviligulata* biomass, are best able to stabilize the substrate (sand).	(Baldwin & Maun, 1983)
	A. breviligulata aids in the building of sand dunes by slowing surface wind velocity and thus trapping sand particles that would otherwise be lost through wind erosion.	(Olson, 1958a)
	Four main episodes are responsible for the formation of the southern Lake Michigan shoreline dunes. Dune vegetation, primarily *A. breviligulata*, has been a key driver of vertical dune development and wind direction has been a key driver of horizontal dune movement and dune shape.	(Kilibarda, Venturelli, & Goble, 2014)
	As a result of its sand-trapping abilities, *A. breviligulata* is specially adapted to require partial sand burial in order to propagate. In response to the burial *A. breviligulata* plants shift their stored resources in order to create new shootborne	(Maun, 1998)

	roots close to the new substrate surface, allowing the dune to grow in size, allowing the positive feedback loop to continue.	
	Erosion rates of the Lake Michigan Hoffmaster dunes was greatest at the blowout areas, which contained no *A. breviligulata* or other vegetation cover. Additionally, lower density in *A. breviligulata* cover on the dunes resulted in overall higher erosion rates.	(Van Dijk, 2004)
Water quality	Of the studied Lake Huron sites, beaches were placed into two categories. "Dry beaches" are categorized by a deep water table and presence of *A. breviligulata*. "Wet beaches" have a shallow water table, and turf grass, which is food for geese and thus attracts them to the shoreline. *E. coli* from their fecal matter seeps into the groundwater and contaminates it. *E. coli* was not present in any of the studied "dry beaches."	(A. Crowe & Milne, 2013)
	Infiltration of *E. coli* from the sand to the groundwater is dependent on the depth of the water table. Dry beaches with *A. breviligulata* have deep water tables and the dry sand on the surface prevents *E. coli* infiltration altogether.	(Whitman et al., 2014)
	E. coli found in sand and water samples from Lake Ontario were predominantly from goose and mallard droppings rather than other sources of fecal matter. Geese and mallards are not attracted to beach grass and will not land there if it is present. Decreasing bird contamination of the shoreline is recommended moving forward in order to improve groundwater quality.	(Edge & Hill, 2007)

2.4.1.3 Supporting ecosystem services

The role of beach grass in the maintenance of biodiversity is widely identified in academic literature (see **Table 2.3**). In general, studies conclude that beach grass acts as the main driver for succession in dune environments and that its ability to stabilize the dune substrate and shelter other plant populations from the harsh conditions of the dune environment are among the most important factors for maintaining biodiversity within beach-dune systems.

Table 2.3 *Results of academic literature review describing the supporting ESs relating to beach grass and beach-dune systems.*

Supporting ES	Findings relating to ES	Source
Biodiversity maintenance	Dune restoration efforts involving monoculture planting of *A. breviligulata* achieve normal restoration goals in terms of diversity and ecosystem properties due to their disturbance predictability of successional trajectories creating ideal conditions for very specifically adapted plant species.	(Emery & Rudgers, 2010)
	A. breviligulata preferentially grows in clean sand, but as litter accumulates in the sand dune, it creates a nutrient-rich substrate, allowing for later-successional species to establish.	(Olson, 1958c)
	Knowing that *A. beviligulata* is able to stabilize sand dunes, it was determined that the establishment of various plant species on sand dunes relies on stability of the sand, more than on nutrient input from litter.	(Chadwick & Dalke, 1965)

	The third most common shoreline class where Great Lakes fish occurred was sandy beaches – dunes (18.4 per cent). This is an important reproductive habitat for the Great Lakes fish community.	(Wei, Chow-Fraser, & Albert, 2004)
	Potassium and magnesium appear to possibly be limiting nutrients for general plant growth in the sand dune environment, but the most significant factor affecting diversity of the studied dune environments was the stability of the substrate, and the sheltering from harsh conditions, both initiated by the presence of *A. breviligulata*.	(van der Valk, 1975)

2.4.1.4 Cultural ecosystem services

Cultural ESs have strong "public good" characteristics, and are highly dependent on cultural and societal values, making it difficult to assign them market values (Postel & Carpenter, 1997).

The contribution of beach grass to the aesthetic enjoyment of the beach is widely identified in academic literature, however, studies tend to be polarized into two schools of thought. When speaking from a more theoretical and philosophical perspective, such as Clarke (1994), Thoreau (1949), and Broughton (1972), emphasize a more intrinsic value and the common theme that emerges is that any preservation of natural ecological features positively influences the aesthetic value of the environment (Broughton, 1972; Clarke, 1994; Thoreau & Torrey, 1949). From a more instrumental perspective, such as Thoreau (1949) and Peach (2006), the common theme that emerges is that beach grass specifically, is often regarded as an aesthetic nuisance (Peach, 2006; Thoreau & Torrey, 1949). There are however exceptions to this. For example, in a study on dune outliers (dunes that lie closer to an urban area rather than to the shoreline), the dunes and their grasses are viewed as an aesthetically pleasing feature (Featherstone et al., 2005). This could be due to the fact that the dunes are within an urban area, wherein many natural features are commonly regarded as desirable (Hammitt, 2000).

In terms of touristic value, many studies cite the removal of beach grass and dunes in order to make the beaches more aesthetically pleasing to tourists and to build shoreline infrastructure specifically for tourists (Davenport & Davenport, 2006; Doody, 2013). While this has been found to have a positive effect on coastal tourism in the short-term, it has also been shown to reduce the stability of the shoreline, causing significant coastal erosion (Doody, 2013) and, in Lake Huron specifically, degrading dry beaches into wet beaches, which then lead to *E. coli* outbreaks in the water (A. Crowe & Milne, 2013). Both of these effects of removing beach-dune systems undermine the safety of the shoreline for visitors and ultimately lead to decreased touristic activity (Doody, 2013; Englebert, McDermott, & Kleinheinz, 2008). When natural shoreline features, such as beach grass, are preserved, it has a greater long-term effect on tourism (Cochard et al., 2008; Doody, 2013), especially when this environmentally-focused beach management is high-lighted by beach certifications such as the Blue Flag award in Ontario (Klein & Dodds, 2018). A summary of the academic literature review for the cultural beach grass ESs discussed above is presented below in **Table 2.4**.

Table 2.4 *Results of academic literature review describing the cultural ESs relating to beach grass and beach-dune systems.*

Cultural ES	Findings relating to ES	Source
Aesthetic enjoyment	Sand gathering devices can alter the natural ecology of the beach, creating aesthetic problems by disrupting the shore's flooding protection and destabilizing the sand. Disrupting the natural beach grass landforms cause beach aesthetics to suffer.	(Clarke, 1994)
	"[Beach grass], which in many places would be an esteemed ornament, is here despised by many on account of its being associated with barrenness. It might well be adopted for the Barnstable coat-of-arms in a [sandy field]. I should be proud of it."	(Thoreau & Torrey, 1949)
	Beach erosion has been exacerbated by mechanized beach raking and removal of *A. breviligulata* by the municipality to maintain the aesthetics of the beach. *A. breviligulata* is not conducive to beach aesthetics.	(Peach, 2006)
	Balance is essential to the aesthetic experience in art, and this translates to natural features, wherein the dynamic stability of the beach-dune ecosystems is what humans find most beautiful.	(Broughton, 1972)
	The forested dune outliers are distinctive within the flat municipal landscape and give an aesthetically pleasing look to the area, from forming an impressive "gateway" into the town to providing important backdrops.	(Featherstone et al., 2005)
Tourism	Blue Flag certification in Ontario is a tourism promotional tool. It is awarded to the beaches that have met high environmental management criteria. Maintaining the natural features of the beach, such as the beach-dune ecosystems, is cited as an example on a Blue Flag certified beach.	(Klein & Dodds, 2018)
	Coastal vegetation such as mangroves and sea grass serve multiple purposes such as hazard protection for material assets (e.g. infrastructure), thus increasing tourism to coastal areas that can be better protected and incur less damage in the face of storm and flooding events.	(Cochard et al., 2008)
	Beach grooming flattens the beach, makes it more susceptible to erosion and severely damages the fragile beach-dune ecosystems. This is done to make them attractive to tourists.	(Davenport & Davenport, 2006)
	The building of infrastructure on coastlines and shorelines for the purposes of tourism, recreation and urbanization are the main causes of sand dune loss in several European countries over the past 50 years. This has had a negative effect on the integrity of the shorelines, leading to many structural and safety issues, causing these development sites to become abandoned and economically non-viable.	(Doody, 2013)
Educational Value	"Here and there were tracts of beach grass mingled with the seaside goldenrod and beach pea, which reminded us still more forcibly of the ocean."	(Thoreau & Torrey, 1949)
	Dunes evaluated in this study add a high natural heritage values to the landscape in addition to providing habitat for several endangered species, such as the eastern hog-nosed snake and the eastern milk snake.	(Featherstone et al., 2005)

	Using historic aerial photographs of Lake Michigan dunes and edge detection software, researchers were able to identify patterns and rates of change in the dunes. This provides information on how the dunes systems function, which can be used for dune management practices.	(Belford, Kenbeek, VanHorn, & van Dijk, 2014)
	Using measurements of aeolian dune surface changes, local wind velocity and archived composite weather maps, researchers were able to establish that cyclonic winds interacting with dune topography are the dominant factors that have acted in the past to shape the Lake Michigan dunes.	(Yurk et al., 2014)
	Using collected sediment cores from Lake Michigan dunes to record and understand how dunes migrated into wetlands 4200-4400 years ago.	(Argyilan, Lepper, & Thompson, 2014)

2.5 Conceptual framework

The relationship among ESs and social well-being is an emerging field of study that helps to link natural and social science perspectives. However, there are many elements of the relationship that remain poorly established, in coastal environments (Adger et al., 2018). ES research in terms of characterizing ES-well-being linkages in a manner intended to assist decision-making or governance is being investigated (e.g., (Armitage et al., 2009; Folke et al., 2005)). However, to address this challenge, it is important to understand the roles of diverse stakeholders in environmental governance, what particular ESs mean to them and how they use them, and spatial and temporal patterns associated with the use and benefits derived from ES (Bennett et al., 2015).

Establishing what specific beach grass ESs mean to the resource users, and how they use them entails understanding the reasons for using, valuing or de-valuing certain ESs. With this information, the social networks and connections among individuals (social constellations) can be outlined and used to create collaboration between stakeholders, resource users and other interest groups, in the context of coastal action planning (Bennett et al., 2015; Wegner & Pascual, 2011). Such a focus can help to further increase an understanding of the relationship among beach grass ESs and various dimensions of social well-being in the southeastern shoreline of Lake Huron, and will shed light on the dynamic and complex nature of the human–environment interactions that are impacting the Lake Huron shoreline (Tengberg et al., 2012).

Drawing greater attention to the WEBs associated with beach grass along the Lake Huron shoreline is crucial for integrated coastal planning. The 'WEBs' conceptual framework used here helps to demonstrate how potential decisions can affect social well-being by altering or restoring ecosystems (Daily et al., 2009). A WEBs perspective also brings insight to the role of the resource user in the creation of their own well-being through conservation of important resources and improving environmental quality (e.g., maintaining beach grass), which is important for coastal planning in the long term.

This conceptual framework (**Figure 2.11**) is structured as a social constellation, which uses systems-thinking and the dimensions of consciousness to identify what is missing or hidden in the system such that the necessary changes can be implemented (Fornés, 2016). Here, the system components that impact beach grass and beach grass ecosystem services along the Lake Huron shoreline are outlined and divided into three layers, each one veering further and further from the direct physical components of the system. These layers are built to correspond to the three dimensions of consciousness: 1) the physical world, 2) the external world that is responsible for driving change in the physical, and 3) the cultural world, containing the culture and beliefs that influence the first two dimensions (Tang, 1998).

The first layer of this conceptual framework is the physical system, containing the policies that govern the shoreline and the external pressures that directly impact the quality of the shoreline environment and the quality of the beach grass ecosystem services. The second layer contains the external actors of the system: the researchers who collect the information, and the culture and economics that the policies are based on. Applying these layers, along with the third layer—people's multi-faceted reasons for using, valuing, or disregarding ecosystem services—to environmental management will contribute to collaboration between stakeholders interest groups for integrated and cohesive decision-making (Bennett et al., 2015).

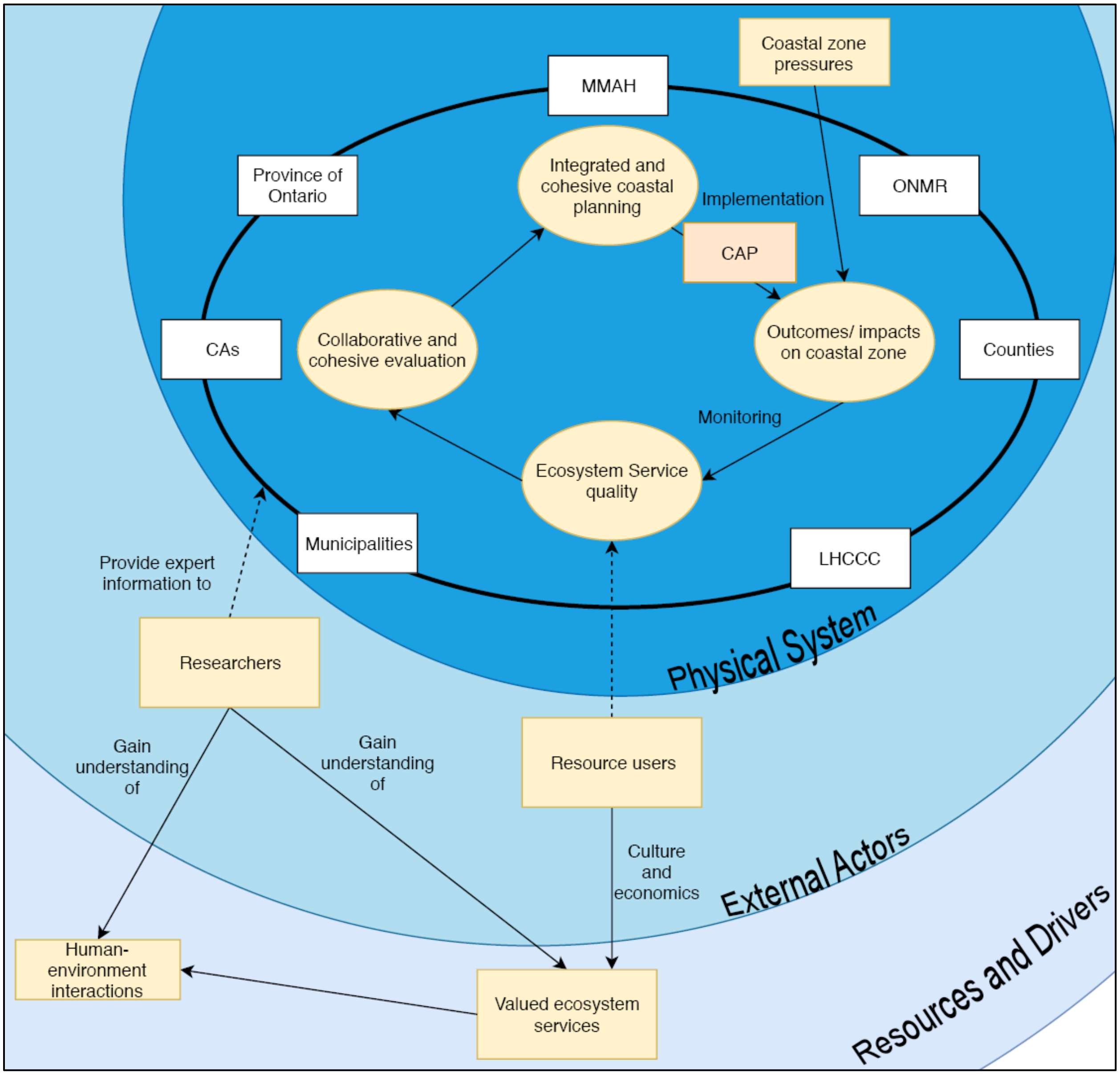

Figure 2.11 *Conceptual framework: MMAH= Ministry of Municipal Affairs and Housing; OMNR=Ontario Ministry of Natural Resources; LHCCC= Lake Huron Centre for Coastal Conservation; CA= Conservation Authority; CAP = Coastal Action Plan of the Southeastern Shoreline of Lake Huron*

2.6 Chapter conclusion

Humans are deeply embedded with the environment, and therefore, coastal planning must take this into account (Beatley, 2009). Beach grass provides regulating, supporting and cultural ESs and is crucial to the stability of the Lake Huron shoreline (Peach, 2006, 2016). Understanding the relationship among beach grass ESs and various dimensions of social well-being can reveal key issues of relevance for more integrated coastal planning (Tengberg et al., 2012). These issues are further assessed in chapters 5, 6 and 7.

<u>Chapter 3 – Case Study Context: The Southeastern Shoreline of Lake Huron, Canada</u>

In this chapter, I present the case study for this research: the southeastern shoreline of Lake Huron. I expand on the case study context provided in Section 1.2. I begin by outlining the specific study areas along the shoreline.

3.1 Geographic context

As depicted in **Figure 1.4**, the southeastern shoreline has a diverse topography, and since the central focus of this thesis related to beach-dune ecosystems, only portions of the shoreline containing these topographical features were of use to this research. How these beach-dune ecosystems formed and where they are located along the southeastern shoreline, as well as the pressures affecting them, are described in this section.

3.1.1 Formation of sandy beaches along the southeastern shoreline

The initial formation of Lake Huron as a glacial lake, the shape of the lake as well as the flow of the water in the lake, essentially dictate the pattern of topographical features and sediments of the shoreline (Thomas, Kemp, & Lewis, 1973).

The southeastern shoreline north of Point Clark, and predominantly, the northern shoreline of Lake Huron are characterized by glacial till, which is the unsorted and unstratified sediments deposited directly by a glacier, as well as bedrock (Pollard, 2014; Thomas et al., 1973). The exposed bedrock and till are characteristic of the remnants of a glacier that has aggressively carved through the land thousands of years ago (Pollard, 2014). The bedrock is still exposed in these areas, because the longshore current of the lake is largely unobstructed. Due to this fast water flow, small sediments, such as sand, cannot accumulate, except in small inlet areas, where the longshore current is forced to slow down (Lapointe, 2015). These inlets are areas such as Sauble Beach to Port Elgin and Kincardine to Point Clark.

Moving south along the shoreline, from Point Clark to Bluewater, sandy beaches only occur where the shoreline has been artificially modified to slow or direct water flow in favor of economic activities (e.g., Bayfield (**Figure 3.4**) and Goderich (**Figure 3.5**)). Also, along this stretch of shoreline are bluffs accompanied by beaches, also known as bluff-backed or dune- and bluff-backed beaches. This shoreline topographical feature forms through the impacts of many water-level fluctuations overtime, each fluctuation depositing more and more sand at the toe of the bluff to eventually form a beach at low water-level (Ruggiero et al., 2013). These are areas such as Huron Sands Beach, Port Albert and Bluewater Beach.

Continuing south along the shoreline, below Bluewater, another curved inlet section of the shoreline (Grand Bend to Kettle Point) slows the longshore current, forming sandy beaches. South of Kettle Point, the high and low bluff features as well as the shape of this stretch of shoreline indicate a more rapid longshore current. Approaching Sarnia, the longshore current slows to flow into the St. Clair River, depositing smaller sediments, such as sand and silt (Lapointe, 2015; Ruggiero et al., 2013). The results of these coastal processes are depicted in the topographical features shown in **Figure 3.1**.

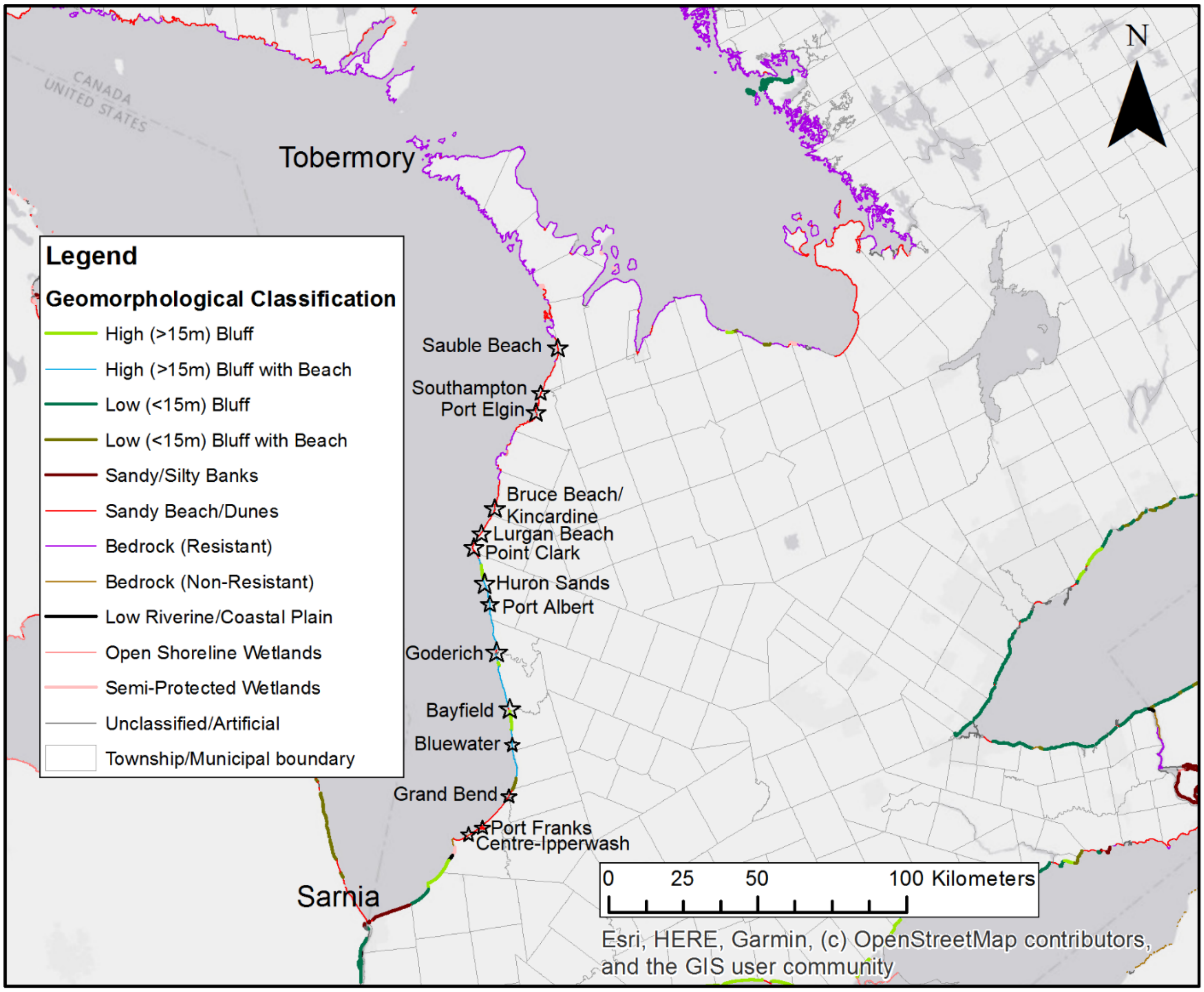

Figure 3.1 *Field sites where data was gathered for this thesis through methods described in Section 4.2.2 (Surveys) (Detroit District U.S. Army Corps of Engineers and Water Issues Division of Environment Canada, 2009; Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2013). Due to the layers of anonymity in the collecting of data, it is undeterminable exactly how many participants were from each field site, or even if any data was collected from one particular field site. Thus, the depiction of field sites here demonstrates the general geographic distribution of data collection as attempted through the methods described in Section 4.2.2.*

Once there are sandy beaches, dune systems can then form. However, dunes cannot form without the help of the grasses that colonize the bare sand areas first. *A. breviligulata* propagates through the production of plagiotropic rhizomes and spreads through vegetative fragments cast on shore by high waves (Maun, 1985). These characteristics make it an ideal pioneer grass species, as it can colonize bare areas very quickly. Once *A. breviligulata* has colonized an area, it promotes the building of sand dunes by slowing surface wind velocity and thus trapping sand particles that would otherwise be lost through wind erosion (Olson, 1958a). From here, other plant species can establish due to the stability of the sand and increased nutrients (Chadwick & Dalke, 1965; Olson, 1958c). *A. breviligulata* has a superior ability to stabilize the sand because it is also extremely tolerant to sand burial, to the point where over time, it has adapted to require partial sand burial in order to propagate (Maun, 1998). Given all these characteristics, areas along the Lake Huron shoreline that are most conducive to development of beach-dune ecosystems would therefore be those with sandy beaches, continuous water-level fluctuations, and high winds for aeolian sand burial.

3.1.2 Human and environmental pressures facing the shoreline

As mentioned in Section 2.1.3, the main human and environmental pressures facing the Lake Huron shoreline are 1) nutrient pollution, 2) artificial shoreline modification, 3) global climate change, and 4) invasive species (Beatley et al., 2002; Cullinan et al., 2006; Egan, 2017). The impacts of these pressures can all be mitigated through beach grass restoration efforts.

Since the 1960s, rural Ontario communities have been undergoing restructuring as family farms have failed and larger commercial farms requiring less labour have taken over (Leach & Winson, 1999; D. Smith, King, & Williams, 2015). These large farms have less diverse cropping systems, require greater fertilizer inputs and have smaller windows of opportunity to complete field operations. Because of this, they tend toward using broadcast applications for their fertilizers which save time and labour, but result in minimal contact between the soil and fertilizer, making it easier for nutrients to runoff into the lake with precipitation (D. Smith et al., 2015). Presently, much of the surrounding areas of the Lake Huron southeastern shoreline are dedicated to agriculture (Ontario Ministry of Natural Resources, 2012). Nutrient loading from these agricultural lands into the Great Lakes has been shown to affect coastal wetland algal communities. Considering that benthic algae makes up the base of the Great Lakes coastal wetland food web, effects here can be cascading (Cooper, Costello, Francoeur, & Lamberti, 2016; Egan, 2017). The presence of beach-dune systems along the shoreline can aid in the mitigation of the effects of nutrient loading because the stabilized dunes and their vegetation acts as natural filters for the excess nutrients and pathogens that run off the landscape toward the lake.

At Lake Huron, it is not uncommon for property owners to eliminate their dunes and replace them with turf grass. However, it is rare that they realize the consequences of these actions. This turf grass attracts geese and mallards to the shoreline beaches (A. Crowe & Milne, 2013; Edge & Hill, 2007). Their fecal matter contains *E. coli* bacteria, which can seep into the groundwater through the sand, contaminating it (Whitman et al., 2014). Infiltration of *E. coli* from the sand to the groundwater is dependent on the depth of the water table. Dry beaches with *A. breviligulata* have deep water tables and the dry sand on the surface prevents *E. coli* infiltration altogether (Whitman et al., 2014).

Before development of the Great Lakes' shoreline and the carving of the fourth seacoast (18th Century), the lakes were essentially land locked. Numerous man-made canals and land alterations needed to be made to navigate ships up the St-Lawrence seaway and bypass Niagara Falls. Originally the goal was to sail to China, which was what was thought to be on the west end of Lake Huron (mistaken for the ocean) at the time (Egan, 2017). Driven by desire for economic development, the Great Lakes' shorelines were quickly developed, and remain today, important economically profitable locations for both Canada and the USA (Beatley et al., 2002; Egan, 2017). These economic centres are able to be so due to various man-made shoreline alterations that were built to change the natural sediment flow and erosion patterns of the shoreline in order to support various human activities that require more physical stability than the dynamic shoreline can provide.

The Lake Huron southeastern shoreline has several of these: groins, jetties, breakwaters and seawalls, which all replace the natural shoreline environment with a heavily human-managed landscape. A groin is a structure built perpendicular to the shoreline designed to trap sediment moving along the shore on one side of the groin, creating a deeper, more eroded area on the other side (Nordstrom, 2003). This effect is optimal in the case where the shoreline beach is used for varying types of recreation, requiring unnatural variations in water depth. In the case of Port Elgin (located along the southeastern shoreline of Lake Huron), a popular public beach is located on one side of the groin, and a marina on the other (**Figure 3.2**). The high sediment accumulation on the beach side of the groin, allows for a large, shallow, swimmable area with little wave action. The high sediment erosion on the other side allows recreational boats to be parked close to the shoreline without hitting the bottom, promoting ease of access for loading and unloading. In Sarnia, the groins are used to increase the sizes of the private beaches for recreational use (**Figure 3.3**).

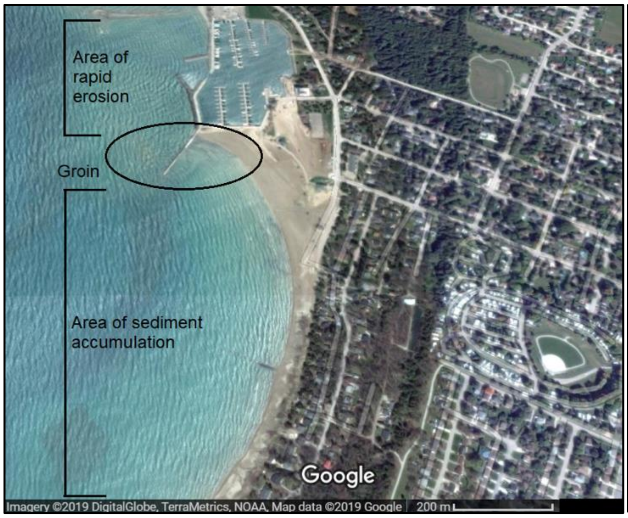

__Figure 3.2__ Groin at the Port Elgin main beach (Google Maps, 2019d).

__Figure 3.3__ Groins along the Sarnia shoreline (Google Maps, 2019e).

Jetties are another type of manmade shoreline alteration that are designed to direct the flow of water at inlets and to provide a barrier to longshore movement of the channel in order to facilitate navigation (Nordstrom, 2003). These are often accompanied by breakwaters which are built parallel to the shore in order to promote calmer waters for marinas and to protect other shoreline structures (McCartney, 1985). Many densely populated areas of the Lake Huron southeastern shoreline have jetties for these purposes (**Figure 3.4**, **Figure 3.5**, and **Figure 3.6**). Seawalls are tall, hard structures built along the coastline at the land/water interface. They protect other coastal infrastructure by stopping the natural movement of sand by the waves, thus preventing the natural landward erosion of the beach (**Figure 3.7**) (Nordstrom, 2003).

All these structures, while beneficial for economic development, interfere with the natural dynamics of the shoreline. Groins and jetties sand-starve their downdrift areas, creating high rates of erosion, converting the shoreline topography to overwash flat and altering vegetation assemblages (Beatley et al., 2002; McCartney, 1985). Seawalls can cause increased erosion in adjacent areas of the beach without seawalls, known as flanking erosion (Beatley et al., 2002; Nordstrom, 2003). All parts of the marine-terrestrial interface are interrelated and dependent on one another, meaning that change or damage to one part can impact the whole ecosystem (Beatley et al., 2002).

The establishment of beach-dune ecosystems in affected areas, can minimize shoreline erosion, increase biodiversity and lead to the creation of healthy, natural beach areas that are economically viable and sustainable (Doody, 2013; Olson, 1958a, 1958c).

Figure 3.4 Jetties at Bayfield Main Beach (Google Maps, 2019a).

Figure 3.5 Jetties and breakwaters at Goderich Main Beach (Google Maps, 2019b).

Figure 3.6 Jetties and a breakwater at the Kincardine marina (Google Maps, 2019c).

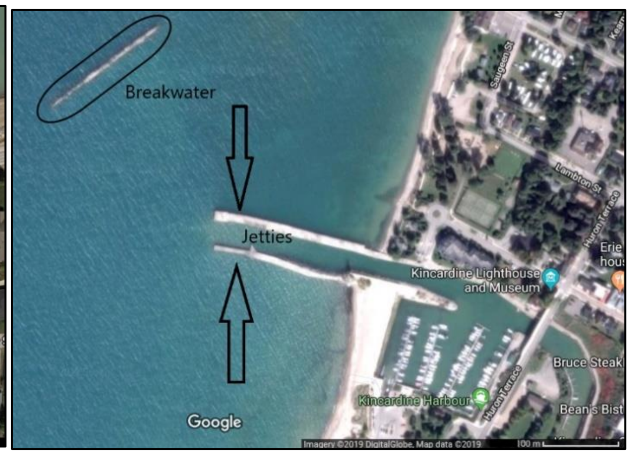

Figure 3.7 Seawall in Sarnia, Ontario (Google Maps, 2019f).

In October of 2018, the United Nations Intergovernmental Panel on Climate Change (IPCC) released a special report as part of their Sixth Assessment cycle. It reported on how global warming projections of 1.5ºC above pre-industrial levels are no longer just projections or model estimations, but are in fact, a reality. By 2030, it is certain that the planet will have warmed an average of 1.5ºC and will face the detrimental consequences of this which include extreme drought, wildfires, mass die-off of the Coral Reef, floods and food shortages for hundreds of millions of people, many of which have already surfaced in many parts of the world (IPCC, 2018). The effects that climate change will have on the Great Lakes basin are expected to include: increased air and water temperatures, decreased winter ice cover, erratic wind and wave conditions, biodiversity shifts (Peach, 2016). These effects are part of a complex system with many contingent interactions, and is best represented by the feedback diagram presented below in **Figure 3.8**.

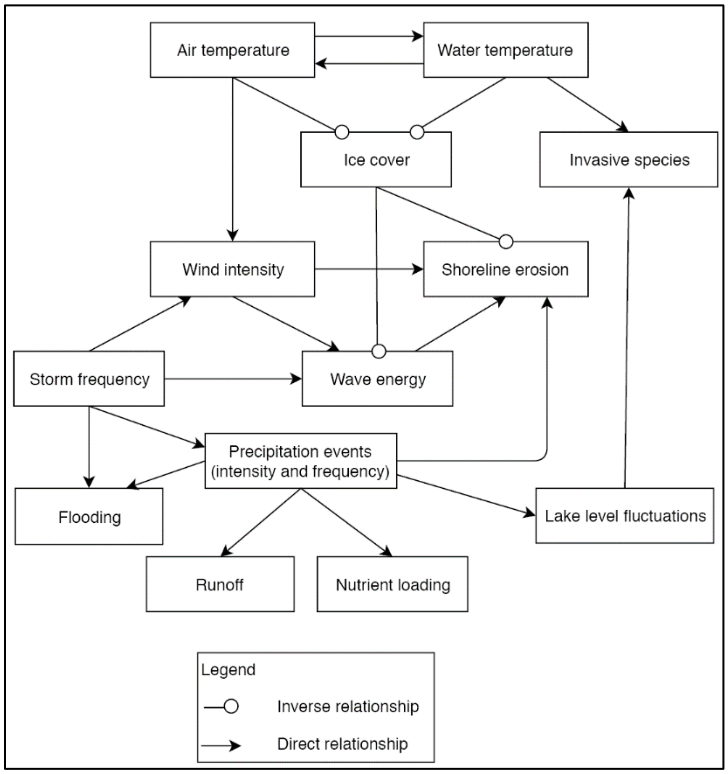

***Figure 3.8** Feedback diagram representing the local impacts of global climate change as described by Peach (2016), Smith et al. (2015), Beatley et al. (2002) and Egan (2017).*

Returning to the focal point of this thesis, knowing that ecosystem integrity is critical to resilience of the climate system at regional scales (Chapin, Kofinas, & Folke, 2009), well-managed dune systems are crucial in the face of climate change because of the many ecosystem services provided by *A. breviligulata*, the pioneer species responsible for trapping the sand and building the dunes, among other things. These will be discussed in detail later in this chapter. Beach areas whose dunes have not been damaged by humans or that have been well restored and managed, will have the strongest ability to recover from wind and wave impacts. In the face of greater extreme precipitation events, intact dunes systems will be better able to filter the excess nutrients and pathogens that run off the landscape. Generally, intact and heathy dune systems are ideal for mitigating many of the effects of climate change facing the Great Lakes, now and in the near future. In order maintain the dunes, protection and restoration measures for *A. breviligulata* must be implemented (Peach, 2016).

There are numerous invasive species affecting the many ecosystems of the GLB. At Lake Huron specifically, the prominent invasive species are *Phragmites australis* (European Common Reed), Garlic Mustard, Round Gobies, Zebra Mussels, and Giant Hogweed (LHCCC, n.d.-b). These species have been introduced from another part of the world into the Lake Huron environment and are wreaking havoc and having devastating effect on Lake

***Figure 3.9** Phragmites australis (LHCCC, 2006).*

Huron's native ecosystems (LHCCC, n.d.-b). The species that has the greatest effect on Lake Huron's beach-dune ecosystems is *Phragmites australis*.

P. australis grows in a monoculture, taking over whole sections of the shoreline and choking-out wetlands (see **Figure 3.10**). Its stalks can grow up to five metres tall, and its roots extend even deeper into the sands and soils. It is able to dominate an area by blocking sunlight to everything below it with its thick biomass. Since it grows so quickly and prolifically, its roots and rhizomes use up much of the available water and nutrients in the substrate, leaving hardly any for other species. *P. australis* is also allelopathic, meaning that it competes with other species by secreting toxins from its roots into the soil, killing any neighbouring plants very quickly (Alexander, 2012).

Figure 3.10 *Occurrence of Phragmites australis along the southeastern shoreline of Lake Huron.*

Native ecosystems are florally and faunally diverse by nature, but *P. australis* stands do not provide such diverse functionality. Wetlands and dunes are habitat to many wildlife species such as frogs, fish and aquatic invertebrates, but they cannot manoeuvre through the thick stalks and leaves of *P. australis* once it has taken over an area (Alexander, 2012).

The impacts of climate change are thought to be even more devastating for Lake Huron because of the prevalent *P. australis* invasion. Low water levels leave open spaces for *P. australis* to further establish. The expanding vegetation changes the ecosystem type completely and interrupts sand input to the dune, diminishing the ability of dune to grow and persist, and thus protect the shoreline communities from the predicted extreme weather events (Alexander, 2012).

P. australis poses a serious threat to the fragile beach-dune systems of the Lake Huron shoreline, as it reduces the natural biodiversity of the dunes, chokes out the beach grass by disrupting the sand cycle that is responsible for beach grass propagation. This shallows the water table below the beach and creates wet beaches that can attract geese and seagulls, contaminating the groundwater with *E. coli* (Alexander, 2012; A. Crowe & Milne, 2013; Edge & Hill, 2007).

3.2 Planning and management context

In terms of shoreline governance, the Ontario Ministry of Natural Resources (OMNR) Southeast Region is divided into several districts to help manage ministry programs and resources. These districts are categorized by their topographic features and township boundaries. There are three districts that cover the southeastern shoreline and surrounding area, Midhurst, Guelph and Aylmer (see **Figure 3.11**).

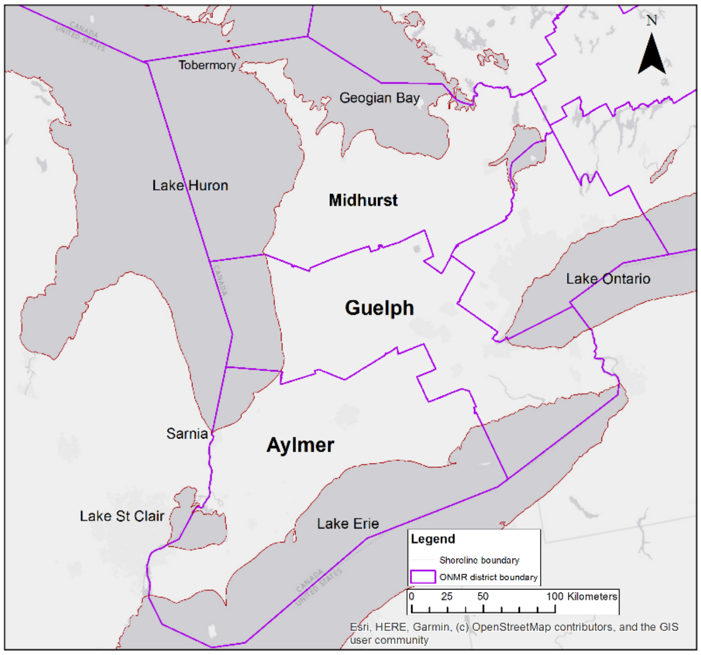

Figure 3.11 *OMNR districts in the southeast region that are along the Lake Huron southeastern shoreline (Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2008b, 2013, 2019b).*

Below this level of management, there are three counties (also called upper-tier municipalities) that govern different sections of the southeastern shoreline: Lambton County, Huron County and Bruce County. Each is divided into municipalities (also called lower-tier municipalities or townships), in which there are 18 that govern different sections of the southeastern shoreline (**Figure 3.12**). Counties and municipalities are responsible for organizing and delivering various public services to their inhabitants such as police and fire protection services, and waste management (Government of Ontario, 2018).

Furthermore, there are five conservation authorities (CAs) that also govern the shoreline: St. Clair Region Conservations Authority (SVCA), Ausable-Bayfield Conservation Authority (ABCA), Maitland Valley Conservation Authority (MVCA), Saugeen Valley Conservation Authority (SVCA), and Grey Sauble Conservation Authority (GSCA). CAs are local watershed management agencies that deliver services and programs to protect and manage water and other natural resources in partnership with all levels of government, landowners and other organizations (Conservation Ontario, 2019). CAs use an integrated watershed management approach with the aim of balancing human, environmental and economic needs. The areas that these CAs govern are organized by watershed, which means that their boundaries differ greatly from that of the municipalities and counties, such that some counties and municipalities are governed by two separate CAs (**Figure 3.13**) (Conservation Ontario, 2019).

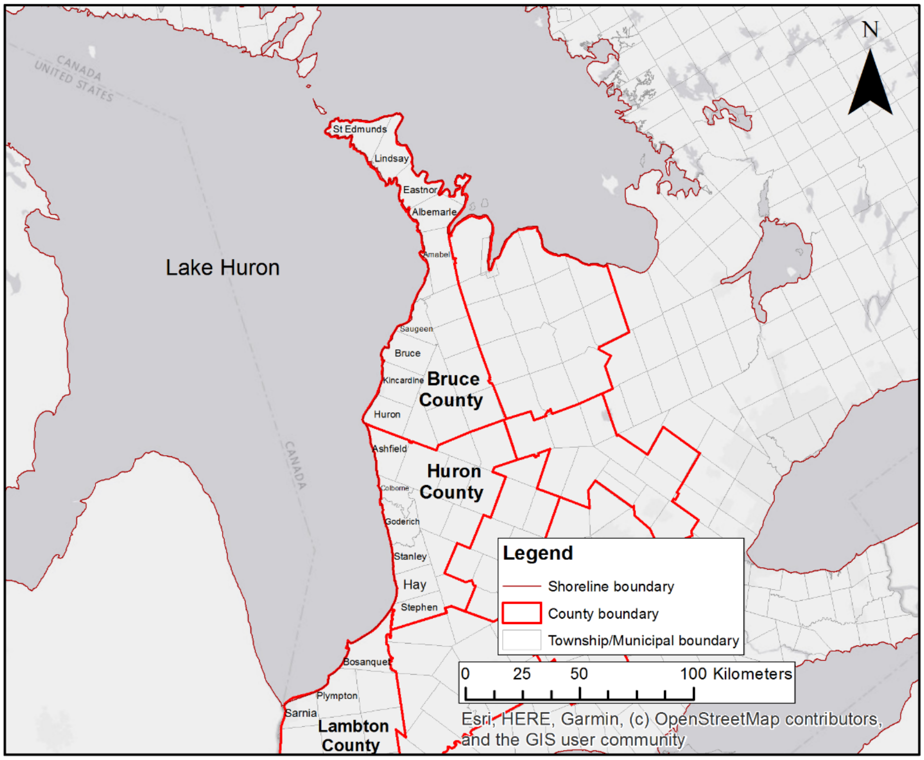

Figure 3.12 *The counties and municipalities located along the southeastern shoreline of Lake Huron (Huron County, 2019; Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2013, 2019b).*

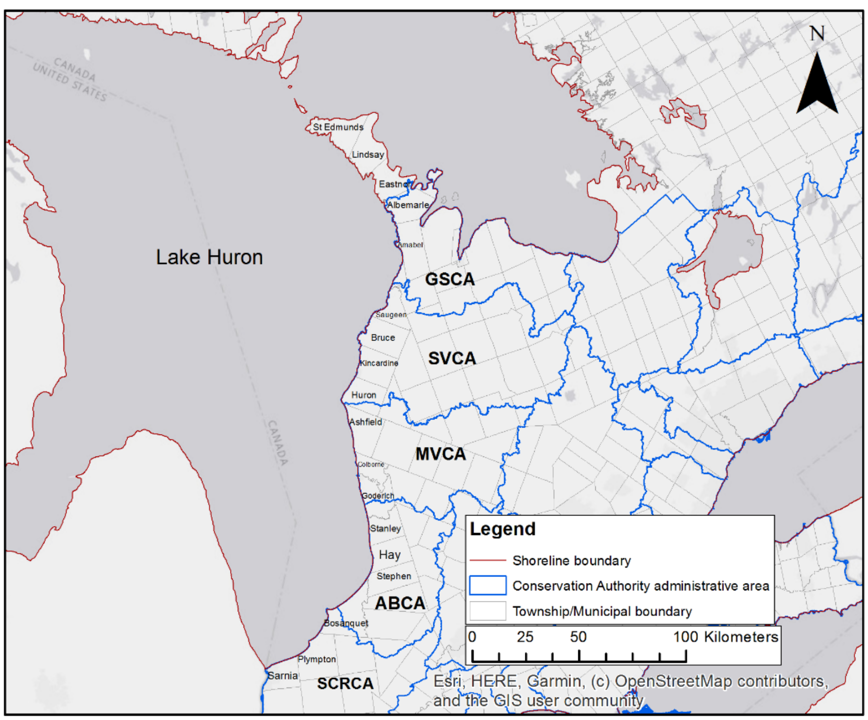

Figure 3.13 *Conservation Authority administrative areas as they overlap with municipalities (Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2013, 2019a, 2019b).*

Prior to the colonization by the British, the Saugeen Anishnaabek occupied a land base of about 8100 km^2 stretching from, what is presently known as the Town of Arthur, west to Lake Huron at the Maitland River mouth, north to Georgian Bay at Collingwood, and east to the Nottawasaga River (**Figure 3.14**). European settlement and treaty negotiations over the past couple of centuries have left the Saugeen Anishnaabek ceding all land except small marked areas of the Bruce Peninsula in **Figure 3.15** (Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2008a; Saugeen Ojibway Nation Environment Office, 2018). Today, many non-Indigenous people also live on some of these lands. For example, non-Indigenous folks living in Saugeen 29, lease the land from the Saugeen Ojibway Nation Band while recognizing and respecting the governing power the Saugeen Ojibway Nation Band has over the land.

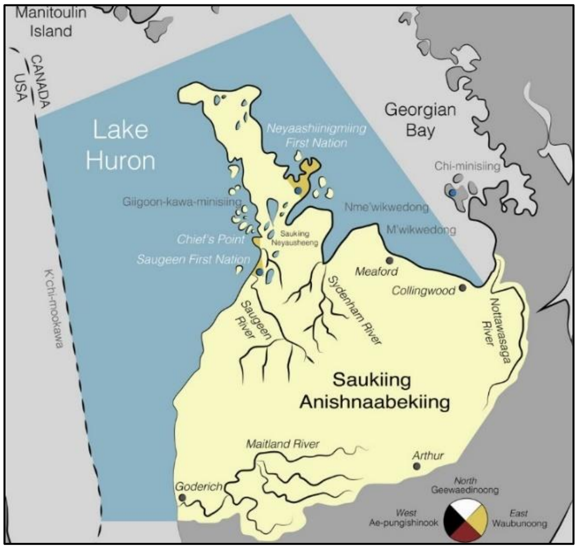

__Figure 3.14__ Map of the full extent of the Saukiing Anishnaabekiing traditional territory (Saugeen Ojibway Nation Environment Office, 2018).

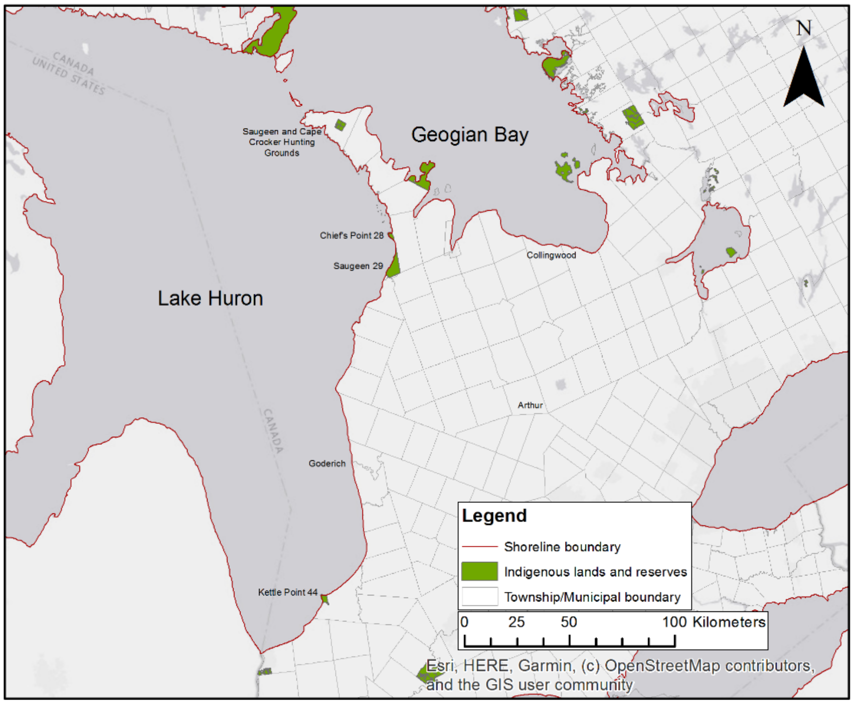

***Figure 3.15** Present-day extent of Indigenous lands and reserves along the shoreline (Ontario Ministry of Natural Resources and Forestry Provincial Mapping Unit, 2008a, 2013, 2019b).*

Under Anishnaabe law, the people are ever mindful of their duty to be stewards of the land (Saugeen Ojibway Nation Environment Office, 2018). They live intimately with the realities of life and survival on Earth, and have immense respect and gratitude for all living beings, the land, gifts of the land, elements of the earth and sky, and the web of life (Brown & Garver, 2009). Given the current anthropogenic impacts to the integral beach-dune systems of Lake Huron, adopting environmental stewardship ethics toward these systems (and all other environmental systems) as the Anishnaabe have, would be beneficial for all people because humans are fully dependent on the quality of the environment (Leopold, 1942). Following in these footsteps would entail treating the land as part of our community and not viewing ourselves as its master. In this way, human perspective of the environment greatly influences the way people treat it. Proper environmental stewardship is thus only possible when we change our perspective on it and cultivate love and respect toward it (Leopold, 1949). This holds true under Anishnaabe law, Aldo Leopold's Land Ethic, and Environmental Virtue Ethics (Leopold, 1949; Sandler, 2013; Saugeen Ojibway Nation Environment Office, 2018).

> *We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect … That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics."*
>
> *–Aldo Leopold (1949)*

3.3 Socio-economic context

The Lake Huron shoreline has a unique socio-economic context. Going by county (**Figure 3.12**), Bruce County's top three economic sectors are tourism, agriculture and energy. Bruce County receives over 2.5 million visitors each year, who bring in over $300 million/year to the local economy employing over 2300 people. The 1928 farms in the county cover more than 2000 km^2 of land and supply 22% of Ontario's beef. Thirty percent of Ontario's power is generated in Bruce County, which is home to the world's largest nuclear power plant. The vast majority (77%) of businesses in the county are located in the major urban centres of the shoreline (Port Elgin, Southampton, the Bruce Peninsula and Kincardine), the majority of which are tourism and recreation related (i.e. accommodation, food service) (Explore the Bruce, 2018).

Huron County has a population of approximately 60 000 people, 40% of who live in municipalities along the shoreline. This is a population that is aging and is older (median: 42.3 years) than the provincial average (39 years). This is a relatively high proportion of seniors (17.9%) compared to the rest of the province (13.6%). The tourism industry of Huron County is expanding, notably so in Goderich. Compared to other regions of Ontario, Huron County's economic profile has a high proportion of agriculture, and relative lack of retail and service businesses. Agriculture in Huron County comprises 35% of all businesses followed by personal, business and other services comprising 21% and retail and wholesale trade comprising 13% (Avon Maitland District School Board & Huron's Community Futures Organization, 2010).

Lambton County, has a more diverse economy than Bruce and Huron. Their top three economic sectors are petrochemicals (Sarnia-Lambton Economic Partnership, 2019b), agriculture (Sarnia-Lambton Economic Partnership, 2019a), and tourism (Sarnia-Lambton Economic Partnership, 2019c). Lambton County has over 4,500 employees in 36 petrochemical-related facilities, and is home to Ontario's largest Petrochemical and Refined Petroleum centres (Sarnia-Lambton Economic Partnership, 2019b). With an aging workforce, Lambton county has a high reliance on neighbouring municipalities to supply the local business needs with appropriately skilled workers for this and other economic sectors (Sarnia-Lambton Economic Partnership, 2015). In terms of agriculture, Lambton County's 2000 farms operating on 2100 km^2 of land, consist of traditional cash crops and animal production, as well as agri-businesses and value-added agriculture opportunities (Sarnia-Lambton Economic Partnership, 2019a). Lambton County has many sandy beaches, namely Grand Bend, and Pinery Provincial Park where popular tourist activities include sailing, wind surfing, swimming, fishing, scuba diving and camping (Sarnia-Lambton Economic Partnership, 2019c).

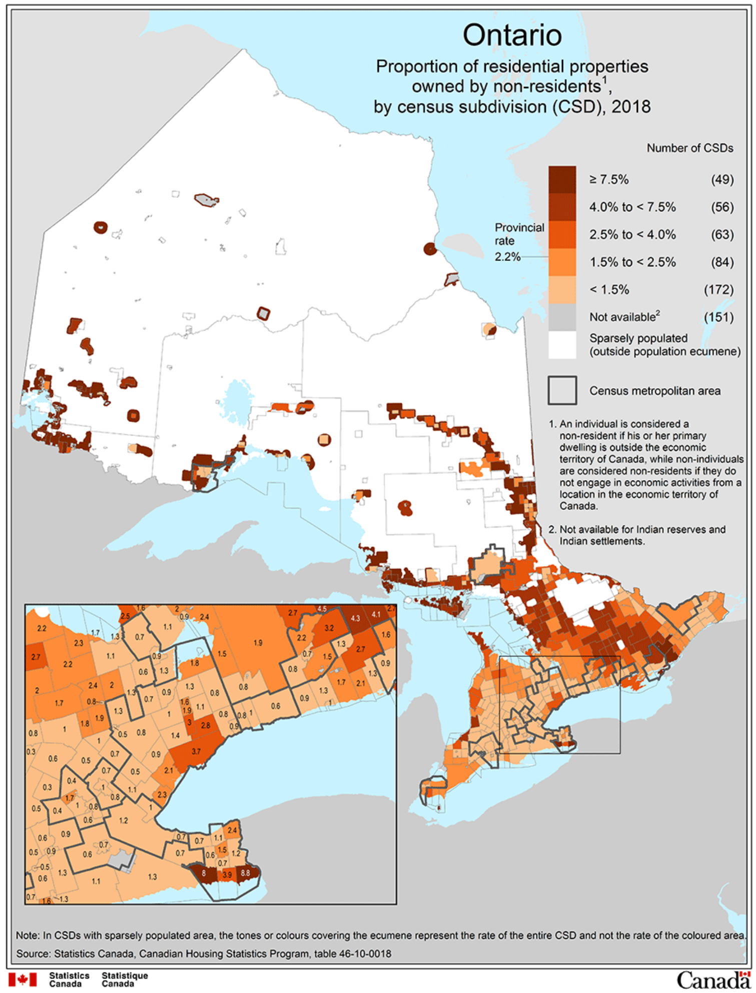

Figure 3.16 *This map shows the share of residential properties owned by non-residents, in percent, 2018 by census subdivision (CSD) in Ontario (Statistics Canada, 2018).*

According to Statistics Canada, the municipalities of the southeastern shoreline of Lake Huron (as well as the north shoreline) have relatively higher rates of residential properties owned by non-residents compared to surrounding municipalities of their respective county (Statistics Canada, 2018). This could be due to the high focus on tourism in the area, causing people to take advantage and earn profits by renting out their properties.

3.3.1 Culturally unsustainable societies

The current anthropocentric paradigm has shaped the over-consumptive patterns of the population that is leading to the global issue of over exploitation of the Earth's resources, the passing of planetary limits and thresholds and climate change (Orr, 2009). Cultures that are built around this anthropocentric world view, promote the misuse and overuse of natural resources, compromise the culture and other opportunities of present and future generations, and are therefore not environmentally sustainable (Robinson et al., 1990).

Human societies are consuming resources and producing wastes at intense rates that are burdening the coastal zone beyond its natural capacity to absorb the impact which is, by definition, unsustainable. These consumption habits and desire for growth threaten the vitality of a healthy, aesthetically pleasing, and productive coastal zone (Beatley et al., 2002). In order for a society to be environmentally sustainable, it must also be culturally sustainable, meaning that the governing system of the society must encompass the needs of the environment as well as the needs and values of the people (Lerner et al., 1997). When the latter and the former are contradictory, reconciling these competing demands can become a serious challenge for coastal planners (Beatley et al., 2002). When consumption and economic growth are prioritized over a sound ecological system, then a culture is considered to be unsustainable. This is the case of many Canadian societies, and the Lake Huron shoreline is no exception.

Impacts of culturally unsustainable societies are exerting great pressures on the shoreline. With coastal and shoreline communities gaining great popularity, population densities of these areas grow with it. When more people are using the limited coastal resources, such as groundwater, land, and fish, the carrying capacity of the region can be exceeded. This is especially concerning for the vacation season, where populations of coastal communities can double or triple (Beatley et al., 2002). All of these people spending more time at the shore must be housed, fed and entertained, putting even more pressure on the local landscape with the creation of houses, hotels, condominiums, restaurants, gas stations, shopping malls, golf courses, and piers, which all necessitate the development of roads, freeways, bridges, and parking lots (Beatley et al., 2002). This development for economic growth and recreational activities has resulted in the destruction of forests, wetlands, and beach-dune systems and degradation of water quality (Beatley et al., 2002; Peach, 2006, 2016). Homes are also becoming larger, and households, more consumptive. In addition to this, much of the new infrastructure occurs in more and more vulnerable locations as land for new construction projects becomes less available (Beatley et al., 2002). The adverse impact of a single project may not always be substantial enough to impact beyond a limited extent, but the cumulation of effects of many with other development projects, becomes a much larger ecological problem, the impacts of which are far-reaching and long-lasting (Beatley et al., 2002). Therefore, the desire of these highly consumptive, resource intensive and demanding societies to build resorts or second homes contradicts the need to preserve the ecosystems' functions in order to maintain shoreline integrity and stability, such that these shoreline and coastal communities can continue to thrive (Beatley et al., 2002; Doody, 2013).

On top of this, the increased surface area of impervious materials for the various development projects and the infrastructure supporting them increases runoff into the lake. This is a significant effect of culturally unsustainable societies because they release a high volume of nutrients into the water systems through their wasteful, disposable lifestyles as well as through intense industrial farming occurring nearby.

Another aspect of culturally unsustainable societies is the endorsement of beach grooming by municipalities as an economic initiative to make the beach more attractive to tourists and other beach users, as flatter beaches are more conducive to typical recreational beach activities (Davenport & Davenport, 2006). Beach grooming is the process of mechanically flattening the beach using a tractor pulling a tilling rake, and is done at several shoreline beaches at Lake Huron (Peach, 2006). While being more attractive to tourists, beach grooming increases the beach's susceptibility to wind and water erosion by damaging the fragile beach-dune ecosystems (Davenport & Davenport, 2006; Doody, 2013). The tilling rake obliterates the sand-binding beach vegetation, particularly, *A. breviligulata*, degrading dry beaches into wet beaches overtime which can then lead to massive *E. coli* outbreaks in the water (A. Crowe & Milne, 2013). Beach grooming thus effectively undermines the critical relationship between lake levels and dune development, compromising shoreline stability and the natural water cycle (Peach, 2006).

3.4 Chapter conclusion

The building of this case study context is crucial for building the skeleton of the survey, the purpose of which is to understand how shoreline community members interact with the beach grass in the environment and how they draw social well-being from the ESs beach grass provides. Understanding the diverse topography, sectoral management structure, and the unique socio-economic setting of the southeastern shoreline of Lake Huron will aid in creating survey and interview questions, as well as in the interpretations of the answers provided by survey respondents and interview participants. The methods used to create the survey and interview guide and analyze the results are outlined in the following chapter.

Chapter 4 – Methodology and Methods

In this chapter, I outline the methodology and methods used to conduct this research, and include information on my approach to data analysis. I also discuss the limitations of my approach, and the strategies used to address any limitations.

4.1 Methodology

My research employed a mixed methods case study-based approach. The case study that is the focus of my research is the defined southeastern shoreline of Lake Huron (Section 1.2.3), and it follows the criteria for a case study outlined by Yin (1998):

1. Explanatory elements to explain how beach grass ecosystems services affect social well-being through perceptions of beach grass;
2. Descriptive elements to document the ESs that are valued by community members and beach visitors; and
3. Exploratory elements to generate data for future research on ES and social well-being policy linkages through community-based management of the shoreline.

These elements aid in the understanding and explanation of the causal links and pathways resulting from ongoing coastal planning efforts, and how a well-being-focused integrated management framework will function within the local community (Yin, 1998). Furthermore, my research involved analysis of 1) attributes of individuals, communities, and the current social-ecological system; and 2) attitudes, values, and beliefs as they relate to beach grass ESs and various dimensions of social well-being.

The quantitative and qualitative methods of this research followed an explanatory sequential research design (**Figure 4.1**) (Creswell & Plano Clark, 2018), in which three sources of data (i.e. literature review, survey and semi-structured interviews), are used to corroborate, or triangulate, research findings (Silverman, 2005).

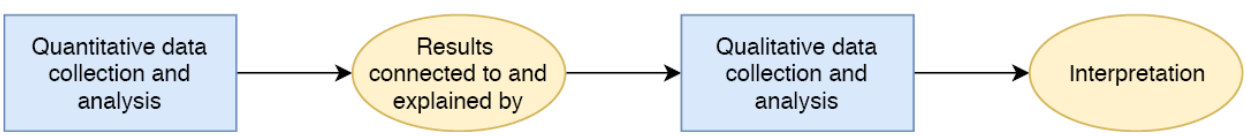

Figure 4.1 *Explanatory sequential mixed methods research design (Creswell & Plano Clark, 2018).*

4.1.1 Case study approach

My research examines a specific group of people in a defined area and is thus considered a case study approach (Yin, 2012). This type of approach is valuable because it embraces the complexity and unique social sphere of a specific issue and permits a deeper understanding when examining an issue (Yin, 2012). Case studies are rarely generalizable in a statistical sense, meaning that they are not designed to be representative of some larger population. They instead, provide great value through analytic generalization, meaning that the theoretical frameworks of case studies can be used to create a logic that might be applicable in other situations (Yin, 2012).

A case study approach is suitable for situations where 1) information on 'what,' 'how' and 'why' questions needs to be captured; 2) contemporary phenomena are to be investigated within their natural contexts; and 3) an experimental approach will not appropriately answer the research questions (S. Crowe et al., 2011; Yin, 1998). My research fits these conditions. First, the main questions to be addressed are: What ecosystem services are valued by shoreline community members and beach visitors? How do knowledge and importance of beach grass interact to influence the actions of shoreline community members and beach visitors toward it? Why is beach grass along the Lake Huron shoreline changing? How are these changes linked to the social well-being of shoreline community members and beach visitors? What gaps exist in current coastal planning efforts that have allowed for changes to beach grass to occur? Why would a community-based management approach work for the southeastern shoreline of Lake Huron? Second, my research highlights issues relating to climate change, cultural sustainability and coastal resource conservation, which are both contemporary and enduring issues. Third, examining human-environment interactions (i.e., effects of beach grass perception on actions/behaviours and how beach grass affects social well-being) in anything outside its natural context can introduce limitations and unreliable research data.

A case study approach further aligns with my main research goal, "to enhance opportunities for coastal protection along the southeastern shoreline of Lake Huron by assessing the underlying drivers of change with regard to beach grass, and understanding how coastal resource users (e.g., property owners) perceive the value of the ecosystem services beach grasses provide." The specific contextual results of this thesis will ideally be useful for and contribute to the CAP.

Embedding a WEBs framework within a case study approach connects the economic valuation of the environment to the lives of real people in real socio-economic settings. Here, the case study approach allows for the translation of abstract ES information into tangible and convincing terms that can demonstrate how ESs affect the social and economic spheres of a given society (A. Wilcox & Harte, 1997).

4.2 Data collection methods

In the context of my case study-based research, I employed both deductive and inductive methods to create an explanatory sequential research design with the intent of complementing the qualitative strand of data with quantitative data (Creswell & Plano Clark, 2018). A deductive approach used the research data to verify the information that had been established through the literature review and conceptual framework.

Creswell and Plano Clark (2018) refer to this as working from the top, down (Creswell & Plano Clark, 2018). An inductive approach served to complement the deductive approach by accommodating the new information that arose throughout the research process, as well as to build a framework in which uncertainties could be analyzed. When conducting qualitative research that involves people, it is important to remain objective by keeping an open mind and being willing to listen (Corbin & Strauss, 2015). This is a crucial aspect of inductive research. Creswell and Plano Clark (2018) refer to this as working from the bottom-up, as it uses the participants' perspectives to build on existing themes, generate new ones and build connections between observations and theories (Creswell & Plano Clark, 2018). The inductive approach proved to be advantageous, as research goals needed to be adjusted to accommodate the emerging data (Corbin & Strauss, 2015).

The three methods used in the data collection process are summarized below in **Table 4.1**. Each one will be more thoroughly discussed in the following sections.

Table 4.1 *Overview of the data collection phases.*

Method	Purpose
Literature review	• Build context for the case study by identifying relevant historical information and establishing familiarity with the research field through geographic, historical, political and ecological lenses • Create the research questions • Form the conceptual framework • Deductively build the survey questions and interview guide in a context-specific manner • Triangulate (assuring the validity of results by using multiple data collection methods) data from the survey and semi-structured interviews
Surveys	• Add a quantitative component to the research • Triangulate data from literature review and semi-structured interviews • Identify specific linkages in ESs, beach grass perception, and dimensions of social well-being • Identify opportunities to improve coastal resource management with respect to beach grass and social well-being of shoreline communities
Semi-structured interviews	• Gather data on beach grass change, and general coastal resource management. • Triangulate data from literature review and survey • Examine linkages between beach grass perception, and dimensions of social well-being in greater detail • Identify opportunities to improve coastal resource management with respect to beach grass and social well-being of shoreline communities

4.2.1 Literature review

The literature review in this thesis was a crucial tool in developing a knowledge base within the research field (Seuring & Gold, 2012). In this context, it was used to provide evidence for the purpose of the study, identify the contextual underlying problems and formulate the research questions based on these issues, and finally to validate collected data (Creswell & Plano Clark, 2018). More specifically, the literature review aided in the understanding of the history of the management of Lake Huron, and the Great

Lakes Basin as a whole. This built context for the research by identifying flaws in the previous management strategies and providing grounds for new management strategies. The literature review also served as the foundation for defining important topics, such as ESs and well-being, and helped to build a and manageable entry point for the project. For example, I explored ecosystem elements that are important to not only basic ecosystem functioning, but also to maintaining social well-being for the Lake Huron environment. The literature review was used to explore how the ES and social well-being discourses can be tied together and incorporated into future management of the Lake Huron.

My entry point for the literature review was to examine ESs related to beach grass (*Ammophila breviligulata*) along the Lake Huron shoreline. This entry point was chosen due to the national significance of the Lake Huron beach-dune ecosystems, their vulnerability to human pressures, contribution to coastal system resilience and ability to mitigate local effects of climate change (Cann, 2018; LHCCC, n.d.-a; Peach, 2016). As noted in Section 1.2.4 (*Beach grass and the changing Lake Huron shoreline*), effective management strategies for beach grass along the Lake Huron shoreline are important for the quality of the beaches, resilience to climate change and thus, the well-being and safety of those who use the beaches and reside along the shoreline.

The literature review also served as the main guide for the creation of the survey questions, and semi-structured interview guide. The literature review contributed mostly to the deductive portion of the analysis (Creswell & Plano Clark, 2018). Thus, the information synthesized in the literature review served as validation for information obtained in the survey, and interviews, but did not place limits on the interpretation of any contradictory or new data that emerged in the results.

4.2.2 Surveys

Property owners and beach visitors in the specific study area of the shoreline were the primary target group for the survey. Since most of the southeastern shoreline is privately owned, this group of people represent a very important feature of the shoreline. To gather survey participants from this group, the method of subject recruitment is important because it needs to produce a sample that can be considered representative of the population of the whole southeastern shoreline of Lake Huron. Recruitment also affects the generalizability of the insights and results. The more subjects recruited, the more generalizable the results can potentially be (Harrell & Bradley, 2009). Since my research ties in directly with the CAP, the results need not be generalizable beyond this area (LHCCC, 2016).

Probability sampling methods are used for surveys and interviews when the researcher wishes to interview a large number of people and generalize the findings to a wider population (Van den Hoonaard, 2012). Non-probability sampling methods are used when the researcher wishes to gain the greatest insight possible about a small and specific group of people and when people with specific qualities are needed to provide the required information needed about the topic at hand (Van den Hoonaard, 2012). That being said, for the context of my research, non-probability snowball sampling was the most appropriate method. Snowball sampling is a process whereby participants refer a researcher to potential other participants, who then refer the researcher to more potential participants, and so on (Noy, 2008). Selecting subjects for the survey and interviews randomly would have likely not been successful because it is possible that many people chosen randomly would not have the qualities needed to provide me with the information needed to achieve my research goals. Snowball sampling avoided these potential issues for both surveys and semi-structured interviews. Additionally, considering that I was initially unfamiliar with the study area, snowball sampling was an efficient method of connecting with shoreline community members, and allowed me to make the best use of my time and resources during my field work.

For this thesis, the goal was to collect between 50 and 200 survey respondents, and 10-30 interview respondents. This sampling process has been shown to increase sampling bias, as there is a tendency of selecting participants based on their availability, willingness, interest in the subject, and friendliness (Salant & Dillman, 1994). It is possible that this bias affected the data collection for this research. The sampling process also potentially increased sampling error in this study because the final sample may not be truly representative of the target population (Salant & Dillman, 1994).

The sampling and participant scoping for this thesis took place in four phases. The first phase consisted of contacting cottage owner associations established along the Lake Huron southeastern shoreline (4.2.2.1). The second phase consisted of contacting organizations established along the Lake Huron southeastern shoreline (4.2.2.2). The third phase consisted of posting in local businesses along the Lake Huron southeastern shoreline (4.2.2.3). The fourth phase consisted of contacting members of the steering committee for the Coastal Action Plan for the southeastern shore of Lake Huron for the key informant interviews (4.2.3.1).

4.2.2.1 Contacting cottage owner associations

The initial participant scoping phase began shortly after approval by the Office of Research Ethics at the University Waterloo (ORE) and creation of the online survey (see Section 4.5). It involved online searches to find the various cottage owner associations established along the Lake Huron southeastern shoreline with the goal of attending their annual general meetings (AGMs). From the publicly available online information, it was established that many cottage associations already had their AGMs for 2018, earlier that summer, and therefore, I attended only two cottage owner association AGMs during the field season. Other cottager associations that I reached out to were still able to distribute the survey information letter to their members via email. For full detail on this process, see **Table 4.2**.

Table 4.2 *Contacting various cottager associations along the Lake Huron southeastern shoreline.*

Cottager Association	Method of contact[1]	Point of contact	Action(s) done[1]
Bluewater Shoreline Residents Association (BSRA)	"Contact Us" form on BSRA website (BSRA, 2019)	Moderator of BSRA AGM	• Meeting moderator left 100 copies of the survey information letter on the seats laid out for the attendees[2] • Information letter posted on BSRA website
Saugeen Cottagers' Organization Incorporated (SCOI)	"Contact Us" form on SCOI website (SCOI, 2019)	SCOI President	• Attended AGM • Spoke to attendees at the end of the meeting • Passed out survey information letter to those that expressed interest in potentially participating in the survey • Information letter posted on SCOI website
Port Franks Beach Homeowners' Association (PFBHA)	Publicly available email address on PFBHA website (PFBHA, 2008)	PFHBA president	• Attended AGM • Made a short presentation. • Passed out survey information letter to those who expressed interest in potentially participating in the survey • Information letter posted on the PFBHA website
Bruce Beach Cottagers' Association (BBCA)	Publicly available email address on (Huron-Kinloss, 2018)	BBCA president	• President distributed survey information letter to the ~450 BBCA members via their email contact list[2]
Ashfield-Colborne Lakefront Association (ACLA)	Publicly available email address (North West Huron, 2008)	ACLA communications coordinator; Huron Sands Beach Association president	• Huron Sands Beach Association president distributed survey information letter to members via their email contact list[2]
Port Albert Citizens' Association (PACA)	Publicly availably email address (PACA, 2019)	PACA president	• President distributed survey information letter to PACA members via their email contact list[2]
Centre Ipperwash Community Association (CICA)	"Contact Us" form on the CICA website (CICA, 2019)	CICA chair	• President distributed survey information letter to CICA members via their email contact list[2]
Point Clark Beach Association (PCBA)	Publicly available email address (Huron-Kinloss, 2018)	PCBA president	• President distributed survey information letter to PCBA members via their email contact list[2]

[1] All verbal and written communications were done using the guidelines created in my recruitment script submitted and approved by the ORE.

[2] They were able to voluntarily read it and contact me if they wished to participate.

Lurgan Beach/Blairs Grove Association	Publicly available email address (Huron-Kinloss, 2018)	Lurgan Beach/Blairs Grove Association secretary	• Secretary distributed survey information letter to Lurgan Beach/Blairs Grove Association members via their email contact list[2]
Port Elgin and Saugeen Township Beachers' Organization	Publicly available email address (Port Elgin and Saugeen Township Beachers' Organization, 2019)	Port Elgin and Saugeen Township Beachers' Organization president	• President completed the survey himself • President distributed survey information letter to members via their email contact list in the E-newsletter[2]

Finally, I contacted[1] Horizon View Estates Cottage Association and Greenough Harbour Preservation Association and received a response back stating that they do not have beach grass in their area, and it would therefore not be appropriate to collect responses from these areas.

There were several cottage owner associations that I contacted[1] and from which I did not receive any responses: the Southampton Residents' Association, Cedar Grove Cottage Association, Bayfield Ratepayers' Association, St. Edmunds Property Owners' Association, Amberley Beach Cottage Association, and Pike Bay Community Association. All cottager associations listed in this first phase of sampling and participant scoping were initially contacted a maximum of three times each, within three months of not responding to the first initiation of contact.

4.2.2.2 Other organizations located along the shoreline

The second participant scoping phase took place in tandem with the first phase, and involved online searches to find various organizations established along the Lake Huron southeastern shoreline. My goal here was to contact shoreline community members that are eligible and willing to take the survey. For full detail on this process, see **Table 4.3**.

Table 4.3 *Contacting various organizations along the Lake Huron southeastern shoreline.*

Organization	Method of contact[1]	Point of contact	Action(s) done[1]
LHCCC	Event listed in the LHCCC monthly newsletter (LHCCC, 2018)	LHCCC staff	• Attended the Goderich shoreline cleanup • Spoke to attendees during the event • Passed out survey information letter to those who expressed interest in potentially participating in the survey
Healthy Lake Huron	"Contact Us" form on website (Healthy Lake Huron, 2019)	Communications Sub-committee member of Healthy Lake Huron	• Posted a call for survey participants on Healthy Lake Huron website • Call for survey participants distributed in Healthy Lake Huron monthly email newsletter
Kincardine Horticultural Society	Publicly available email address on website (Kincardine, 2019)	Kincardine Horticultural Society president	• President distributed survey information letter to members via their email contact list[2]

Grand Bend Yacht Club	"Contact Us" form on website (Grand Bend Yacht Club, 2019)	Grand Bend Yacht Club Commodore	• Commodore distributed survey information letter to members via their email contact list[2]
Bayfield Breeze	Publicly available email address from website (Bayfield Breeze, 2018)	Editor-in-Chief	• Posted a call for survey participants on in Bayfield Breeze newspaper in two weekly issues
Kincardine Tourism	Publicly available email address from website (Kincardine Tourism, 2016)	Kincardine Tourism Coordinator	• Posted a call for survey participants on Kincardine tourism social media channels
Ausable-Bayfield Conservation Authority	"Contact Us" form on website (ABCA, 2019a)	Healthy Watersheds Manager	• Forwarded survey information letter to their cottage owner association contacts
Ontario Phragmites Working Group	Publicly available email address from website (Ontario Phragmites Working Group, 2019)	Ontario Phragmites Working Group Representative	• Completed the survey herself • Forwarded survey information letter to their contacts at Windsor Park Association, Richmond Park Cottagers' Association, and Armstrong East and West • Posted a call for survey participants on their website
Pine River Watershed Network	Publicly available email address from website (Pine River Watershed Network, 2019)	Office manager	• Forwarded survey information letter to their cottage association contacts • Posted a call for survey participants on their website

There were several organizations that I contacted[1] and from which I did not receive any responses: Kincardine municipality, Kincardine News, Kincardine Independent Newspaper, Bluewater Municipality, Goderich Signal Star, Lambton Shores Phragmites Community Group, Lambton Shores municipality, and Grand Bend Horticultural Society. All organizations listed in this phase of sampling and participant scoping were initially contacted a maximum of three times each, within three months of not responding to the first initiation of contact.

4.2.2.3 Postings in local businesses

The third participant recruitment phase took place in tandem with the first two phases, and involved visiting or emailing local businesses at various field sites and asking permission to post a call for survey participants in their establishment with the goal of getting in contact with shoreline community members that are eligible and willing to take the survey. For more information on this process see **Table 4.4**.

Table 4.4 *Contacting various local businesses along the southeastern shoreline of Lake Huron.*

Establishment	Method of contact[1]	Point of contact	Action(s) done[1]
Sauble Beach Library	Publicly available email address from website (Bruce County Public Library, 2019a)	Sauble Beach Library	• Posted a call for survey participants on their bulletin board
Southampton Public Library	Publicly available email address from website (Bruce County Public Library, 2019b)	Southampton Library	• Posted a call for survey participants on their bulletin board
The Culinary Poet (Goderich)	In-person visit	Staff member	• Posted a call for survey participants on their bulletin board
Fincher's Books and Gifts (Goderich)	In-person visit	Staff member	• Posted a call for survey participants on their bulletin board
Cravings (Goderich)	In-person visit	Staff member	• Posted a call for survey participants on their bulletin board
The Dollar Store (Goderich)	In-person visit	Staff member	• Posted a call for survey participants on their bulletin board
Ashanti Café (Port Elgin)	In-person visit	Staff member	• Posted a call for survey participants on their bulletin board
Port Elgin Community Complex	Publicly available email address from website (Town of Saugeen Shores, 2019)	Programs and Facilities Booking Coordinator	• Visited community complex • Posted a call for survey participants on their community bulletin board
Bayfield Town Hall	Publicly available email address from website (Bayfield Townhall, 2019)	Rental Coordinator	• Forwarded survey information letter to contacts with high interest in the shoreline • Posted a call for survey participants on their community bulletin board

There were several local businesses that I contacted[1] and from which I did not receive any responses: Tobermory Public Library, Tiverton Public Library, Ripley Public Library, Port Elgin Public Library, Kincardine Public Library, Fitness Corner Southampton, Fitness Corner Port Elgin, and Saugeen Shores Centennial Pool. All businesses listed in this phase of sampling and participant scoping were initially contacted a maximum of three times each, within three months of not responding to the first initiation of contact.

4.2.2.4 Outcomes of participant recruitment and survey structuring

A total of 127 survey responses were collected. Of these, two were completed over the phone at the respondent's request, and the rest were completed online. Four online survey respondents did not fill out the consent form, despite answering other survey elements, and were therefore removed from the respondent pool (n=123). Survey participants rarely completed the entire survey, and thus, each question varies in its final sample size (n). The survey used in this thesis aimed to address all of the research objectives (Section 1.1, *Research goals and objectives*).

The survey included multiple-choice, and Likert-scale questions to gain basic information on the respondent regarding their interaction with the Lake Huron shoreline (and beach grass in particular), perceived social and ecological benefits of beach grass, observed changes in beach grass along the shoreline, impacts on the three dimensions of social well-being, and insights from the respondents for better management practices for beach grass along the Lake Huron shoreline. These questions were structured to elicit specific information as per the issues noted above. As such, the goal of the survey is to assess a larger number of respondents more efficiently (Bryman, 2016). However, as the surveys were self-administered (with the exception of the two telephone interviews), opportunities to clarify questions is limited. This potentially led to variations in interpretations of key questions and terms among respondents.

Additionally, the questions in the survey may not have included all options that a respondent believed to be the most relevant option, leading to invalid data collected and lack of appropriate variance in responses (Bryman, 2016). To mediate this as best possible, various ‘other’ options were provided, wherein the respondent can add in a different response or elaborate. For example, in the question referring to the change in area/extent of beach grass on a specific beach within the past 5-10 years, there could be many reasons for this and many different perceptions of change. These responses might not be captured in a short, multiple choice question. Therefore, the most common reasons, obtained from the literature review, are listed in the question, while space for the respondent to add a different perceived reason was included. All survey questions can be found in Section 11.1 (*Appendix A*).

Example survey question: In your view, what is the main reason for the change?

a) It naturally died out
b) Intentional removal
c) Impacted by invasion of European Common Reed (*Phragmites australis*)
d) Other (if so, specify) ___________
e) Unsure

4.2.3 Semi-structured interviews

Semi-structured interviewing allows the researcher to view the research topic from the perspective of the interviewee, and typically, someone who is directly involved in a particular issue or context. Semi-structured interviews help to provide insights into a specific context by connecting it to real world experiences accounted for by the interviewee (Cassell & Symon, 2004). Semi-structured interviews can also help the researcher understand how organizations function by offering insight to how behaviours and systems are interrelated, as well as capture the ways in which people interpret events, experiences and relationships (van Teijlingen, 2014). The aim of semi-structured interviews is to ask guiding questions that help understand the data in its appropriate context. 'What' and 'how' questions establish what the issues at hand are. 'Who,' 'where' and 'when' questions focus on specific events, and involve individuals and activities that are related to issues of concern. The 'why' questions aim to understand the thoughts and reasoning behind people's actions, how they think and what makes sense to them in a particular situation (Berg, 2004). Semi-structured interviewing can be particularly effective where interviewees elaborate on issues and perspectives directly linked to research objectives, or where unexpected or new information surfaces during the interview. Such insights can be further investigated during the interview.

The semi-structured interviews in my research thesis examined the views of key informants from relevant organizations. More specifically, the aim of the semi-structured interviews in this thesis was to address research objectives 1, 2, 4 and 5 (see Section 1.1, *Research goals and objectives*) and to validate and add richness to the survey responses.

4.2.3.1 Interview sampling

The fourth participant recruitment phase was devoted to finding participants for the key informant interviews. This phase took place after the preliminary results of the survey had been collected and briefly summarized. It involved contacting[1] members of the steering committee for the Coastal Action Plan for the southeastern shore of Lake Huron, and arranging phone interviews with those who were interested.

As the starting point of the snowball sampling for the interviews, nine members of the steering committee were initially contacted with the intention using these members as points of contact for further snowball sampling. In total, four members responded to this initial contact, and therefore only four interviews were performed. In this respondent pool, these key informants have extensive background knowledge of the Lake Huron shoreline, as well as of various levels of governance that take place along the shoreline. The pool of key informants interviewed includes LHCCC staff, OMNR officials, and CA employees. These interviews were recorded with the verbal and written consent of the interviewees. All participants were asked the same set of questions as presented in the interview guide (Section 11.2 (*Appendix A*)), however, as with all semi-structured interviews, flexibility in the questioning was allowed to further explore a specific topic or question when needed.

4.3 Data Analysis Methods

This section describes the methods used to analyze the data collected from the survey, and semi-structured interviews, and includes an explanation of how the multiple components of the results were synthesized.

4.3.1 Survey analysis

The data collected from the survey included quantitative and qualitative responses. Quantitative responses were primarily analyzed with descriptive statistics, including simple percentage calculations, Likert scale scoring, Spearman correlations, and Likert-scale score categorization. Qualitative responses were coded in NVivo and manually to identify general patterns and common insights, as well as unique insights that added insight on the survey results.

4.3.1.1 Quantitative analysis

Descriptive statistics (e.g. percentage calculations) were used to analyze the following survey data sets:

1. Beach user types (**Table 5.2**)
2. Beach user access frequency (**Table 5.3**)
3. Observed beach grass change (**Table 5.4**)
4. Self-reported knowledge levels (**Table 5.8**)
5. ES importance levels (**Table 5.9**)
6. Actions/behaviours toward beach grass (**Table 5.10**)
7. Valued ESs (**Table 6.2**)

The equations used in these calculations can be found in Chapter 12 (*Appendix B*).

Spearman correlation calculations were used to analyze the following data sets:

1. Relationship between self-reported knowledge and importance levels of beach grass ESs (**Table 5.11**)
2. Relationship between beach grass ES importance and actions/behaviour toward beach grass (**Table 5.12**)
3. Relationship between self-reported knowledge levels and actions/behaviours toward beach grass (**Table 5.12**)
4. Relationship between dimensional changes of beach grass and average material well-being of survey respondent. (**Table 7.4**)
5. Relationship between average changes of beach grass and material well-being indicators. (**Table 7.5**)

6. Relationship between dimensional changes of beach grass and relational well-being of survey respondents. (**Table 7.9**)
7. Relationship between average changes of beach grass and relational well-being indicators. (**Table 7.10**)
8. Relationship between dimensional changes of beach grass and subjective well-being of survey respondents. (**Table 7.14**)
9. Relationship between average changes of beach grass and subjective well-being indicators. (**Table 7.15**)

In order to carry out these calculations, the narrative responses for each data point was converted into a numerical scale (see the coding system summarized in **Figure 4.2**).

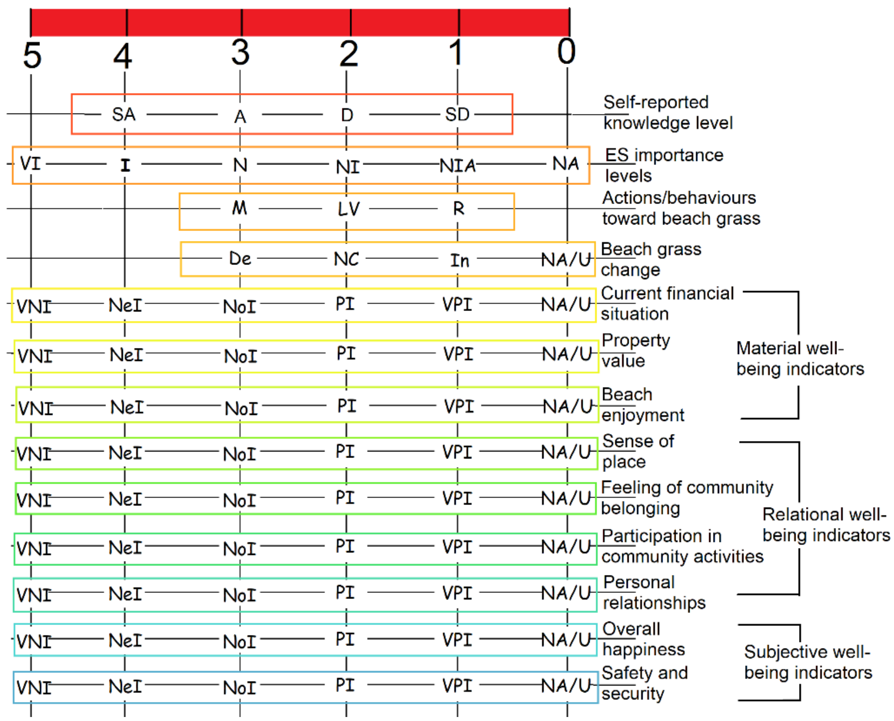

Figure 4.2 *Coding used to convert worded answers from Likert scales to numeric values. SA= Strongly Agree; A= Agree; D= Disagree; SD= Strongly Disagree; VI= Very Important; I= Important; N=Neutral; NI= Not Important; NIA= Not Important at all; NA= Not Applicable; M= Maintain/Augment it; LV= Leave it be/take no action; R= Try to get rid of it; De= Decrease; NC= No change; In= Increase; U= Unsure; VNI= Very Negatively Impacted; NeI= Negatively Impacted; NoI= No Impact; PI= Positively Impacted; VPI= Very Positively Impacted.*

As outlined in **Figure 4.2**, not all data sets to be correlated are on the same numeric scale. To remediate this issue, all Likert scales were converted to a five-point scale. The scale conversions were completed using **Equation 4.1** and **Equation 4.2**.

$$X_5 = \frac{(B-A)(X_4-a)}{b-a} + A \text{ (Colman, Norris, \& Preston, 1997)}$$

Equation 4.1 *To convert values from a 4-point Likert scale to equivalent 5-point Likert scale values.* X_5 *represents the value on the 5-point Likert scale, B is the maximum value of the 5-point Likert scale, A is the minimum value of the 5-point Likert scale,* X_4 *represents the value on the 4-point Likert scale, a is the minimum value of the 4-point Likert scale, and b is the maximum value of the 4-point Likert scale.*

Using **Equation 4.1**, the four points on the Likert scale for self-reported knowledge were fitted to the five-point Likert scale: "Strongly Agree" valued at 5, "Agree" at 3.66, "Disagree" at 2.33, "Strongly Disagree" at 1.

$$X_5 = \frac{(B-A)(X_3-a)}{b-a} + A \text{ (Colman et al., 1997)}$$

Equation 4.2 *To convert values from a 3-point scale to equivalent 5-point scale values.* X_5 *represents the value on the 5-point scale, B is the maximum value of the 5-point scale, A is the minimum value of the 5-point scale,* X_3 *represents the value on the 3-point scale, a is the minimum value on the 3-point scale, and b is the maximum value of the 3-point scale.*

Using **Equation 4.2**, the three points on the Likert scale for actions/behaviours toward beach grass and observed beach grass changes, were fitted to the five-point Likert scale: "Maintain it/Try to augment it" valued at 5, "Leave it be/take no action" at 3, and "Try to get rid of it (i.e. consider it a nuisance)" at 1; "Decrease" valued at 5, "No change" at 3, "Increase" at 1, "Not applicable/Unsure" at 0.

From here, the distribution of all datasets to be correlated were tested using a Shapiro-Wilk parametric hypothesis test of composite normality (Saida, 2014). From the outputted W (<0.99) and H (=1) values, it was determined that none of the datasets were normally distributed, and therefore, Spearman correlations (as opposed to Pearson) were carried out (Leontitsis, 2002). These were done using MATLAB R2018a. The codes and data used are provided in Chapter 13 (*Appendix C*) and Chapter 15 (*Appendix E*)

Numeric valuation of all Likert scales pertaining to the social well-being of survey respondents was also calculated to arrange them categorically from high to low social well-being levels, as **Figure 7.1**, **Figure 7.4**, and **Figure 7.7** depict. The manner in which this was done in general, was that the level of agreement correspondsing to a higher level of well-being, was converted to a lower score. The details of this process are depicted in **Figure 4.3**.

For each social well-being dimension, the scores for each respondent were added up and were then categorized in the following manner: "Very high material/relational well-being [0-5]," "High material/relational well-being [6-10]," "Medium material/relational well-being [11-15]," "Low material/relational well-being [16-20]," and "Very low material/relational well-being [21-25]" (see **Figure 7.1** and **Figure 7.4**); "Very high subjective well-being [0-4]," "High subjective well-being [5-8]," "Medium subjective well-being [9-12],” “Low subjective well-being [13-16],” and “Very low subjective well-being [17-20]” (see **Figure 7.7**).

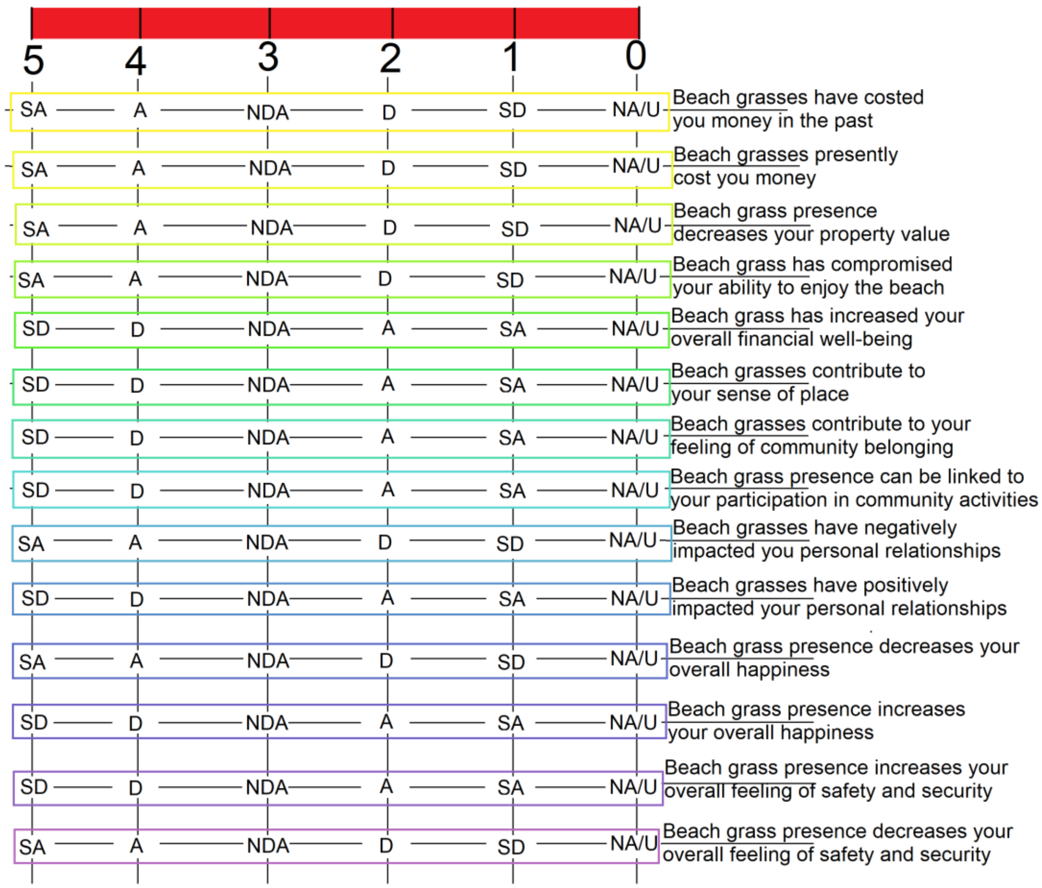

Figure 4.3 *Coding used to convert worded answers from Likert scales to numeric values. SA= Strongly Agree; A= Agree; NDA= Neither Disagree nor Agree; D= Disagree; SD= Strongly Disagree; NA/U= Not Applicable/Unsure.*

A similar process was undertaken for the social well-being impact categorization. Each social well-being indicator was valued as depicted in **Figure 4.2**. Each well-being dimension has a different number of indicators, thus, the scores for each respondent and each well-being dimension were added up and categorized in the following manner:

Material well-being impact (see **Figure 7.2**):

Very positively impacted material well-being [0-3],

Positively impacted material well-being [4-6],

No material well-being impact [7-9],

Negatively impacted material well-being [10-12],

Very negatively impacted material well-being [13-15]

Relational well-being impact (see **Figure 7.5**)**:**

Very positively impacted relational well-being [0-4]

Positively impacted relational well-being [5-8]

No relational well-being impact [9-12]

Negatively impacted relational well-being [13-16]

Very negatively impacted relational well-being [17-20]

Subjective well-being impact (see **Figure 7.8**)

Very positively impacted subjective well-being [0-2]

Positively impacted subjective well-being [3-4]

No subjective well-being impact [5-6]

Negatively impacted subjective well-being [7-8]

Very negatively impacted subjective well-being [9-10]

4.3.1.2 Qualitative analysis

The majority of the survey anlysis was completed quantitatively, but in order to complete much of the quantitative anlysis, survey questions that contained "other" options also required qualitative, inductive analysis. For example, the survey question referring to the perceived reason for change in area/extent of beach grass on a specific beach within the past 5-10 years, included space for the respondent to add a different perceived reason. All comments in the "Other" category were coded and then further categorized. An example of this process is depicted in **Figure 4.4**.

40	Erosion high water level The lake is currently high so at lot of sand has come in and covered it. Beach grass still exists further away from the water to help protect the shoreline.	9/27/2018 10:19 AM
41	Erosion high water level Erosion from the higher waters	9/25/2018 2:36 PM
42	Erosion foot traffic erosion by natural/ foot traffic	9/20/2018 4:00 PM
43	Erosion high water level storm High water levels complicated by extreme storms	9/18/2018 12:40 PM

Figure 4.4 *An example of how comments from the "Other" category were tagged and categorized. These four comments were all sorted into the "Erosion" category.*

This question was mainly geared toward reasons for general beach grass coverage decrease, however, as noted in Section 5.2 (*Observed changes in beach grass*), respondents mainly reported general increases in beach grass area/extent. Many respondents who selected "Other" reported increases in coverage, but not all reported reasons for this. For example, the comments: "It actually has grown more" and "It had grown/spread - not diminished," were therefore sorted into the "Unsure" category. Two comments addressed increase by natural propagation, and thus, to simplify the categorization process, the "It naturally died out" category was expanded to "Natural causes" to accommodate responses that indicate both positive and negative natural changes in beach grass. A large amount of comments referred to erosion by high water levels, wave/storm action, and foot traffic. These were placed into a new category, "Erosion." The category of "Impacted by invasion of European common reed (*Phragmites australis*)" was broadened to "Invasive species" as several comments cited unspecified or multiple invasive species as drivers of beach grass change. For example, the comments "Invasive species are impacting (phrag [sic], sweet clover, etc.), planting of different kinds of grasses," was therefore placed in this category. Several comments described intentional planting, for example, "Increase where I transplanted." These comments were therefore placed in the new category of "Intentional planting." Lastly, another overarching category emerged as "Nutrient runoff." For example, several responses described increase in beach grass area and visual health due to higher nutrients present in the area where the beach grass is growing. However, two responses were discounted from the overall total as they did not specify a main driver for beach grass change, and therefore did not answer the question and could not be categorized accurately. The question referring to the nature of beach grass changes also contained space for the respondent to add a different perceived reason in the "other" section. These comments were then coded and categorized into existing and new categories and added to the respondents' answers. An example of this coding process is depicted in **Figure 4.5**. For the full analysis, see Chapter 14.3 (*Appendix D*).

6	Natural loss of sand to take hold and regenerate	11/11/2018 9:47 PM
7	Gradual The growth of the grasses is slow. The growth of the weeds is too fast.	10/31/2018 5:13 PM
8	Gradual Pose challenges gradual changes, concern that they cause elevated sand dunes that obstruct views of the lake and shore, birds etc	10/31/2018 5:51 AM
9	Pose challenges I was appalled by the action of our neighbour; and concerned about what would happen to the shoreline in front of our cottage as a result.	10/29/2018 10:05 AM
10	Cyclical Natural A natural part of the cycle of the lake	10/29/2018 6:42 AM

Figure 4.5 *Example of comment coding for the nature of changes of beach grass.*

4.3.2 Semi-structured interview analysis

A total of four semi-structured interviews were completed. Each interview took place over the phone and were audio-recorded. Transcripts of all interviews were created manually. Following this, they were analyzed inductively and deductively using open and axial coding in NVivo. Inductive analysis means that the themes for the coding processes are not predetermined, but will emerge within the analysis (Fedy, 2018). Deductive analysis means that the themes for the coding process are pre-determined, in this case, through the preliminary results of the literature review (Fedy, 2018). Coding is defined as "the process of grouping evidence and labeling ideas so that they reflect increasingly boarder perspectives" (Creswell & Plano Clark, 2018). Open coding is the identification of emergent themes and patterns within the interview transcript (Burnard, 1991). Axial coding is the process of making connections between the open codes/patterns identified (Kendall, 1999). NVivo was the chosen Computer Assisted Qualitative Data Analysis Software (CAQDAS) for the coding of interview transcripts (Silverman, 2005). Given the small amount of interview data, NVivo was chosen due to its 1) simplistic design and ease of use, 2) ability to examine the complex interrelationships of exported codes and 3) increased the rigour of interview analysis (Creswell & Plano Clark, 2018; Silverman, 2005).

Through the open coding process each interview transcript was preliminarily organized into deductive (e.g., ES categories that appear in the literature). Simultaneously, they were was also organized into inductive categories (e.g., social influence and convenience as drivers of actions/behaviour toward beach grass) that emerged during analysis. These codes are referred to as “nodes” in the NVivo program. NVivo aided in organizing the interview data into prominent themes and categories, acting as a digital filing cabinet. Three rounds of open coding were completed for all transcripts to ensure thorough and exhaustive coding. Following this, the nodes were axially coded by hand to connect the emerged themes.

4.4 Assumptions and limitations

There were certain assumptions and limitations associated with several aspects of my research, including those related to case study research, researcher positionality, the exploratory research design, application of inductive and deductive methods, surveys, and interviews. For example, a limitation of mixed methods research that must precede the explanation of other limitations is that despite multiple approaches of analysis and data collection, it is impossible to ever obtain “the whole picture” Acknowledging the partiality of the collected data is necessary, despite efforts to capture as much complexity (Silverman, 2005).

4.4.1 Case study research assumptions and limitations

Case study research carries a unique set of inherent assumptions. First, case studies are assumed to be theory-laden, not theory-determined (George & Bennett, 2005). Since each case is unique in its variables, they carry inductive power leading to the possibility of the creation of new hypotheses and the identification of new variables during the research process (George & Bennett, 2005). Second, case studies examine the operation of causal mechanisms in individual cases in detail. The assumption here lies in that these mechanisms operate only under these certain conditions (George & Bennett, 2005). Third, similar or subsequent case studies are assumed to not be independent of one another. In many cases it is useful to examine whether the lessons or outcomes of an earlier case played a causal role in the outcomes of a later one (George & Bennett, 2005).

Case studies are limited in their ability to be represented simply, and in their generalizability. Case studies are very useful to reveal the hidden and unknown complexities of specific situations. However, it is often difficult to capture and explain this complexity in a manner that is accessible (Hodkinson & Hodkinson, 2001). Simply by their definition, there is no way of empirically knowing to what extent any specific case study will be able to be statistically generalized beyond the study area (Hodkinson & Hodkinson, 2001). Case studies are specialized in identifying whether and how a variable matters to the outcome as opposed to how much it matters (George & Bennett, 2005; Yin, 2012). In this same way, case study results cannot be generalized to other groups or scenarios, however they can offer suggestions (George & Bennett, 2005; Simon & Goes, 2013; Yin, 2012).

4.4.2 Assumptions and limitations associated with the researcher

Every researcher has a set of perspectives, biases and assumptions that they bring with them into the research process. These are built into the methodology and shape their approach to data analysis. This is not always harmful, and there is much that can be done to remediate the effects (Corbin & Strauss, 2015). My position as an outsider in this case study context comes with a unique academic perspective. The questions asked to the participants in the survey and interviews were thus academically informed, sometimes containing terms that the participants are not necessarily familiar with. Additionally, my assumptions and biases regarding the knowledge and perceptions of shoreline communities stem from my background growing up in a highly urbanized area. I assumed that very few community members cared or knew about the ecological functions of beach grass and other aspects of the shoreline ecosystem. Because of this, I also assumed that the outcomes of this research would demonstrate more negative perceptions toward beach grass than positive ones. To navigate around these assumptions and biases, it was important to acknowledge the views and knowledge of the participants such that the resultant data emerged from there and not from my own biases.

The philosophical assumptions that this research is built upon are thoroughly described in Section 4.4.3, as they are also associated with the approach of the explanatory sequential research design. Inductive methods incorporated into the methodology work to prevent the assumptions, biases and perspectives brought in by the researcher from clouding any new information that does not align with them. Being aware of the assumptions, biases, and perspectives brought in by the researcher, keeping an open mind, and being willing to listen are also conducive to objectivity during the research process (Corbin & Strauss, 2015).

One limitation associated with the researcher and mixed methods research in this thesis is that I had limited experience in conducting qualitative research. Prior to conducting my research, I had experience in conducting short in-person surveys consisting of only 2-5 questions (question sequencing was dependent on previous answers), but no experience in conducting interviews. I had no experience in formulating questions for surveys or interviews based on specific goals, and therefore, a lack of experience was a limitation faced in this thesis.

4.4.3 *Explanatory sequential research design assumptions and limitations*

The explanatory research design carries different philosophical assumptions for the quantitative and qualitative phases of the research. Postpositivism, the assumption that research is influenced by a number theories and values brought in by the researcher, guided the quantitative phase of the research (Creswell & Plano Clark, 2018; Mackenzie & Knipe, 2006). This was done to select the instruments of data collection, identify questions that need to be asked, variables that need to be measured, potential relationships that should emerge from this phase of the research and assess statistical results (Creswell & Plano Clark, 2018). This assumption aided in the pursuit of objectivity by recognizing the possible effects of researcher biases (Lather, 1986). Constructivism, the assumption that social reality is a product of social interactions with experience in the real world and does not represent objective reality, guided the qualitative phase of this research (Creswell & Plano Clark, 2018; Delanty, 1997). This assumption aided in the inductive development of the pattern and connection of emerging themes in the research (Creswell & Creswell, 2018).

The main intent of the explanatory research design is to use the qualitative results to provide insight and explanation to the quantitative results. Therefore, the limitation associated with this design is the lack of reflexivity when comparing the qualitative findings back with the initial quantitative results, as this would be contradictory to the research design and comparisons would not be as meaningful. Resolution of this limitation is simple and was used in this thesis. Determining how the emerging qualitative themes and codes can provide additional insight into the quantitative data, keeps consistent with the explanatory research design while allowing for a more reflexive approach (Creswell & Plano Clark, 2018).

The philosophical assumptions within the explanatory research design carry inherent limitations of their own. Firstly, constructivism dictates that reality can only be known through our own cognitive structures, holding true that objective reality exists, but cannot be measured in this way. Therefore, social science based on constructivism is designed to produce knowledge of something other than itself but is confined by the limits of its own foundations and methodology (Delanty, 1997). Secondly, constructivism states that knowledge is always produced from specific social and historical perspectives that reflect the interests and culture of the groups in question, meaning that truth is merely a product of its location, socially, temporally, and geographically (Delanty, 1997). This notion is also held by a postpositivist philosophical assumption, wherein the results of research are also shaped by the specific social location of the researcher (Mackenzie & Knipe, 2006).

4.4.4 *Inductive and deductive methods assumptions and limitations*

Inductive approaches are able to capture elements of a concept by looking at observed patterns in data. However, because this process relies mainly on human judgment, it is not immune to error, and results are likely to differ greatly between geographic locations due to social and cultural differences (Gerring, 2012). Deductive approaches derive indicators from the defining attributes of a concept of a larger descriptive argument. Inductive and deductive categories can never really be exclusively so, because concepts and percepts are inseparable. The deductive and inductive categories that emerge have the potential to be influenced by the biases, assumptions and perspectives of the researcher, meaning that all inductive approaches have a deductive element and all deductive approaches have an inductive element (Gerring, 2012).

4.4.5 Survey and interview assumptions and limitations

In order to get the data required to answer the research questions, the survey and interview data collection process made a number of assumptions: 1) the respondent knows what is being asked, 2) provides a relevant response, 3) is willing to accept the response, and 4) is willing to disclose the response to others (Guppy & Gray, 2008). It is also problematic to assume that the context in which people are responding to the surveys and interviews is stable and consistent. Each respondent inevitably answers a question based on their own context and experience (Silverman, 2005).

Surveys and interviews with time constraints could potentially allow less people to commit to taking the survey, as they may simply not have the time in their daily life schedules (Delva, Kirby, Knapper, & Birtwhistle, 2002). In the case of this research, the surveys and interviews themselves were not time constrained, but there was a specific date after which responses stopped being collected. In addition to time constraints, the survey itself took an average of 10 minutes to complete (according to the survey software), and the interviews took between 45 and 80 minutes which could have potentially limited the number of people willing to participate.

The design of the survey itself may have been limiting. Questions where there were only a limited number of responses could have forced respondents into certain categories, limiting the range of possible answers (Simon & Goes, 2013). Likert scale questions could also be limiting to data analysis, as the difference between two categories (e.g. “Agree” and “Strongly Agree”) could be irrelevant to the participant but the difference in responses still affected the analysis of the results (Simon & Goes, 2013). Additionally, questions could not be clarified to the respondents in the online survey. Respondents were limited to the original text of the question to respond to it. This is where the assumption of “the respondent knows what is being asked” comes into play, but as illustrated here, could have also been a limitation if this did not hold true for a specific respondent (Simon & Goes, 2013).

Another limitation in this research is that participant observation was not an option given this particular case study context. Because of this, the survey answers and verbal formulation given in the surveys and interviews had to be treated as a substitute for the observation of actual behaviour. This is where the assumption that the respondent "is willing to disclose the answer to others" comes into play but as illustrated here, can also be a limitation if this does not hold true for a specific respondent (Silverman, 2005).

4.5 Ethics

This project received full clearance from the University of Waterloo Office of Research Ethics on August 2, 2018 (ORE #: 22119) (see *Appendix F* for ethics clearance notice).

4.6 Chapter conclusion

In this chapter, I outlined the methodology used for this thesis, which incorporated both quantitative and qualitative methods (see Section 4.1). I then described the data collection process (Section 4.2), followed by the quantitative and qualitative methods used to analyze the survey and semi-structured interviews (Section 4.3). I ended with a detailed discussion of the assumptions and limitations associated my research design (Section 4.4). In the next chapter, I present the key results (quantitative and qualitative) that emerged from my data collection activities.

<u>Chapter 5 – Results: Changes in Beach Grass Along the Lake Huron Shoreline</u>

In this chapter, I present the findings for Objectives 1 and 2 of this thesis respectively (see **Table 5.1**). Specifically, I identify the changes observed in beach grass area/extent, density, and visual health that were noticed by survey and interview participants, and the perceived drivers and natures of these changes. I also evaluate the relationship among beach grass perceptions and actions of survey participants using an ecosystem service lens.

Table 5.1 *Research objectives.*

1. **Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors.**
2. **Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.**
3. Identify beach grass ecosystem services of value by property owners and visitors along the shoreline
4. Establish how beach grass changes are linked to social well-being from the perspective of property owners and shoreline visitors.
5. Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.

5.1 Overview of survey and key informant respondents

The first two questions of the survey directed at Lake Huron shoreline community members were aimed at establishing basic information of survey respondents regarding their relationship to the Lake Huron shoreline. The first question pertained to physical beach access and asked respondents to indicate whether they are property owners with a private or adjacent beach or an occasional beach visitor. The distribution of survey respondents throughout these three categories is presented below (**Table 5.2**). Survey results show that approximately 94% of survey respondents are closely connected to the coast, meaning that they own land, and thus, spend a large amount of their time close to the shoreline.

Table 5.2 *Distribution of respondent pool according to physical beach access.*

Category	**Percentage of respondents (%)**	**n**
Landowner/property owner with adjacent beach	55.29	68
Landowner/property owner with beach access (public or private)	39.03	48
Occasional beach visitor (non- landowner/property owner)	2.43	3
No answer	3.25	4
Total	100.00	123

The second question of the survey pertained to the frequency of beach access and asked survey respondents how often they generally access the Lake Huron shoreline beaches. The wording of this question assumed respondents to indicate year-round beach access frequency. Here, the choices given were: "Daily," "2-3 times per week," "Once per week," "Once per month," and "Less than once per month." The distribution of survey respondents throughout these categories is presented below (**Table 5.3**). The results of this show that 85% of survey respondents visit the beach at least once per week. The information obtained from these two survey questions implies that survey respondents are likely able to identify any sudden or gradual changes to the shoreline or the lake in general, due to their prolonged presence and high frequency of visits to the shoreline. These results also imply a strong association with the shoreline, close interactions with shoreline resources, and potentially other community members also well-connected to the lake.

Table 5.3 *Distribution of survey respondents according to frequency of beach access.*

Category	Percentage of respondents (%)	n
Daily	49.59	61
2-3 times per week	21.14	26
Once per week	13.81	17
Once per month	7.32	9
Less than once per month	4.07	5
No answer	4.07	5
Total	100.00	123

As mentioned earlier, key informant interviews were also completed, wherein survey results were briefly discussed. One key informant commented on the scope of the survey respondent pool, reinforcing the idea that respondents were well-placed to identify changes or issues:

> *"In the survey, your knowledge base would probably be generally higher than average. These are folks that perhaps live in the area and use the area and therefore know more about the importance of beach grass."*
>
> *– Interview participant 2, November 2018*

5.2 Observed changes in beach grass

This section will directly address Objective 1 (see **Table 5.1**) of this thesis. When asked to report general observed changes in beach grass along the area of the Lake Huron shoreline that they are most familiar with, 92.45% of respondents reported changes. This figure refers to overall change in presence of beach grass over that past 5-10 years, and does not specify positive or negative change nor does it specify the type of change observed (i.e. area, density, or health). More specifically, changes reported in beach grass area/extent, density and visual health by survey respondents are depicted in **Table 5.4**. The information obtained here from survey respondents is likely to be reduced in accuracy, as it does not reflect measured changes in beach grass, but only perceived changes.

Table 5.4 *Percentage of respondents reporting observed changes in beach grass by category.*

Category of Change	Increase (%)	No Change (%)	Decrease (%)	Not Applicable/ Unsure (%)	n
Area/extent	60.21	3.22	31.18	5.37	93
Density	53.84	19.78	18.68	7.69	92
Visual Health	31.52	42.93	15.21	10.87	92

Overall, the majority of respondents reported an increase in both the area/extent and density of beach grass. In terms of visual health, most respondents did not observe any changes. The wide variation in results likely represents the wide geographic range of survey respondents along the Lake Huron shoreline. For example, measures in place to increase beach grass are not consistent throughout all shoreline public beaches and are certainly not consistent between individual property owners.

Figure 5.1 *Flat, lifeless area of Sauble Beach, used for daily beach visitors to park their cars. Dunes have been considerably pushed back from the shoreline. Photograph: Charlotte Hings.*

Figure 5.2 *Station Beach, Kincardine, Ontario. Here, there is a healthy dune ecosystem with beach grass spread far and wide, but not a single person on the beach. Photograph: Charlotte Hings.*

The contrasting environments of public beaches, Sauble Beach (**Figure 5.1**), and Station Beach in Kincardine (**Figure 5.2**) depict how a wide geographic range along the shoreline can depict such a drastic variation in reported beach grass change over the past decade, due to the varying drivers of change in these different areas.

5.2.1 *Nature of beach grass changes*

Survey participants were asked to describe the nature of their reported changes. Respondents were able to select as many options that apply among the following: "Significant/Substantial," "Sudden/Abrupt," "Pose significant challenges to local communities, managers, others," and "Other." Respondents who selected "Other" were asked to describe what they meant in the comments section. These responses were categorized using the methods described in Section 4.3.1.2 (*Qualitative analysis*).

Of the 94 respondents for this survey question, 64 reported that the changes they noticed were significant/substantial, whereas only two respondents noted that the changes were slight, and one noted that they were moderate. Eighteen respondents noted that the changes they noticed were sudden/abrupt and 11 noted that they were gradual in nature. Thirteen respondents noted that the changes they noticed were natural, four reported that they were cyclical, and four reported that they were constant. Of those that reported natural changes, three mentioned that they were also cyclical, and one mentioned that they were also constant and cyclical. The high number of respondents reporting natural, cyclical, constant and gradual changes, further emphasizes the implications drawn from the previous section (5.1); that the survey respondent pool consists of individuals with a strong ability to identify any changes to the shoreline or the lake in general, due to their prolonged presence and high frequency of visits to the shoreline, and that it is easy to observe one's environment, but not always easy to see one's place in it (Thoreau & Bode, 1967).

One respondent referred to the changes being important with a positive connotation, and 27 respondents reported that the changes they noticed posed significant challenges to local communities, managers and others. The majority of these comments refer to beach grass having detrimental effects on the quality of the beach-going experience, such as accessing the beach, laying in the sand, and participating in recreational activities (see Section 14.3). Of those 27 respondents, 15 also noted that the changes they noticed were also significant/substantial changes, and six noted that they were also sudden/abrupt changes. Those six respondents also noted that the changes were significant, thus, selecting all three of the possible survey responses without commenting about any other aspects of the changes. **Figure 5.3** depicts the full range of responses from participants regarding the nature of observed changes.

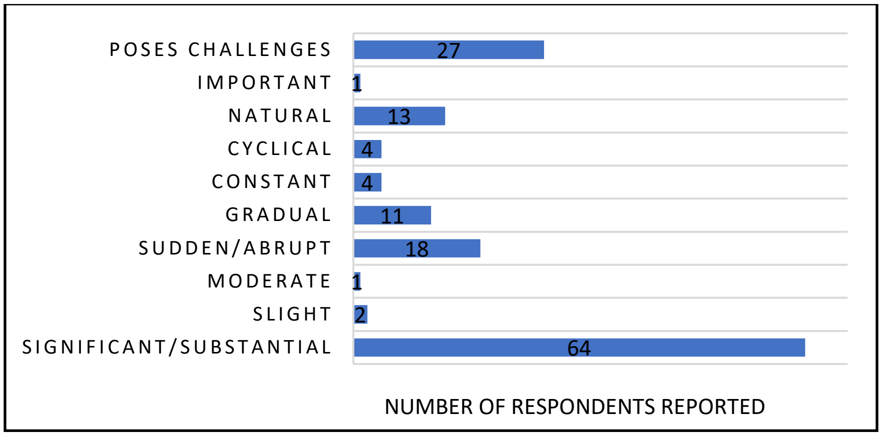

Figure 5.3 *Summary of respondents regarding the nature of the reported changes (n=94). Respondents were able to select more than one response.*

5.2.2 Perceived drivers of changes

In addition to specifying the types of changes observed, survey participants were also asked what they perceived to be the main cause of the reported changes. Participants made an effort to identify, broadly, what they perceived the main cause of their reported changes to be. Respondents were given the following choices for this survey question: "Directly Human-caused," "Indirectly human-caused," "Not Human-caused," and "Unsure." The results of the broad-level perceived drivers of change by survey respondents are depicted in **Figure 5.4**.

To identify the more specific drivers of beach grass change, survey participants were asked to identify what they perceived as the main driver of the beach grass change that they reported. To do this, they were presented with the following options in the survey question: "It naturally died out," "Intentional removal," "Impacted by invasion of European common reed (*Phragmites australis*)," "Unsure," and "Other." If the respondent chose the "Other" option, they were required to specify what they meant by typing it in to the online survey or describing it during the phone survey. Overall, n=99 participants responded to this question, and 62% chose the "Other" option. These responses were categorized using the methods described in Section 4.3.1.2 (*Qualitative analysis*). The results of the perceived drivers of change by survey respondents are depicted in **Figure 5.5**.

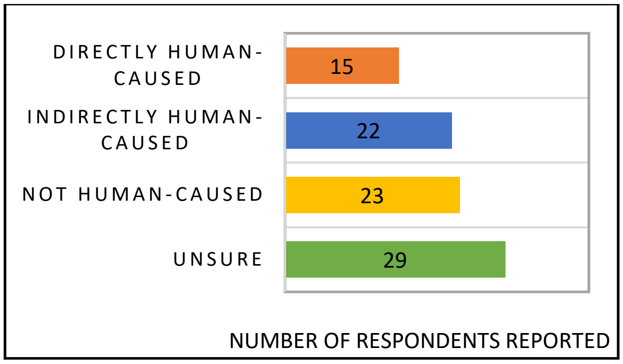

Figure 5.4 Broad-level drivers of beach grass change as perceived by survey respondents (n=89).

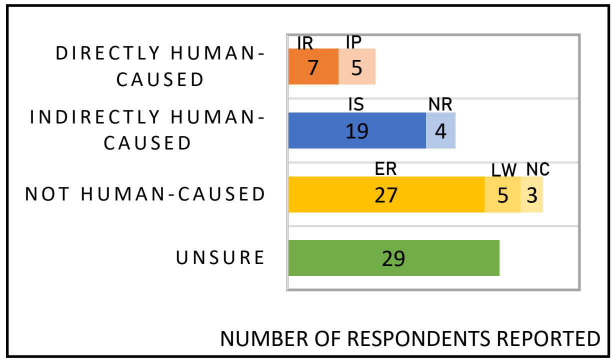

Figure 5.5 *Main drivers of beach grass changes as perceived by survey respondents (n=99). IR= Intentional removal; IP= Intentional planting; IS= Invasive species; NR= Nutrient runoff; ER= Erosion; LW= Low water levels; NC= Natural causes.*

The general results depicted here and in Section 5.2 were discussed with key informants, and during which they also discussed their perceived drivers of beach grass change. Key informants cited natural shoreline topography combined with wave uprush and fluctuating water levels as the main ecological drivers. These are characteristics of the natural shoreline's physical system and are responsible for natural fluctuations in dune height and beach grass coverage.

Table 5.5 *Interview data regarding ecological drivers of beach grass change.*

Interview Participant	**Quotation**
1	"[…] you're dealing with a lot of erodible bluffs and that, combined with wave uprush, would cause a lot of confusion down on the beach as far as what vegetative species can resurrect themselves. The higher water levels that we have at the moment would aggravate that even more."
	"You've got a lot of limited beach areas, beaches which are probably, 20 feet in depth, if even that, and when you get a lot of wave up rush, combining with slope failure of clay bluffs, you're going to cover up so much of that beach with eroded clay and get so much movement and disruption there."
2	"Because of the fluctuating water levels, we've had low water levels the past several years on Lake Huron, and then the water level coming up to higher level means less beach."
3	"We are seeing a higher water level mark right now. It is taking away much of the sandy beach which be perceived that there is more grass because there is less beach. The opposite of that would be when the water levels recede, and you have grass growing further in toward the water."
4	"High level waters would take away dune grasses along the areas where it is established and eroding that."

These results align with the data from the survey. Considering the drivers that are categorized as "Not human-caused," the majority of survey respondents cited that the changes were due to erosion from higher water levels, which were the main ecological drivers discussed by key informants. Additionally, results from the literature review also align with these ecological drivers of beach grass change (Forbes, Parkes, Manson, & Ketch, 2004; Olson, 1958b; Peach, 2006; Shaw, Taylor, Forbes, Ruz, & Solomon, 1998). This further supports the implications drawn from the survey respondent sample, that the survey respondent pool consists of individuals with a strong ability to identify any changes to the shoreline or the lake in general, due to their prolonged presence and high frequency of visits to the shoreline. This also implies greater accuracy in the survey results of perceived drivers of change.

In terms of indirectly human-caused drivers of beach grass change, the invasive species of *Phragmites australis* (commonly referred to as "*Phragmites*") was cited as a very powerful driver of change by most key informants. This is considered to be indirectly human-caused because the establishment of *Phragmites australis* within the Great Lakes ecosystem is the accidental result of human actions and movement.

Due to the prevalence of *P. australis* and the various measures in place to reduce its spread along the shoreline, the vegetation perceptions of many community members and beach visitors have been affected. This perception affects that of beach grass as well because it gets aggregated into the same category as *P. australis*, and without the proper means to correctly identify each grass type, humans can end up accidentally removing native grasses.

There are many impacts of climate change that can affect the Great Lakes system as a whole, but the main one identified here by one key informant as affecting beach grass along the Lake Huron shoreline is the relatively quick fluctuation of lake water levels. The exact response of the lakes to human-induced climate change is unclear but is expected to be, higher frequency and intensity of storms and precipitation, and lower winter ice coverage leading to higher levels of evaporation (Fisher & Hansen, 2014; Peach, 2016). These erratic changes in the lakes' water budget could lead to rapid water level fluctuations in Lake Huron. Nutrient runoff was also mentioned briefly by one interview participant. This is also considered to be indirectly human-caused, as the nutrients entering the lake and surrounding waters, are also the accidental result of human actions.

Table 5.6 *Interview data regarding indirectly human-caused drivers of beach grass change.*

Interview Participant	**Quotation**
2	"[*Phragmites australis*] is a monoculture, which decreases biodiversity by huge amounts."
	The lake's fluctuations seem to be quicker. […] What we are finding in the last 10-15 years is that the water level from high to low is swinging much more quickly and that is causing a concern from people who use the shoreline." (Referring to potential impacts of climate change)
3	"We are seeing fluctuating temperature and more extreme storms, with that can come invasive species. Those storm surges are going to influence the way that the shoreline looks in terms of erosion."
4	Also, changes in the invasive species, in particular, phragmites, taking over areas.

	The invasive species of phragmites is the biggest concern. […] It's not a new driver but it's going to be a continuing driver to change the shoreline and may impact the dunes.
	"The low water provides space and room for invasive species to grow and outcompete dune grasses."

These results also align with the data from the survey. Considering the drivers that are categorized as "Indirectly human-caused," the majority of survey respondents cited that the changes were due to impacts of *P. australis* or other invasive species, which was also the main indirectly human-caused driver discussed by key informants. Additionally, results from the literature review also align with the impacts of *P. australis* on beach grass reported by key informants and survey respondents (Alexander, 2012; Bickerton, 2007; Ontario Ministry of Natural Resources, 2011; Strybos, Andreae, Carroll, & Van Zwol, 2011).

The way in which beach grass is perceived by community members and beach visitors has a profound effect on their actions and behaviours toward it. This concept was noted by one interview participant who stated that many community members already have a negative perception of vegetation along the beach because of what they know about the impacts of *P. australis.* This concept will be discussed further in the following section (5.3, *Perceptions of beach grass ecosystem services along the Lake Huron shoreline*).

There was no mention of the impacts of climate change by survey respondents as a driver of beach grass change. This could be because it was not an option in the survey, and because of the many degrees of separation between the direct causes of climate change and the changes in beach grass make the two difficult to connect without referring to hundreds of years of historical data. Additionally, results from the literature review also align with the impacts of climate change on beach grass. Beaches and dunes respond to water level fluctuations. At high water levels, beaches and dunes will experience erosion, in response to storm activity. Overall increases in wind speeds will also cause higher levels of aeolian erosion, leading to sand loss unless dune conservation measures are in place (Forbes et al., 2004; Peach, 2006, 2016; Shaw et al., 1998).

Nutrient runoff was mentioned by four survey respondents, which suggests that this issue may be a very geographically isolated one. It was also mentioned by one of the key informants, but they referred to a specific septic tank problem as the cause. This could suggest that the impacts of nutrient runoff on the beach grass is much less significant than that of invasive species. Additionally, some results from the literature review mention the impacts of nutrient runoff as generally positive for the beach grass, but not so much for the water (Seliskar, 1995; Van Der Putten, 1990).

The congruency between what survey respondents identified as the main indirectly human-caused drivers of beach grass change and what key informants stated in their interviews on this topic, further supports the implications drawn from the survey respondent sample, that the survey respondent pool consists of individuals with a strong ability to identify any changes to the shoreline or the lake in general, due to their prolonged presence and high frequency of visits to the shoreline. This also implies greater accuracy in the survey results of perceived drivers of change.

In terms of directly human-caused drivers of beach grass change, survey respondents only generally reported two different drivers. However, key informant interviews identified many more. Beach grass restoration by planting and other human conservation methods such as boardwalks, were mentioned by three of the four interview participants. Very few survey respondents mentioned beach grass restoration by planting, but none referred to any other methods such as roping-off sections of beach grass or installation of boardwalks, which are prevalent in many government planning documents (ABCA, 2019b; Nottawasaga Valley Conservation Authority, 2005; Peach, 2006; Town of Saugeen Shores, 2013).

Physical removal of beach grass by just ripping it out to view the lake or to expand their property line when water level is low, was identified by two of the four interview participants as well as a small handful of survey respondents. The Town of Saugeen Shores (TSS) made note in their Waterfront Master Plan that there have been many dunes removed due to their perception of being unsightly on both public and private property (Town of Saugeen Shores, 2013). Peach (2006) also discusses how dune vegetation had been physically removed to accommodate sunbathing, picnicking, and other beach activities at some locations of Sauble Beach (Peach, 2006).

With regard to Sauble Beach, and despite some survey respondents being from this area, none identified the specific issue of vehicular disruption of beach grass from cars parking and driving on the beach. This issue was identified by two of the four interview participants and was also identified during field site visits (**Figure 5.1** and **Figure 5.6**).

Figure 5.6 *Tourists flock to the flat towel-zone of Sauble Beach to park their cars and enjoy a nice sunny day at the beach. Photograph: Charlotte Hings.*

Lack of information on where to acquire beach grass plantings is a new issue that arose in the interview process. Education of shoreline residents and beach visitors with regards to beach grass conservation is crucially important for reducing negative impacts on beach grass. Disseminating information regarding the means to acquire beach grass plantings for private beach owners would thus contribute to this type of education. The importance of education in beach grass conservation will be discussed in further detail in Section 5.3.2.

Beach grooming is done at several Lake Huron shoreline beaches in order to make the area more suitable for various touristic activities but this is extremely detrimental to the beach-dune ecosystems

(Peach, 2006). This issue was mentioned by three of the interview participants, but not identified by any survey respondents as a driver of beach grass change. Recognition of the detrimental effects of beach grooming on beach grass is present in several government planning documents (Peach, 2006; Town of Saugeen Shores, 2013) and was also explained in a conference presentation that was attended by members of the public, as well as representatives from various shoreline governing bodies (Cann, 2018). While beach grooming is important to reduce *E. coli* buildup in the beach sands, measures must be take such that it also does not cause damage to the integrity of the shoreline by harming the beach-dune systems (Edge & Hill, 2007; Whitman et al., 2014).

Table 5.7 *Interview data regarding directly human-caused drivers of beach grass change.*

Interview Participant	Quotation
1	"The human effort to plant [beach grass], are [sic] generally limited and isolated to certain areas."
	"That's why you see boardwalks for example. We are trying to channel people to certain areas and limit them from putting lawn chairs and spreading out all their umbrellas in the beach grass areas."
	When you've got a private beach area, people tend to see that as an unusable area, so they might try to pull out some of that beach grass so that they can create a little patio or something.
	"[…] any kind of vehicular disruption, takes away from [beach grass] wanting to establish even if they could naturally on their own."
	"When water levels have been low in the past, people along the shoreline would, rightfully or not, claim additional land as their own. They would push their property further toward the lake than it had been before."
	They know what it is, they know what they can do, they don't know where to go." (Speaking about how many people don't know where to find beach grass to plant on their property)
2	[…] the towel zone is so narrow, they feel they need for economic development, they need to groom the beach. This is affecting the dunes and the beach grass.
	"[…] controlled access walkways, they are there to control damage to the dunes while also getting people from point A to point B."
	"[…] the enlightened communities have realized [vehicular parking on the beach] is detrimental to the shoreline and the beach, especially if you have old leaky vehicles that have gas an oil leaking. That's the most obvious one, but also the compaction of the sand under the wheels."
3	"Removal of invasive species would go hand in hand with restoration because when you are removing invasive species, then you are also hopefully planting in those spots."
	"Another one would be, not using lawn mowers or brush saws or other heavy machinery on those dune grasses. That can compact soil and lead to wet beaches."
4	"So often we will get disturbances to the natural dunes and grasses because of removal of those ecosystems and habitats so that people can see the lake."
	"Whether there is a designated public access or designated public access, people still want to have their own pathway access through the dunes and the beach grass. This creates erosion and […] impacts the dune systems as well."

	"Beach grooming and removing [the beach grass]."
	"[…] municipalities that want to provide trail access along shorelines for their residents and this is impacting the dune grass, beach, and the dunes by establishing and maintaining these pathways."

The information obtained in the interviews about directly human-caused drivers of beach grass change contained much more variety, depth and detail than the survey data. This lack of congruency could imply a lack of education regarding the many different directly human-caused drivers of beach grass change, especially when it comes to measures that are in place on public beaches. This could be due to negative perception of the boardwalks and roped off areas. Many beach visitors may overlook their benefits and view them as nuisances. This also implies lower accuracy in the survey results of perceived directly human-caused drivers of change.

In general, interview participants put more emphasis on social drivers than on ecological drivers, whereas, in the survey it was the opposite. Key informants have more background and knowledge on this front, and take an outside perception on these issues. This could be why they were able to identify more social drivers of change than the survey respondents. By learning and studying our place in the world, we become aware of the consequences of our actions. This is best put by Henry David Thoreau, in one of his many philosophical writings from 1861 (Thoreau & Bode, 1967):

> *"All this is perfectly distinct to an observant eye, and yet, could go unnoticed by most."*
>
> *–Henry David Thoreau*

5.3 Perceptions of beach grass ecosystem services along the Lake Huron shoreline

As defined in Section 2.1.4 (*Pathways to coastal sustainability*), perception is formed through the interactions of an individual's life experiences and their personal relationships, which define what values/objects/resources are most important to them, and the knowledge they have gained throughout their life (**Figure 5.7**). Perception of any particular item is constantly changing as a person collects new life experiences, meets new people, gains more knowledge and develops new opinions.

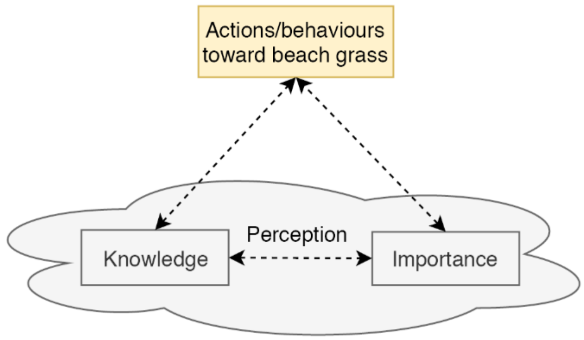

Figure 5.7 *The interacting forces of an individual's knowledge about a particular topic, the importance of it to them, and what actions they choose to take toward that. In terms of beach grass, exactly how these forces interact among community members and beach visitors in general, has not yet been determined, therefore, these lines remined blurred, or dotted, for now.*

The perceptions of beach grass by community members and beach visitors along the Lake Huron shoreline is important to evaluate because it can help determine what aspects of perception have the most influence on their understanding (e.g., of ES and well-being), actions and behaviours toward beach grass. Once this is established, shoreline management techniques that are better tailored to shifting the perception of beach grass can be developed. This section is directly related to Objective 2 of this thesis (see **Table 5.1**).

In the survey, respondents were asked about their general knowledge about beach grass. To assess this, they were presented with the statement "I am knowledgeable about beach grass," and then asked to state their level of agreement with this statement on a four-point Likert scale. The responses collected here were then assigned values from 1 (strongly disagree) to 4 (strongly agree) and these values were used in the correlation calculations presented later in this section. The majority of respondents (see **Table 5.8**) stated that they agree that they are knowledgeable about beach grass, which indicates that survey respondents are generally informed about beach grass benefits and ESs.

Table 5.8 *Survey results for self-reported knowledge levels of survey respondents.*

Agreement level	Strongly Disagree (%)	Disagree (%)	Agree (%)	Strongly Agree (%)	n
"I am knowledgeable about beach grass."	0.00	15.25	55.09	29.66	118

Table 6.2 summarizes the results of the ESs identified by survey respondents. Following this, in the survey, respondents were asked to also indicate the level of importance they attribute to each of the identified ESs (**Table 5.9**). To assess this, they were presented with the question "How important are these services to you?" Respondents then had to choose options from a five-point Likert scale. They also had the option to choose "Not applicable (N/A)." The responses collected here were then assigned values from 1 (Not important at all) to 5 (Very important) and "N/A" was scored as 0. These values were used in the

correlation calculations presented later in this section. Generally, all ESs were valued as very important by the majority of survey respondents, however, the most important ESs to survey respondents were the regulating and supporting beach grass ESs. This means that most respondents generally value the regulating and supporting properties that beach grass brings to the Lake Huron shoreline ecosystem.

Together, as indicated in **Figure 5.7**, the knowledge (**Table 5.8**) and importance (**Table 5.9**) of beach grass and beach grass ESs, form the perceptions of the individual respondents.

Table 5.9 *Survey results for beach grass ES importance levels of survey respondents.*

ES category	**Beach grass ES**	**Not important at all (%)**	**Not important (%)**	**Neutral (%)**	**Important (%)**	**Very important (%)**	**Not applicable (%)**	**n**
Regulating	Weather/ storm moderation	0.96	3.85	4.81	23.08	64.42	2.88	104
	Erosion prevention	0.00	0.95	2.86	15.24	79.05	1.90	105
	Water quality	0.96	0.00	4.81	17.31	75.00	1.92	104
Supporting	Biodiversity maintenance	0.00	3.85	5.77	22.11	67.31	0.96	104
Cultural	Aesthetic enjoyment	0.96	3.85	11.54	27.88	54.81	0.96	104
	Tourism	1.92	10.58	24.04	23.08	39.42	0.96	104
	Educational value	0.00	0.00	14.56	21.36	56.31	7.77	103

In the survey, respondents were asked about their actions/behaviours toward beach grass in general. To assess this, they were presented with the question "Do you have beach grass on or around your property or is it on the beach you normally visit?" Respondents who answered "yes" were then presented with three options to select from regarding their actions toward beach grass. These options were "Maintain it/try to augment it," "Leave it be/take no action," and "Try to get rid of it (i.e., consider it a nuisance)." The responses collected here were then assigned values from 1 (Try to get rid of it) to 3 (Maintain it) and these values were used in the correlation calculations presented later in this section. Most respondents indicated that they either take no action or maintain/augment the beach grass on their property or on the beach they visit (**Table 5.10**). This means that generally, beach grass is perceived positively by most survey respondents.

Table 5.10 *Survey results for actions/behaviours toward beach grass according to survey respondents.*

	Try to get rid of it (%)	**Leave it be/take no action (%)**	**Maintain/try to augment it (%)**	**n**
Actions/behaviours toward beach grass	15.90	57.00	27.10	107

5.3.1 Relationship between knowledge and importance levels of beach grass ESs

First, to establish how the dimensions of perception, knowledge and importance of beach grass influence each other, self-reported knowledge levels of beach grass in relation to attributed importance levels for each ES was evaluated using a Spearman correlation and the scale-conversion methods described in Section 4.3.1.1 (*Quantitative analysis*). The results are presented in **Table 5.11** below.

Table 5.11 *Relationship between self-reported knowledge and importance levels of beach grass ESs.*

Beach grass ES	**Spearman correlation coefficient (ρ)[3]**	**p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)**	**Correlation strength**	**n[4]**
Weather and storm moderation	0.2602	0.0089, very strong	Weak, positive	100
Erosion prevention	0.4139	0.0000153, very strong	Moderate, positive	102
Water quality	0.4453	0.00000307, very strong	Moderate, positive	101
Biodiversity maintenance	0.3555	0.000245, very strong	Weak, positive	102
Aesthetic value	0.3628	0.000179, very strong	Weak, positive	102
Tourism	0.2115	0.0329, Strong	Weak, positive	102
Educational value	0.2502	0.0150, Strong	Weak, positive	94
Average over all ESs	0.2077	0.0343, Strong	Weak, positive	104

All calculated correlation coefficients represent weak-to-moderate relationships, but all are very significant correlations. The ESs with the strongest connection between knowledge and importance levels are water quality, erosion prevention, and aesthetic value. These results indicate that improved knowledge of beach grass leads to increased importance of the ESs that beach grass provides to survey respondents.

[3] Calculations for this were done using MATLAB R2018a and can be found in Section 13.1. Data used in these calculations can be found in Section 13.2.
[4] Includes those that answered both survey questions regarding self-reported knowledge level and the importance level of the corresponding beach grass ES

This implies that the connection between knowledge about beach grass and the importance drawn from the ESs that it provides is a relatively weak one, and that improving one's knowledge about beach grass will make it only slightly more important.

5.3.2 *Relationship between importance levels, knowledge and actions*

Next, to establish which dimensions of perception have the greatest influence on the actions/behaviours of survey respondents, the relationship between respondents' average reported ES importance levels and their actions/behaviours toward beach grass was evaluated using a Spearman correlation. Additionally, the relationship between respondents' self-reported knowledge levels and actions/behaviours toward beach grass was evaluated using a Spearman correlation. This was done using the scale-conversion and methods described in Section 4.3.1.1 (*Quantitative analysis*). The results are presented in **Table 5.12** below.

All calculated correlation coefficients represent weak relationships, but all are very significant correlations. Overall, the results indicate, that increased knowledge of beach grass and importance of beach grass ESs to survey respondents have significant impact on the choices they make regarding their behaviour toward beach grass on their properties and at frequented beaches. Themes emerging from the interview data pointed to some aspects of beach grass management that interview participants felt had a strong influence on the beach grass perceptions and behaviours of community members and beach visitors.

Table 5.12 *Relationship between beach grass ES importance levels, and self-reported knowledge levels with actions/behaviours toward beach grass of survey respondents.*

Variables	Spearman Correlation coefficient (ρ)	p-value, evidence for rejecting H_0 when $\alpha=0.05$ (where H_0: no correlation)	Correlation strength	n
Beach grass ES importance level average **Actions/behaviours toward beach grass**	0.3467[5]	0.000469, very strong	Weak, positive	98
Self-reported knowledge level **Actions/behaviours toward beach grass**	0.2631[6]	0.0092, very strong	Weak, positive	97

The first theme is "convenience." Several interview participants pointed to the need to make beach grass conservation efforts convenient for beach users, such that behaviour change will be easy for them. The creation of boardwalks is a convenience measure that almost forces beach users to take a specific path,

[5] Calculations for this were done using MATLAB R2018a and can be found in Section 13.3. Data used in these calculations can be found in Section 13.4.
[6] Calculations for this were done using MATLAB R2018a and can be found in Section 13.5. Data used in these calculations can be found in Section 13.6.

and thus avoid trampling the beach grass. Depending on the approach taken to the boardwalk set-up, beach users can read signs to learn about why the boardwalk is there, why they should be using it, and are subsequently given a convenient way to change their behaviour when it comes to their walking path along the shoreline. This can increase their knowledge, change their behaviour, but not necessarily change the importance that they place on different beach grass ESs.

Having shuttle busses to the beach to prevent vehicle traffic falls under the "convenience" theme of beach grass management, for similar reasons as the boardwalks. Rather than beach users making a conscious stewardship choice to change their behaviour, and park their car further from the beach, they are being given a convenient way to go about this change or are possibly being forced to if they want access to the beach. Once again, this can increase their knowledge, change their behaviour, but not necessarily change the importance that they place on different beach grass ESs.

The Butt-Free-Beach initiative is also a convenience measure, wherein appropriate cigarette butt disposal is made easier for beach users by providing them with an easy-to-assemble ash tray and disposal bin. This, along with the education signs at the disposal sites, increases knowledge of beach users, and increases the likelihood that they will change their behaviour by being provided with a convenient way to do so. Increasing general garbage disposal bins on the beach areas, serves the same purpose.

Beach management for convenience, does not always lead to desirable environmental outcomes. For example, as stated by Interview Participant 4 (see **Table 5.13**), the creation of direct access trails along the shoreline provides convenience to the beach users, but destroy the integrity of the shoreline. It is important to note that, convenience is an important driver of behaviour change, as noted in the literature (Barr, 2003; Bernstad, 2014; Brandstätter, Gigerenzer, & Hertwig, 2006; Budeanu, 2007; Michie et al., 2005; Vining & Ebreo, 1990) and by several interview participants (**Table 5.13**). Therefore, convenience must be directed toward maintaining the integrity of the shoreline, and not appealing only to the beach users' desires, that may not be focused on long-term outcomes. This will ensure that the behaviour changes made by beach users are ones that will promote the integrity of the shoreline and support quality of beach grass ESs.

Table 5.13 *Interview data pointing to the emerging theme of "convenience" in beach grass management.*

Interview participant	Quotation
1	"The human effort to plant these things, is generally limited and isolated to certain areas. Because some of these grasses are sensitive to human activities, people have to alter their activities to minimize disruption due to the sensitivity of the plant species. That's why you see boardwalks for example. We are trying to channel people to certain areas and limit them from putting lawn chairs and spreading out all their umbrellas in the beach grass areas."

2	"If you think of Pinery where they have controlled access walkways, they are there to control damage to the dunes while also getting people from point A to point B."
	"There are examples from other areas, not necessarily on Lake Huron, where you park and there are shuttle busses to get to the beach."
	"The Coastal Centre has a program called the "Butt-Free Beach" which is a simple one […] with signs on the beach, providing little ash trays that are extremely simple in design. It's just about trying to make it convenient for people to do the right thing."
	"If it's just garbage, then obviously, the reason for the garbage is that people don't have a disposal facility close enough to use or they don't have the idea of 'pack it in, pack it out.'"
4	"[…] now municipalities want to provide trail access along shorelines for their residents and this is impacting the dune grass, beach, and the dunes by establishing and maintaining these pathways."

The second theme is "social influence." Several interview participants discussed how social influence shapes beach grass perception, which has implications for behaviour change in beach grass conservation efforts. Planting beach grass and improving other shoreline protection measures are more effective when there is a greater amount of social support and community backing to these measures. Being part of a community structure working toward a common goal brings a sense of meaning to people's lives, something that represents a natural urge that is common among all humans (Becker, 1997). From an ecological standpoint, acting as a community to support the integrity of the shoreline is highly effective, as one small plot of land planting beach grass will have no overall effect, simply due to its scale. Social influence shapes the beach visitors' perceptions of beach grass by increasing their general knowledge of beach grass (learning from others) and raising the importance of participation in beach grass conservation methods (natural seeking of meaning and belonging). This increases the likelihood of behaviour change related to participation in beach grass conservation initiatives along the shoreline.

Social pressure (also referred to as peer pressure) is a form of social influence that has been shown to have great effects on behaviour change when it comes to beach and beach grass management. The more people are seen using the boardwalks and cigarette butt disposal infrastructures, the more likely others are to use them as well, out of fear of being called out or not conforming to the rules. This shapes the beach visitors' perceptions of beach grass by raising the importance of participation in beach grass conservation methods (natural seeking of meaning and belonging) but does not necessarily increase their knowledge base as to why these measures are in place. This increases the likelihood of behaviour change related to participation in beach grass conservation initiatives along the shoreline.

Social influence is effective for inducing behaviour change, as presented in the literature (Barr, 2003; Becker, 1997; K. Chan, 1998; Michie et al., 2005) and can be explained most innately by Becker (1997), who states that the conformation of people to societal roles and cultural norms is a built-in defense mechanism against acknowledging their inevitable fate of eventual death (Becker, 1997). According to

Becker, this is one of the most important drivers of human behaviour. The contribution of social influence to behaviour change for Lake Huron beach management is supported by all interview participants (**Table 5.14**).

Table 5.14 *Interview data pointing to the emerging theme of "social influence" in beach grass management.*

Interview Participant	Quotation
1	"The other challenge is that if you want to [establish beach grass] properly, you have to have a coordinated effort amongst neighbors. The benefits are not going to come through unless there is a community effort."
	"Effective shore protection needs to be done on a group basis, not individual. They need to know that they are a part of it, but it is not only up to them alone."
	"If you're going to plant, to maximize the benefit [of planting beach grass], you have to get a broader support form the community that you're in."
2	"[…] stewardship work on a reach basis, or littoral cell basis, in other words, not property by property but the whole community, it is much more effective because the lake will deal with each property in very similar ways."
	"The more people [using the boardwalks], the more peer pressure will correct that. In other words, people will hopefully call people out on not using the path. That will prevent damage and promote proper stewardship."
	"[…] the "Butt-Free Beach" […] is using peer pressure, with signs on the beach, providing little ash trays simple in design. It's just about […] using peer pressure to get people to recognize that leaving the cigarette butt is no longer acceptable behaviour.
3	"[…] starting your own groups of some sorts, like a stewardship group within your area and getting those people together." (Referring to changes in management that will improve overall coastal sustainability)
4	"Empowering them to be able to have the knowledge as to what their actions are and what their actions shouldn't be. They can then share that with others in the community and share that with other resource users and also improve the shoreline aspects, the ecological services along there, and prevent the destruction of the area or help share, communicate information to others."

The third theme is "targeting other values." Rather than tackling beach grass conservation issues by simply disseminating general ecological information, this technique involves educating the public about what beach grass does for them, how it helps them, by targeting aspects of their lives that are already important to them. This raises the importance placed on the various beach grass ESs by association. One interview participant summarized this theme very well:

"Humans are the ones using the land on the coast and so it needs to be focused on how we use and value the coast, and beach grass specifically […]. Once you know why someone values a particular ecosystem or ecosystem attribute, you can understand how to plan for those uses. Whether those values are being with your family and swimming on the beach, going fishing or just sitting and viewing the area because it brings you some sort of calm or nostalgia or whatever the feeling is; once you tap into that, you then can work with the people on how to keep that environment there for future generations."

–Interview Participant 3, February 2019

All interview participants discussed various ways in which beach grass extends beyond ecological value, to also provide benefits to those living along the shoreline and visiting the beaches. For example, those that value the view of the lake need to plant beach grass strategically, in certain locations, as opposed to pulling it all out and putting their property at future risk. For those that value access to the beach, it is important to use the boardwalks provided, such that the beach grass that keeps the water at swimmable quality, that holds the beach together, and that keeps the beach looking natural and beautiful, stays intact and can perform the ecological functions that it is intended to do. Associating the maintenance of the quality of beach experience with the maintenance of beach grass and beach-dune ecosystems, increases the importance that beach users place on various beach grass ESs, as well as increases their knowledge about these ESs. This will influence their behaviour toward the maintenance and care of beach grass in their local environment.

There is also the legacy value that many beach users find appealing. If they enjoy the shoreline environment as it is, in whatever way, then they will want their children, grandchildren etc., to have the same experiences. Understanding how to conserve the shoreline's resources and how beach grass is a key player in this process, is crucial. The same goes for their physical property or cottage, in terms of financial value. Maintaining the beach grass on the property, and the overall integrity of the shoreline, will prevent flooding of the home and erosion of the property line, leading to greater property value that can be sustained over the long-term. Associating the legacy value and financial value of their property with the maintenance of beach grass and beach-dune ecosystems, increases the importance that beach users place on various beach grass ESs, as well as increases their knowledge about these ESs. This will influence their behaviour toward the maintenance and care of beach grass in their local environment.

For those that value their drinking/tap water and swimming in the lake, it is important to understand what role beach grass plays in ensuring that water quality remains high enough for the groundwater to remain potable and the lake water to remain swimmable. A healthy dune ecosystem promotes the creation of a healthy dry beach, with good quality groundwater beneath and a higher chance of swimmable lake water nearby. Associating the value of good quality drinking and lake water with the maintenance of beach grass and beach-dune ecosystems, increases the importance that beach users place on various beach grass ESs, as well as increases their knowledge about these ESs. This will influence their behaviour toward the maintenance and care of beach grass in their local environment.

In terms of hazard protection, something as simple as a healthy dune ecosystem along the shoreline can have tremendous socio-economic impacts inland. Interview Participants 2, 3 and 4 speak about this (see **Table 5.15**). When beach grass establishment is compromised, the dune is vulnerable to erosion and blowouts. Many small shoreline towns have been constructed with one main road, and if this road becomes flooded because it lacked protection from the shoreline dunes, then this could have drastic impacts on the safety of the community members, as well on the economic prospects of the town as a whole.

Targeting other values is an important driver of behaviour change, as noted in the literature (Becker, 1997; Brandstätter et al., 2006; Michie et al., 2005; Steg, Bolderdijk, Keizer, & Perlaviciute, 2014; Szmigin, Carrigan, & McEachern, 2009) and by all interview participants (**Table 5.15**). This is best explained by Steg at al. (2014), wherein a key driver behind "pro-environmental" behaviour is a person's "gain goals," in other words, they are getting something else out of acting in favour of the environment (e.g. saving money) (Steg et al., 2014). Therefore, the association of various beach grass ESs with these "gain goals," increases the importance that beach users place on various beach grass ESs, as well as increases their knowledge about these ESs, leading them to act in favor of the shoreline environment.

Table 5.15 *Interview data pointing to the emerging theme of "targeting other values" in beach grass management.*

Interview Participant	Quotation
1	"If the planning efforts are trying to encourage planting of beach grass generally, then they usually also say in the same breath that you have to alter your own human activities to accommodate that, to go hand in hand. If you want the view, then you plant strategically, if you want access to the beach then you put a boardwalk in."
	"To promote a culturally sustainable society we've got to say 'here is the physical area. If you're in that area and you're one of these following users…' then write it up like a BMP and by doing all of these best management things, you're going to create a more culturally sustainable neighborhood for you, your family, future generations."
2	"The CAP is more of a voluntary awareness initiative. [It deals] with hazards but also the issues of socio-economic value, the whole idea of what draws people to the shoreline, what types of things they are looking for to maintain property values, and enjoyment of their properties."
	"[…] if the dune is removed, then when the water level comes back up, you'll get flooding around your home or cottage."
	"In that case, appealing to their triggers is the most effective way to get that message across, whether it's property value … By decreasing the attributes of the shoreline, whether they are dunes, wetlands or bluffs etc., by not understanding how that coastal ecosystem works and interacts with the lake, you are decreasing your property value. That's always one way to go. […], and like improving the situation for future generations, for example if

	they are leaving their cottage to their family, sons and daughters, there is always a legacy appeal. That is sometimes more successful if you have somebody with environmental values already.
	"[…] a healthy dune ecosystem, which means a healthy water quality nearby. That's an important connection that people can wrap their heads around and recognize that this is also another reason why you would want to keep the dune grass intact."
	"One access route in extreme weather, is very vulnerable to being cut off. If you have bluff erosion, or gulley erosion, for example, and this impacts the road, then this impacts the residents. Even just to get emergency services in there, that is troubling."
	"Having a targeted campaign and actually making sure that they're website has information about coastal stewardship and coastal management, making it applicable to them."
3	"[…] we were able to find that dunes and dune grasses can provide natural services that equate to a value of about $2000 per linear metre. That is a pretty big return on your investment."
	"Bringing attention down to the values piece, once you define your resource user, you can understand more about their lifestyles. You can see how the values align with the community as well, which can then provide another perspective as to how the public in that area uses that resource."
4	"[…] the increase or decrease with the issues along the shoreline would cause a financial change to their properties, assessment wise. If they were families, they may have loss of income as a result.
	"What are the hazards related to the shoreline in any one area and tying in what is the beach grass doing for that hazard protection and protecting the property, building, people. Not just the fact that it's significant habitat area, ecosystem in itself, but the benefits behind maintaining those areas for hazard-related reasons."

The final emerging theme is education. From the survey results, knowledge accumulation shows only a weak impact of the actions and behaviours of survey participants. However, the importance of increased knowledge, especially ecological knowledge when interacting so intimately connected with the shoreline ecosystem, is not to be dismissed.

The Lake Huron shoreline has many different resource users. Some come from far away, and do not have the same knowledge base as would someone who has lived along the shoreline for many years. It is not necessarily that they cannot comprehend or do not care about the value of the beach grass ESs to the integrity of the shoreline ecosystem, it is that they have not been presented with the opportunity to learn about it. This is where an increase in knowledge can have a large impact on the actions and behaviours of beach visitors toward beach grass.

The shoreline environment is dynamic and always changing. As development increases, the environment changes as new drivers come about. The invasion of *Phragmites australis* into the dune environment is a relatively new driver of change to the shoreline, that many are still learning about. When left uncertain of how to identify invasive or harmful species from native ones that are critical to the ecosystem, it can lead to, residents removing native vegetation as well as invasive, as Interview Participant 2 brought up. Increasing knowledge in this new area can lead to positive behaviour changes for shoreline residents, as they will be removing the invasive species (not the native species) before they have a chance to spread and cause more detrimental issues for the shoreline, as Interview Participant 3 mentioned.

Increasing knowledge of beach grass ESs influences one's perception of them, in more ways than one. Typically, the bulk of education surrounding beach grass ESs focuses on the regulating ESs, which brings connection to the shoreline environment, and thus a sense of responsibility toward its preservation, as stated by Interview Participant 3. However, beach grass education is not limited to these regulating ESs, just as its benefits are not. Education about beach grass to the public can also be about the "gain goals" or other values people have that beach grass contributes to. This rounded education of beach grass will increase knowledge and importance, changing beach grass perception from both angles and strongly influencing behaviour.

Education about various beach grass ESs is an important driver of behaviour change, as noted in the literature (Barr, 2003; K. Chan, 1998; Hines, Hungerford, & Tomera, 1987; Singhirunnusorn, Donlakorn, & Kaewhanin, 2012) and by all interview participants (**Table 5.16**). This is best explained by Hines et al. (1987), wherein knowledge of issues and knowledge of action strategies were two key factors in modelling and predicting environmental behaviour (Hines et al., 1987). Therefore, improving the knowledge of shoreline residents and beach visitors can also affect the importance that they place on various beach grass ESs, leading them to act in favor of the shoreline environment.

Table 5.16 *Interview data pointing to the emerging theme of "education" in beach grass management.*

Interview Participant	Quotation
1	"I think because the beach grass is easy to move and disrupt, people have to understand why it's there."
	"You've got a variety of coastal users with huge variance in their backgrounds of understanding. […] I assume that these guys are from the city somewhere and they have no regard for the beach and no understanding. It's just a sandbox to them."
2	"[Non-local beach users] probably have the capacity to understand, but they don't necessarily have the opportunity to learn about how fragile the coastal ecosystem is, so fragile, and you' don't want to be driving on it. Again, that is where awareness has improved, but there is still work to be done there."
	"Awareness is the key, about the importance of beach grass protecting the dunes and the importance of dunes protecting the inland areas."
	"Not knowing the different types of vegetation, feeds into this, as they may ere on the side of caution and remove everything."
	"Our hope is that the awareness of the importance of beach grass in the dune ecosystem is something that […] will increase and more people will be willing to make the stewardship efforts needed to protect them."
3	"I hope that with more education the perceived notion of beach grass is more positive."
	"Education on why those processes are there in the first place. […] When you learn the why behind it, hopefully it will help foster that change in attitude which would then help your end goal when it comes to coastal conservation."

	"With phragmites, we are trying to catch it before it overtakes an area, but a lot of our efforts are on intense removal in a particular area. If we were more heavily focused on educating property owners on how to identify invasive phragmites and removing that prior to over-take, then we wouldn't have to be doing the band-aid solution."
	"When you know how something works, you feel more connected to your environment. Hopefully that creates a sense of wanting to work and keep it for the better and keep it from degrading."
4	"Municipal and public spaces, that might be an area where, if education were provided and guidance was given, we might have an increase in dune grass and dunes."
	"Education, communication, identify the role, the need to protect the areas, I think it's all good and would enhance and empower the people coming to the beach. It would get them thinking about what they are doing and what impacts they have on the beach areas."

5.4 Chapter summary

Survey respondents consisted primarily of those who are closely connected to the shoreline, and therefore have close interactions with shoreline resources, and potentially other community members also well-connected to the lake. The changes to beach grass area/extent, density and visual health reported by survey respondents varied greatly, which was likely due to geographic differences and the various dune conservation efforts in place at specific locations along the shoreline. In terms of drivers of change, survey respondents mainly reported ecological drivers of change such as changes in lake levels leading to changes in erosion and beach grass patterns (**Figure 5.8**). Interview participants mainly reported social drivers of beach grass change such as physical removal, lack of education, and beach grooming. This difference in types of reported changes could imply that the more someone is able to observe, learn, and understand about their environment, the more aware they are about the consequences of their actions.

The examination of the perceptions of beach grass ESs using the survey was able to provide a better understanding of how the main drivers of survey respondents' actions and behaviours toward beach grass interact (see **Figure 5.9**). The survey data lined up with many of the emerging themes from the interview data. Both sources of data, as well as data collected through the literature review, point to increased knowledge of beach grass ESs, when paired with an increase in the importance of beach grass ESs to survey respondents has the most dramatic influence on actions and behaviour toward beach grass.

Based on the results from the literature, survey data, and interview data, the connections between beach grass perception and actions/behaviours toward it can be drawn more clearly (**Figure 5.9**).

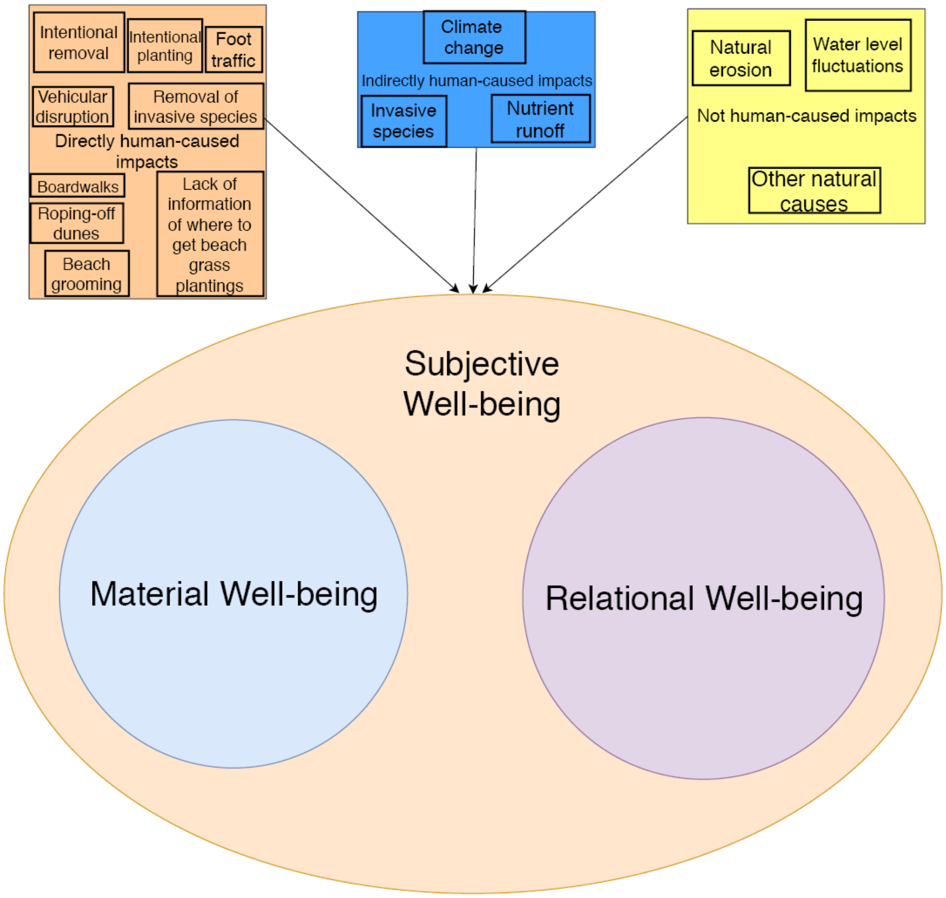

Figure 5.8 *The drivers of beach grass change reported by survey respondents and interview participants. These changes impact the various dimensions of social well-being. Exactly how, will be explored further in the coming chapters.*

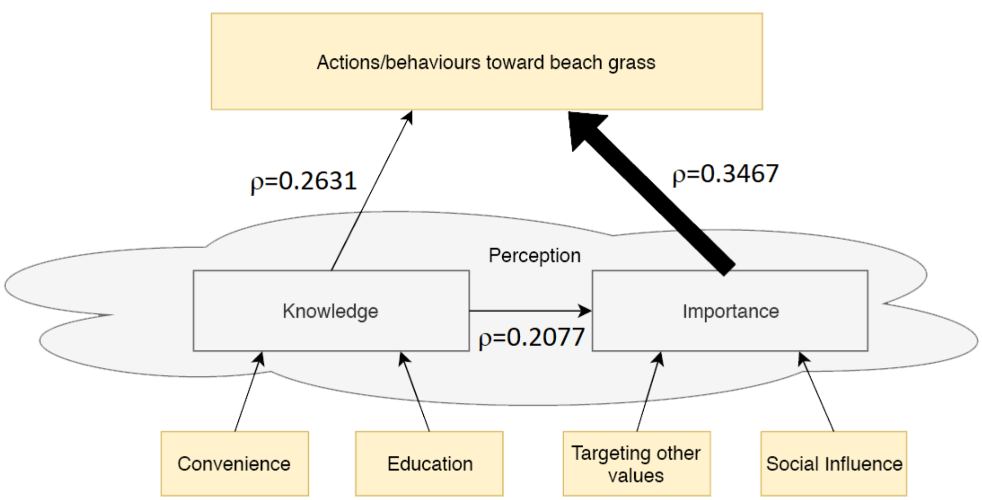

Figure 5.9 *Interactions and influencers of knowledge and importance of beach grass ESs and how they each influence the actions and behaviours of resource users toward beach grass. Larger arrows imply a stronger connection. The strength of the connections here are categorized relatively to their correlation strengths, presented earlier in this chapter. Weaker connections are still valuable connections in this sense.*

Chapter 6 – Results: Beach Grass Ecosystem Services of Value to Lake Huron Shoreline Community Members

In this chapter, I present the findings for Objective 3 of this thesis (see **Table 6.1**). Specifically, I identify the regulating, supporting and cultural ecosystem services that are valued by survey participants, and explore the interview data to bring context and additional detail about the identified ESs.

Table 6.1 *Research objectives.*

1.	Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors.
2.	Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.
3.	**Identify beach grass ecosystem services of value by property owners and visitors along the shoreline**
4.	Establish how beach grass changes are linked to social well-being from the perspective of property owners and shoreline visitors.
5.	Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.

6.1 Valued ecosystem services

Ecosystem services are broadly defined as the benefits that humans or society as a whole receive from the environment (Steinman et al., 2017), and can be divided into four categories: provisioning, regulating, supporting, and cultural. I identified an initial set of ESs specifically relating to beach grass from which survey participants could select. This is directly related to Objective 3 (see **Table 6.1**) of this thesis.

In the survey, these ESs were presented as 'statements' that could be answered using a Likert scale (e.g., "the presence of beach grass in general serves to stabilize and/or maintain the beach (e.g., prevent erosion))." If a participant answered "agree" or "strongly agree" to the statement regarding a specific beach grass ES, then that ES was considered valued by that participant. Key beach grass ESs valued by survey participants are presented by category in **Table 6.2**. All categories of ESs were represented in the survey except provisioning ESs because the benefits that humans receive from beach grass are drawn from the presence of beach grass on the beach, in its natural state, performing its naturally intended functions and not from its physical extraction.

Table 6.2 *Beach grass ecosystem services identified by survey participants.*

ES category	Beach grass ES	Benefits provided	n	% of survey participants that value the ES
Regulating	Weather and storm moderation	Beach grass builds the sand dunes along the shoreline. This allows the dunes to supply replacement sand to the beach during periods of heavy wave action (Emery & Rudgers, 2010; LHCCC, n.d.-a).	107	80
	Erosion prevention	Beach grass and other dune vegetation trap sand in the dunes, thus preventing sand loss from the beach system by wind erosion (Emery & Rudgers, 2010; LHCCC, n.d.-a).	108	83
	Water quality	In areas where beach grass has been intentionally removed, and turf grass has been planted, more Canadian geese are attracted to the beach areas. The increase in fecal matter close to the shoreline increases the amount of *E. coli* bacteria that seeps into the water table below (A. Crowe, 2018).	104	47
Supporting	Biodiversity maintenance	Sand dunes allow the creation of more complex plant communities nearby and act as pioneer species in the ecological succession of sand dunes (Emery & Rudgers, 2010).	107	79
Cultural	Aesthetic Value	The presence and visual health of beach grass in beach dune systems contribute to their aesthetic functions along the shoreline (Nottawasaga Valley Conservation Authority, 2005; Peach, 2003).	106	49
	Tourism	A healthy and established population of beach grass indicates a healthy, stable shoreline environment. Since it also contributes to increasing dune biodiversity, it also increases the overall aesthetic value of the beach, which has an impact on tourism (Emery & Rudgers, 2010; Nordstrom, 2003).	106	35
	Educational value	The dunes along the Lake Huron shoreline formed over 6000 years ago as a result of glacial subsidence (Peach, 2006), but their presence today serves a reminder of the natural heritage of the lake (Nottawasaga Valley Conservation Authority, 2005) and that the Lake Huron shoreline is a dynamic system (Van Dijk, 2004).	104	66

6.2 Regulating ecosystem services

As noted in Section 2.4.1.2 (*Regulating ecosystem* services), **Table 2.2** displays the temporal and geographic extent of documentation of regulating beach grass ESs in the academic literature. The effects of beach grass on water quality in the Great Lakes, is a very geographically specific issue and has only been documented in the literature within the last 12 years, whereas the other ESs have been documented many times over the past 60 years. This could account for the large differences in identification of these ESs by survey respondents. All key informants described at least one of these regulating ESs, despite not necessarily being explicitly asked about them (**Table 6.3**).

Table 6.3 *Quotations from interviews identifying regulating ESs.*

Interview Participant	Quotation	Tagged themes
1	"If [beach grass] is already present and being removed, that could have negative effects [...]. It could lead to increased erosion or flooding."	Regulating ESs Erosion prevention Flooding moderation
2	"[…] dunes and dune grass are the best shore protection you can have because it replenishes itself after it gets eroded away by storms and slow movement of waves over the summer creates the dunes again.	Regulating ESs Erosion prevention Storm moderation Shore protection
	"A heavy storm would take all that away, and without the resupply of sand and without the dynamic rebuilding, you'll run into a lot of structural problems."	Regulating ESs Erosion prevention Storm moderation
	"The dune grass is the glue that holds sand dunes together. Without the dune grass, you will get blowing sand going further inland. Without dune grass, you won't have a dune. Dunes are the best shore protection that people can have."	Regulating ESs Erosion prevention Shore protection
	"[…] if the dune is removed, then when the water level comes back up, you'll get flooding around your home or cottage."	Regulating ESs Flooding moderation
	"If you think of a septic system with a septic field, that must have a certain amount of cover over those tiles. If you think of a dune field, if that dune is healthy and has the right depth, then the septic system will function the way it should. If the dune is deflated, in other words, the dune grass is taken away and the sand blows inland, the depth of the material overtop those septic fields is much less. You get breakouts of moisture affluent and bacteria in that. That can cause issues along the shoreline where that water seeps to the shore."	Regulating ESs Water quality Erosion prevention
	"During high waters, dunes will erode and dune grass will erode away into the water which is a natural process and it's one that is encouraged to happen because if we didn't have that then the storm waves would roll up the beach much further and cause damage to infrastructures buildings and cottages."	Regulating ESs Erosion prevention Shoreline protection Storm moderation
3	Beach grass's roots can grow up to three metres deep underground so that stabilization and prevention of flooding during storm events has a proactive piece to flooding. […] If you have a basement, flooding can then have negative effects on your septic system […], there is potential for some leakage, which has its own effects on nutrient flow into the groundwater and local water. There is potential for *E.coli* and bacterial outbreaks.	Regulating ESs Erosion prevention Flooding moderation Storm moderation Water quality
4	"[…] if they haven't kept their dune grass and the dunes, then they could have erosion problems and then facing hazard issues of the lake, whether it's the wave uprush or the ice spray and the water spray during storm surges and winter or just the erosion and then loss of beach."	Regulating ESs Erosion prevention Storm moderation Weather moderation

Additionally, the regulating ESs presented in **Table 2.2** are widely recognized in many government planning documents (GSCA, 2013; Ministry of Municipal Affairs and Housing, 2014; MVCA, 2016; Schaller, 2014; SCRCA, 2013; SVCA, 2018). Most specifically, the most recent Provincial Policy Statement (PPS) of Ontario, forbids development in areas they refer to as “dynamic beach hazards,” “flooding hazards,” and the “100-year flood zone” that will compromise “ecological function” (Ministry of Municipal Affairs and Housing, 2014).

[illegible]

Dynamic beach hazard: means areas of inherently unstable accumulations of shoreline sediments along the *Great Lakes - St. Lawrence River System* and *large inland lakes*, as identified by provincial standards, as amended from time to time. The *dynamic beach hazard* limit consists of the *flooding hazard* limit plus a dynamic beach allowance.

Ecological function: means the natural processes, products or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes. These may include biological, physical and socio-economic interactions.

[illegible]

Flooding hazard: means the inundation, under the conditions specified below, of areas adjacent to a shoreline or a river or stream system and not ordinarily covered by water:

a) along the shorelines of the *Great Lakes - St. Lawrence River System* and *large inland lakes*, the *flooding hazard* limit is based on the *one hundred year flood level* plus an allowance for *wave uprush* and *other water-related hazards*;

b) along *river, stream and small inland lake systems*, the *flooding hazard* limit is the greater of:

1. the flood resulting from the rainfall actually experienced during a major storm such as the Hurricane Hazel storm (1954) or the Timmins storm (1961), transposed over a specific watershed and combined with the local conditions, where evidence suggests that the storm event could have potentially occurred over watersheds in the general area;
2. the *one hundred year flood*; and
3. a flood which is greater than 1. or 2. which was actually experienced in a particular watershed or portion thereof as a result of ice jams and which has been approved as the standard for that specific area by the Minister of Natural Resources;

except where the use of the *one hundred year flood* or the actually experienced event has been approved by the Minister of Natural Resources as the standard for a specific watershed (where the past history of flooding supports the lowering of the standard).

Figure 6.1 *Definitions of key terms provided in the most recent PPS (Ministry of Municipal Affairs and Housing, 2014).*

The five governing CAs of the Lake Huron southeastern shoreline (SCRCA, GSCA, SVCA, ABCA, and MVCA) echo this principle (ABCA, 2019b; GSCA, 2013; SCRCA, 2013; SVCA, 2018). Moreover, such definitions will encompass many beach-dune systems located along the Great Lakes (**Figure 6.1**). Therefore, the five CAs that govern the southeastern shoreline will not permit any development that compromises the dunes along the shoreline as well as other shoreline ecosystems and features that fall within the specified zones. These regulations are not just in place for the integrity of the shoreline beaches, but also for the safety of the community members, that rely on the integrity of the shoreline.

Maps and figures provided on several CAs’ websites outline vulnerable zones, where development is not permitted, which clearly include many beach-dune systems (e.g. **Figure 6.2**, **Figure 6.3**, and **Figure 6.4**).

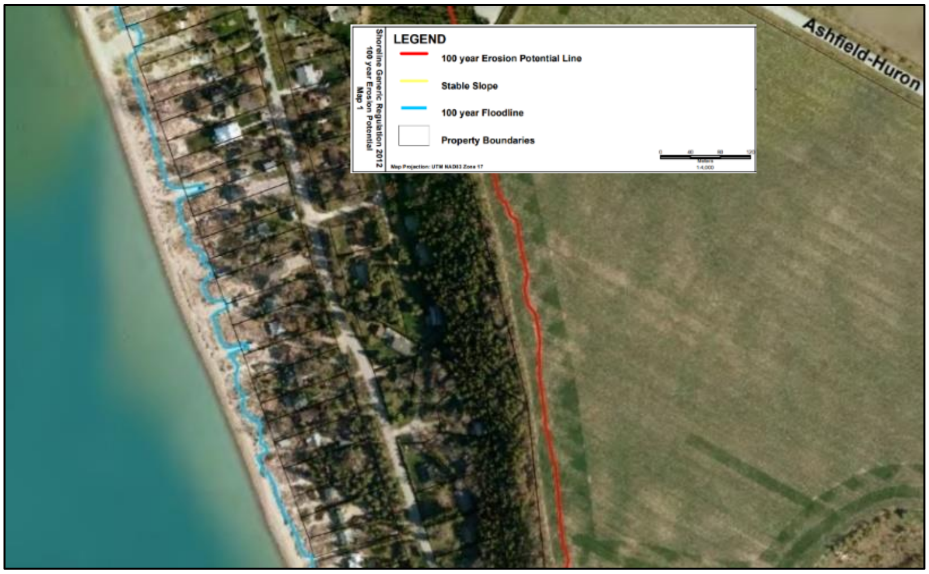

Figure 6.2 *Portion of a map of the Lake Huron shoreline from the Maitland Valley Conservation Authority website, featuring the 100-year floodline, outlined in blue, and the 100-year erosion potential line, outlined in red (MVCA, 2012).*

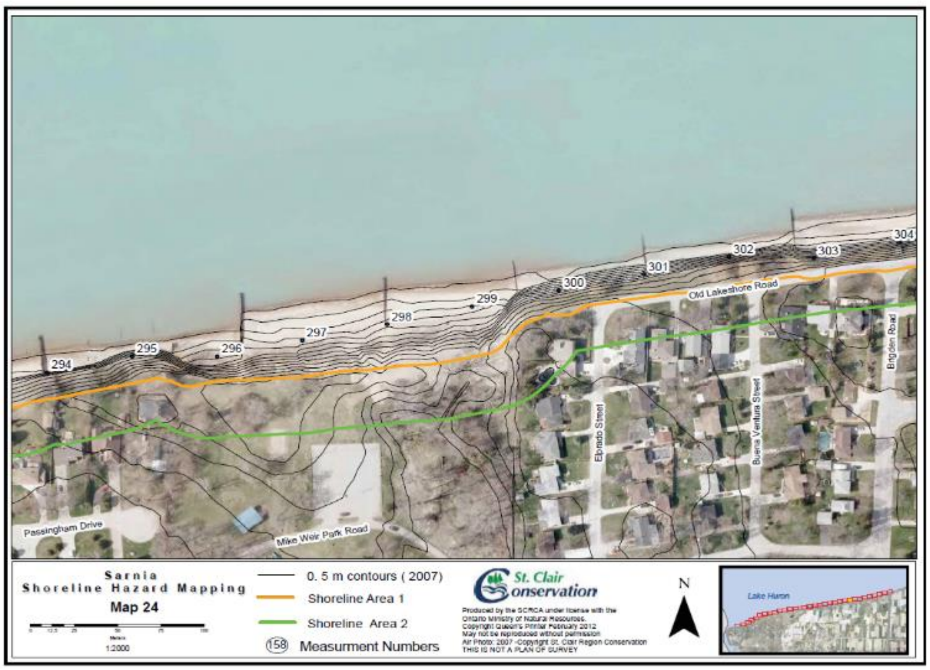

Figure 6.3 *Map of the Lake Huron shoreline from the St. Clair Conservation Authority website featuring Shoreline Area 1 which is the most vulnerable area of the shoreline, outlined in orange (W.F. Baird & Associates Coastal Engineers Ltd., 2011).*

It is not clear the extent to which survey respondents living along the shoreline are aware of the regulations in place by their governing CA, and possibly the reasons behind the regulations. However, there is some evidence to indicate a general level of awareness. This is reflected in the results presented in **Table 6.2**, where 80% of survey respondents identified that beach grass aids in weather and storm moderation, and 83% identified that beach grass prevents erosion along the shoreline. In terms of water quality, less than half of survey respondents (47%) identified this as a beach grass ES. Since the role of beach grass in controlling water quality is associated with maintaining the natural shoreline ecosystem structure, this ES would be considered part of an essential ecosystem process and thus encompassed in the CA planning documents. It is, however, less direct than the other regulating beach grass ESs, as the magnitude of its effects is more contingent on what feature replaces the beach grass than its actual removal. This could account for the low identification rate of this ES by survey respondents.

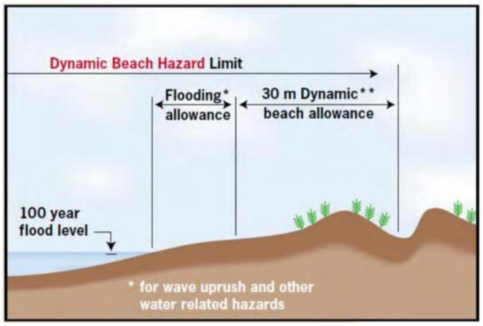

Figure 6.4 *Dynamic beach hazard limit, as defined by the Ontario ministry of natural resources (ABCA, 2019b).*

Even without knowledge of the CAs' regulations, the simple act of visiting the shoreline beaches of Lake Huron on a regular basis could make survey respondents aware of the regulating beach grass ecosystems services addressed here (e.g. **Figure 6.5**, **Figure 6.6**, **Figure 6.7**, **Figure 6.8** and **Figure 6.9**).

Figure 6.5 *The dunes at Pinery Provincial Park, Grand Bend, Ontario, are approximately two metres in height, (see Charlotte (1.63m) for scale). These dunes have a dense beach grass covering and are noticeably able to protect against normal lake fluctuations (~2 m) and possibly, large wave uprush. Visibly, they shield the area beyond them from flooding. Photograph: Ruth Stewart-Patterson.*

Figure 6.6 *Signs at Sauble Beach, Ontario, advising beach visitors to avoid stepping on the dunes, following this is a explanation as to why the dunes must be protected, emphasizing their natural shore protection abilities. Photographs: Charlotte Hings.*

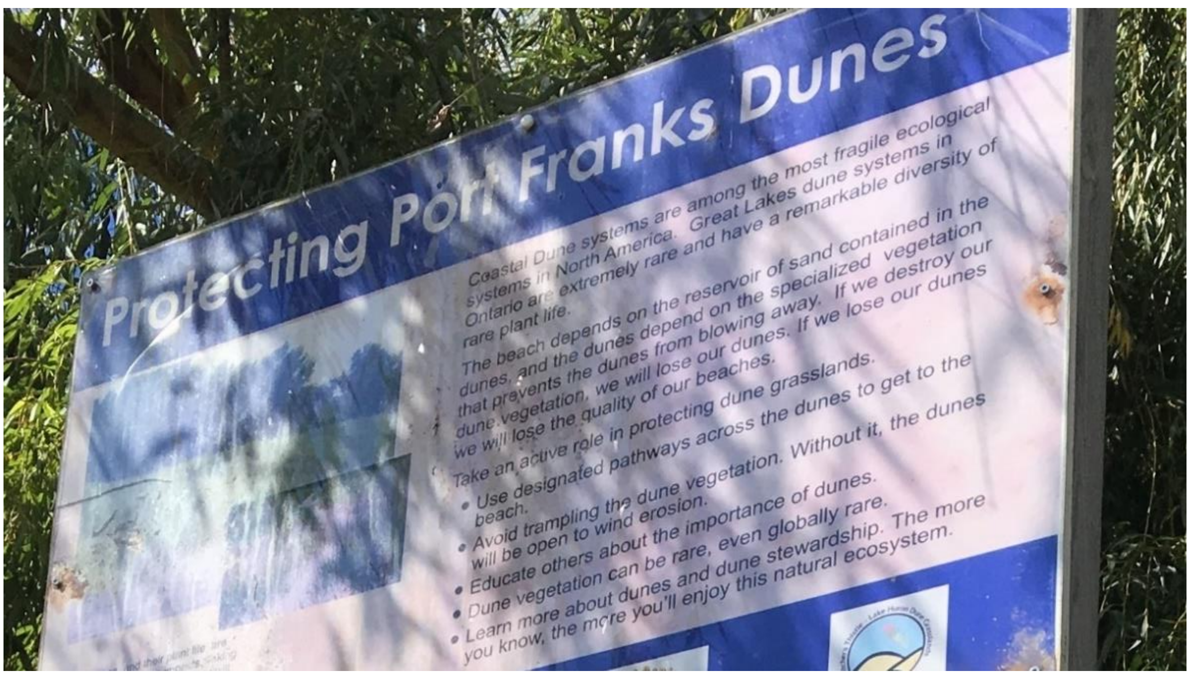

Figure 6.7 *Signs at Port Franks main beach, Ontario, advising beach visitors to avoid stepping on or destroying the dunes. There is a more detailed explanation of how the dunes and their vegetation are crucial for erosion prevention and how it connects to the ability to enjoy the beach as it is. Photograph: Charlotte Hings.*

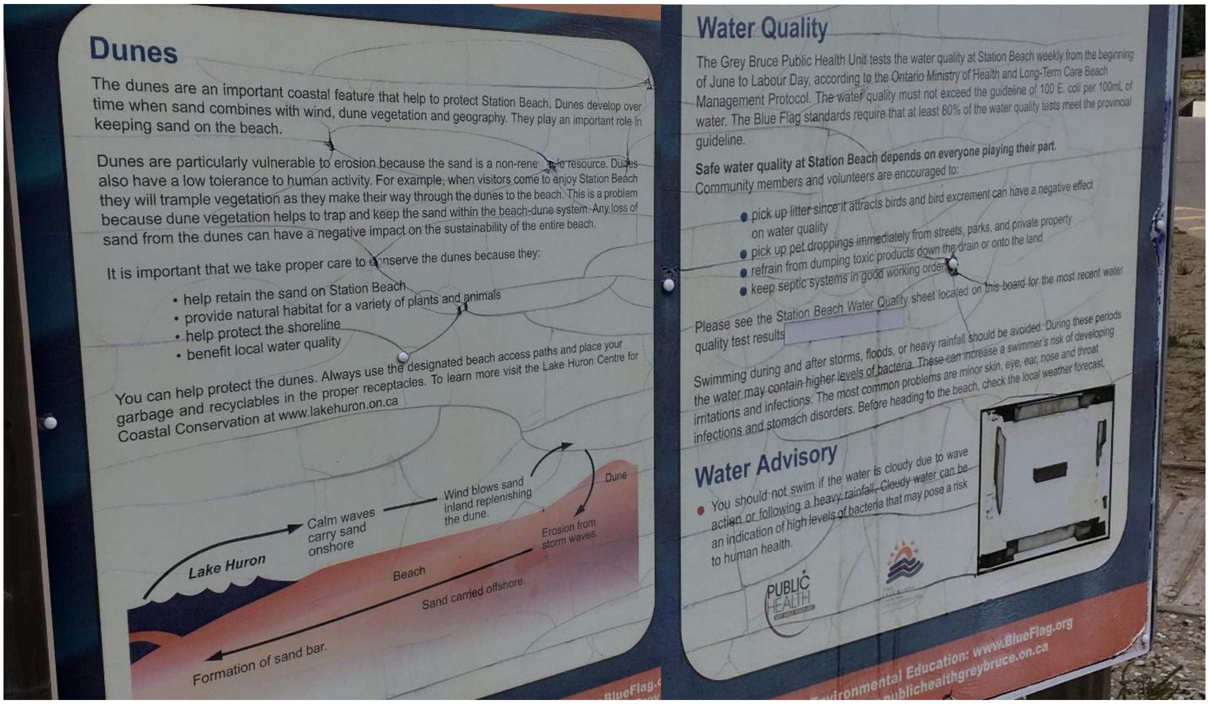

Figure 6.8 *Signs at Station Beach, Kincardine, Ontario. These advise beach visitors to not step on the dunes, citing their importance in protecting the shoreline, preventing erosion, maintaining biodiversity, and improving water quality. Photograph: Charlotte Hings.*

Figure 6.9 *LHCCC staff sorting garbage collected along the Goderich shoreline by volunteers. Litter can attract birds, and toxic substances left on the beach, such as cigarette butts, can have a negative impact on water quality when they leach into the sand and lake water. Photograph: Charlotte Hings.*

6.3 Supporting ecosystem services

The supporting beach grass ES, maintenance of biodiversity, was identified by 79% of survey respondents. This ES has a more indirect benefit for humans than the other ESs presented in **Table 6.2**, however its identification rate by survey respondents was still relatively high. As noted in Section 2.4.1.3 (*Supporting* ecosystem services), **Table 2.3** displays the temporal and geographic extent of documentation of the beach grass ES of biodiversity in the academic literature. It has been documented many times over the past 60 years. This could account for its high identification rate by survey respondents.

In the key informant interviews, three participants described biodiversity maintenance as a beach grass ESs, despite not necessarily being explicitly asked about it (**Table 6.4**).

Table 6.4 *Quotations from interviews identifying supporting ESs.*

Interview Participant	Quotation	Tagged themes
1	"Successful establishment of beach grass allows for other vegetation to creep through. Then it can all work together in one big fabric."	Supporting ESs Biodiversity maintenance
	"Leaving debris on the beach helps with the establishment of vegetation. Some areas are groomed routinely, but most are not."	Supporting ESs Biodiversity maintenance
	"One thing leads to another. If you get a good crop of dune grass, you'll get other stuff coming up in there too."	Supporting ESs Biodiversity maintenance
	"That's a planning effort that is combining beach grass and creating a wetland for the lake wildlife species." (describing a project on Lake Ontario)	Supporting ESs Biodiversity maintenance
2	"[…] beach grass is the pioneer species of vegetation on beaches that have enough sand to create dunes."	Supporting ESs Biodiversity maintenance
4	"Not just the fact that it's significant habitat area, ecosystem in itself, but the benefits behind maintaining those areas for hazard-related reasons."	Supporting ESs Biodiversity maintenance

In terms of direct benefits drawn from this ES by community members and beach visitors, the creation of a diverse wildlife habitat can increase property value for buyers who value a more natural experience (Schaller, 2014). Additionally, this same group of people will also experience greater enjoyment out of their local beach environment with a greater floral and faunal diversity (Schaller, 2014). As mentioned by Interview Participants 2 and 3, non-local beach visitors tend to come in with an idea of how the beach should look, typically from seeing larger, coastal beaches in the USA or Central and South America. However, they do not have any knowledge of the unique and fragile Lake Huron ecosystems. **Table 6.5** contains quotations from the interview portion of this thesis, explaining this complexity.

Table 6.5 *Quotations from interviews explaining the different expectations of tourists and locals.*

Interview Participant	Quotation	Tagged themes
1	"[…] people like to wiggle their toes and feet in the sand, build sand castles. The beach, when you've got beach grass, is not conducive to that type of activity."	Tourism Beach grass perceptions Beach perceptions
	"Some [resource users] come from such a great distance away […] and they have no knowledge, no appreciation or understanding of a beach environment."	Tourism Beach perceptions
2	"People who come to the beach as tourists and haven't been there before, they would not be aware of […] how dynamic [the Lake Huron] environment is and therefore don't understand that [beach vegetation] is an entirely natural process."	Tourism Beach grass perceptions Beach perceptions
	"The whole idea of the thousands of people that use the Florida Beaches is […] that 'they do [beach grooming] in Florida, so it must be good to do here in Ontario.'	Tourism Beach grooming Beach perceptions
3	"I think there might be a notion that we do have that turquoise water like in the Caribbean in the warmer parts of the world, so there might be a perception that you need to have that clear beach as well with no vegetation. But that's not the case here. It is a very different ecosystem."	Tourism Beach grass perceptions Beach perceptions
4	"[…] more people are renting out their properties, so you're getting non-residential people coming in and using the shoreline. They don't have a vested interest in maintaining the shoreline the way they see it and the natural spaces. 'I'm just here for the weekend and I don't know or care what I'm doing.'"	Tourism Beach perceptions

The survey sample consisted primarily of local beach visitors who would therefore be more likely to have a greater understanding of the Lake Huron ecosystem, more knowledge of what a healthy Lake Huron shoreline should look like, and experience a greater enjoyment on a diverse beach. This could also account for the high identification rate of biodiversity maintenance as an ES by survey respondents. Observable at various field sites are clear examples of how beach grass presence can go hand-in-hand with increasing and maintaining biodiversity. Visiting the shoreline beaches of Lake Huron on a regular basis can contribute to making survey respondents aware of this relationship, (e.g. **Figure 6.10**, **Figure 6.11** and **Figure 6.12**), but other factors are likely also at work (e.g., education and training experiences, exposure to awareness raising information).

Figure 6.10 *Dunes with beach grass and other wildflowers and plants growing on them, at Sauble Beach, Ontario. Photograph: Charlotte Hings.*

Figure 6.11 *Fenced-off dune area with a lot of beach grass and other plant diversity, at Station Beach, Kincardine, Ontario. Photograph: Charlotte Hings.*

Figure 6.12 *Roped-off area of beach grass that has allowed for other wildflowers to thrive among it, in Port Elgin, Ontario. Photograph: Charlotte Hings.*

6.4 Cultural ecosystem services

All cultural ESs evaluated in the survey received relatively low identification rates by respondents. For example, aesthetic enjoyment of the beach, was identified by 49% of survey respondents as important. Tourism value was identified by 35% of survey respondents. Educational value was identified by 66% of survey respondents (**Table 6.2**).

Polarized opinions on the aesthetic value of beach grass along with the indirect and unobvious benefits for tourism and education noted in the literature review (**Table 2.4**), align with the low identification rate of these ESs by survey respondents. Additionally, given that most individuals in the survey respondent pool are local shoreline residents, and not tourists, could mean that they are less likely to participate in touristic activities and thus gain less touristic value from beach grass, even though it represents an important ES in general.

The contribution of beach grass to the education of shoreline and coastal visitors is not directly documented in the literature. Incidentally, much of the educational value obtained by shoreline and coastal visitors comes from information originally collected by academic researchers from evaluating the biophysical and historical properties of the various beach dune systems along the Great Lakes shorelines and disseminated to the public. This aligns with the relatively low identification rate of this ES by survey respondents, as they may not be achieving educational value directly from beach grass and the dunes, but from information distributed to them either in formal documents or on beach signage that has originally been collected by academic researchers using measurements taken from various properties of the beach grass and dunes.

In terms of government planning documents, several reference the contributions (Nottawasaga Valley Conservation Authority, 2005) or detriments (Town of Saugeen Shores, 2013; Van Zwol et al., 2012) that beach grass provides to the aesthetic enjoyment of the Lake Huron shoreline beaches. The Nottawasaga Valley Conservation Authority (NVCA) recognizes the importance of the aesthetic functions that the beach-dune systems provide to the Wasaga Beach shoreline. The Town of Saugeen Shores (2013) and Van Zwol et al. (2012) both referenced that community members had removed beach grass and other vegetation to improve shoreline aesthetics. The same *theoretical versus practical* pattern that was observed in the academic literature review is also presented through these planning documents (Town of Saugeen Shores, 2013; Van Zwol et al., 2012).

Multiple government planning documents display similar patterns as the academic literature review in terms of the benefits of beach grass on tourism in Lake Huron. The TSS recognizes that because flat, cleaned beaches are more attractive to tourists, this has been done on several beaches, but that it also must be rectified through ecological restoration (Town of Saugeen Shores, 2013). The NVCA acknowledges the intense pressures from tourism to create shoreline developments, however, the beach-dune systems remain intact along the Wasaga Beach shoreline (Nottawasaga Valley Conservation Authority, 2005). The most recent PPS states that rural areas should be supported by providing opportunities for sustainable tourism, which includes the preservation of natural assets (Ministry of Municipal Affairs and Housing, 2014). However, the beach-dune ecosystems do not fall in what is defined as rural areas, and are not subject to these opportunities for sustainable tourism. The PPS does mention that long-term economic prosperity should be supported by providing opportunities for sustainable tourism development. Although the term "sustainable tourism" is not explicitly defined in the PPS, from the results of the literature review, it can be inferred that this should include the preservation of natural assets such as the beach-dune ecosystems along the shoreline.

The education value of beach grass holds a unique place in several government planning documents. The TSS, Van Zwol et al. (2012b) and NVCA, all discuss placing signage on public beaches near the dunes with beach grass in order to give a visually immersive educating experience to the beach users (Nottawasaga Valley Conservation Authority, 2005; Town of Saugeen Shores, 2013; Van Zwol et al., 2012). Placing signs near the dunes themselves, presents the information collected in the past about dune functioning while using the dunes as a visual representation of this information.

At many field sites, the impact of beach grass on tourism and vice versa, is clearly visible from a short trip to the beach during the height of tourist season (June-July-August). Areas that are flat and have no vegetation are areas where there are the most tourists (**Figure 5.1**, **Figure 5.2**, and **Figure 5.6**).

Signage on the beach was present near many dunes and beach grass patches at various field sites. They are short and straight forward, presenting complex scientific information in a publicly accessible manner (**Figure 6.6**, **Figure 6.7**, **Figure 6.8**, **Figure 6.10**, **Figure 6.11**, and **Figure 6.12**).

6.5 Chapter summary

The beach grass ESs identified in the literature review and incorporated into the survey were all considered to be of value by the majority of survey respondents except for water quality (47%), aesthetics (49%) and tourism (35%). Interview participants discussed the value and contributions of regulating and supporting beach grass ESs, as well as the impacts that degradation of these ecosystems can have to various dimensions of social well-being that were congruent with the literature review. The details of these relationships will be explored in detail in the following chapter.

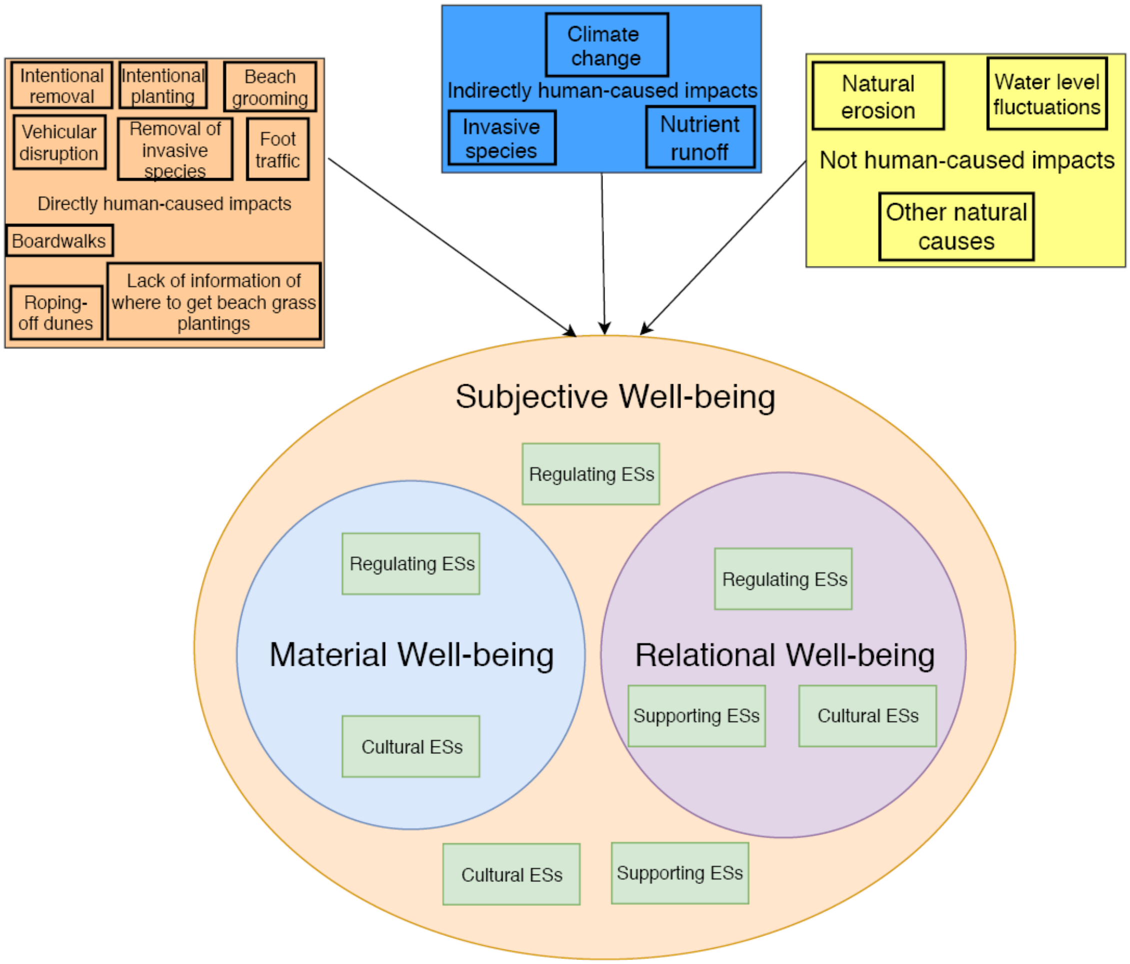

Figure 6.13 *The drivers of beach grass change reported by survey respondents and interview participants. These changes impact the various ecosystem services and thus the dimensions of social well-being that they support.*

Chapter 7 – Results: Linking Beach Grass Ecosystems Services and Social Well-Being

In this chapter, I present the findings for Objective 4 of this thesis (see **Table 7.1**). After identifying changes in beach grass along the Lake Huron shoreline and the ecosystem services valued by survey respondents in the previous chapters, here I identify how these changes impact the material, relational and subjective well-being dimensions of survey participants.

Table 7.1 *Research objectives.*

1. Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors.
2. Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.
3. Identify beach grass ecosystem services of value by property owners and visitors along the shoreline
4. **Establish how beach grass changes are linked to social well-being from the perspective of property owners and shoreline visitors.**
5. Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.

7.1 Social well-being

Social well-being has three dimensions, as described by Britton and Coulthard (2013), material, relational and subjective. In terms of environmental resources, social well-being can be seen as the ability of an individual's resource pool, materially, relationally or subjectively, to overcome the obstacles and challenges that they face (Britton & Coulthard, 2013; Dodge et al., 2012).

Changes in ecosystems can affect various dimensions of social well-being, and this chapter will explore how this occurs, and what these interactions are in order to understand how these conditions affect the survey respondents' behaviours and actions toward their biophysical environment (Larson, 1993). This section will therefore evaluate how the various dimensions of social well-being are affected by changes in beach grass and respondent perceptions about beach grass as an ecosystem service. Chapter 8 will then explore these findings and identify specific issues that participants are experiencing and develop recommendations for policy action and better coastal resource management of the Lake Huron shoreline.

7.1.1 Material well-being

Material well-being is defined by the physical, material resources that people have (Britton & Coulthard, 2013). Survey participants were asked to respond to a series of statements (**Table 7.2**) relating to material well-being and then had to choose from the options: "Strongly agree," "Agree," "Neither agree or disagree," "Disagree," "Strongly disagree," and "Not applicable/unsure" to state their level of agreement.

Table 7.2 *Material well-being Likert-scale questions in the survey.*

Beach grasses have costed you money in past (e.g., for removal)
Beach grasses presently cost you money (e.g., for removal)
Beach grass presence decreases your property value
Beach grass presence has compromised your ability to enjoy the beach
Beach grass presence has increased your overall financial well-being (e.g., increased your property value)

These questions were used to establish a baseline of how the presence of beach grass affects the overall material well-being of the respondents. The choices on the Likert scale were each assigned a value from 1-5 points, where a higher score would represent a lower level of material well-being, and the "Not applicable/unsure" option was scored as zero (this process is described in **Figure 4.3**). The total score across the five material well-being questions was calculated by adding up the score for each question, resulting in scores ranging from 0-25 points. These scores were then categorized as described in Section 4.3.1.1 (*Quantitative analysis*). The results of this question are presented below (**Figure 7.1**).

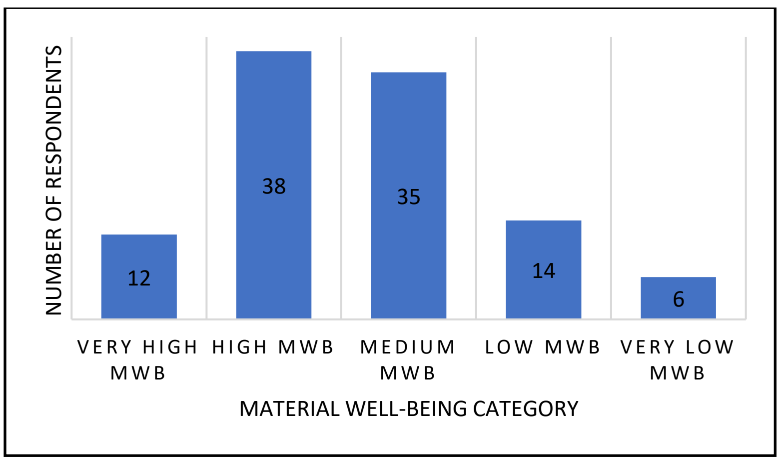

Figure 7.1 *Number of respondents in each of the material well-being categories based on their answers pertaining to the material well-being indicators in the survey. MWB= material well-being; n=105.*

Table 7.3 Material well-being indicators from the survey.

Current financial situation
Property value
Enjoyment of the accessed beach area

In the survey, participants were then presented with several material well-being indicators and were asked to identify how the changes in beach grass they reported earlier in the survey[7], have impacted these indicators.

Here, respondents had to indicate whether the changes they reported "Very positively impacted," "Positively impacted," "Not impacted," "Negatively impacted," or "Very negatively impacted" that specific material well-being indicator. Respondents also had the option to indicate of the specific statement was "Not applicable/unsure" to them. These responses were assigned a value from 1-5 as indicated in **Figure 4.2**. The total score across the three material well-being indicators was calculated for each respondent and categorized as described in Section 4.3.1.1 (*Quantitative analysis*). The results of this question are presented below (**Figure 7.2**).

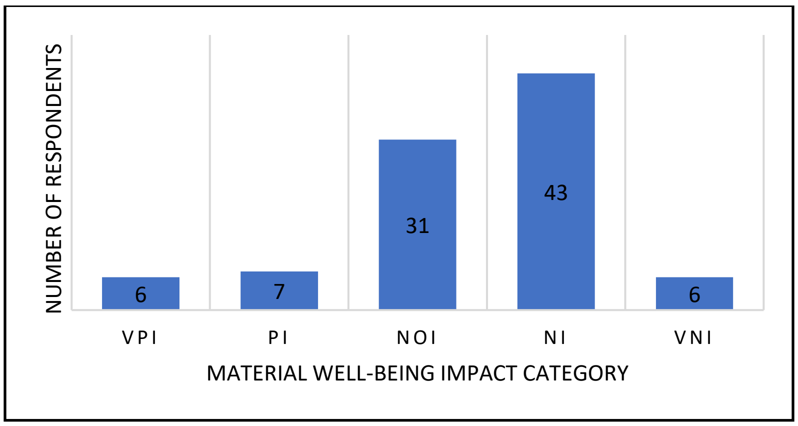

Figure 7.2 *Number of respondents in each of the material well-being impact categories based on their answers pertaining to the material well-being indicators in the survey. VPI= very positively impacted; PI= positively impacted; NOI= no impact; NI= negatively impacted; VNI= very negatively impacted; n=93.*

In general, the changes in beach grass, have led to negative to no material well-being impacts for survey respondents. To determine the specific types of beach grass changes leading to changes in material well-being, the average value for each respondent's material well-being impact score was taken and then correlated (Spearman) with the respective responses to the various dimensions of reported beach grass change. As noted earlier, in Section 5.2, respondents could choose from "Increased (1)," "No change (2)," "Decreased (3)," and "Not applicable/Unsure (0)" for each of the dimensions of beach grass change. Each was assigned a value from 1-3 as indicated above, and **Equation 4.2** was then used to convert the values from this three-point scale to a five-point scale in order to compare the variables on an equivalent scale

[7] This refers specifically to question 14 of the survey, addressing the specific types of changes in beach grass observed by respondents. The results of this question are presented in **Table 5.4**

such that “Increased” was valued at one point, “No change” at three points, and “Decreased” at five points. “Not applicable/Unsure” was consistently valued at zero points for both scales. The results are presented in **Table 7.4**.

Table 7.4 *Relationship between dimensional changes of beach grass and average material well-being of survey respondent.*

Dimension of beach grass change (x) correlated with average material well-being impact (y)	Spearman correlation coefficient (ρ)[8]	p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)	Correlation strength	n
Area/extent (x_1)	0.2112	0.0433, strong	Weak, positive	92
Density (x_2)	0.2060	0.0488, strong	Weak, positive	92
Visual Health (x_3)	0.1740	0.0972, weak	Very weak, positive	92
Average change (x_{avg})	0.1406	0.1814, very weak to none	Very weak, positive	92

Of the three dimensions of beach grass change evaluated here, change in area/extent of beach grass has the greatest impact on the material well-being of survey respondents. These results indicate that a general decrease in beach grass coverage, and density lead to a slight decrease in material well-being of survey respondents. This means that in general, financial well-being, property value and beach enjoyment tend to decrease when the beach grass ESs are compromised.

Alternatively, the relationship between average beach grass changes reported by survey respondents and the various material well-being indicators was evaluated using a Spearman correlation. Each variable was valued the same as described above and the results are presented below in **Table 7.5.**

Table 7.5 *Relationship between average changes of beach grass and material well-being indicators.*

Indicator of material well-being impact (y) correlated with average beach grass change (x)	Spearman correlation coefficient (ρ)[9]	p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)	Correlation strength	n
Current financial situation (y_1)	0.4262	0.00002277, very strong	Moderate, positive	92
Property value (y_2)	0.1426	0.1752, very weak to none	Very weak, positive	92
Enjoyment of the beach (y_3)	0.0551	0.6018, very weak to none	Very weak, positive	92
Average impact (y_{avg})	0.1406	0.1814, very weak to none	Very weak, positive	92

Of the three indicators of material well-being evaluated here, average beach grass change has the greatest impact on current financial situation. These results indicate that a general increase in beach grass

[8] Calculations for this were done using MATLAB R2018a and can be found in Section 15.1. Data used in these calculations can be found in Section 15.2. Participants who did not answer both questions were thus not counted in these calculations.

[9] Calculations for this were done using MATLAB R2018a and can be found in Section 15.3. Data used in these calculations can be found in Section 15.4. Participants who did not answer both questions were thus not counted in these calculations

coverage, density and health leads to a slight increase in the financial well-being and thus, overall material well-being of survey respondents.

The relationship between material well-being and beach grass ESs s important because from the information depicted in the previous chapter (6.2 *Regulating ecosystem services*, and 6.4 *Cultural ecosystem services*), there are many reasons why supporting these ESs could lead to greater material well-being. Although not necessarily aesthetically pleasing for the purposes of property valuation, the beach grass and dunes work to prevent erosion and flooding of the shoreline properties. This alone mitigates against property damage, increasing financial well-being. This was addressed by all interview participants (**Table 7.6**).

In terms of enjoyment of the beach, many survey respondents complain of beach grass being a nuisance to this and interview participants echoed this. What many beach visitors may not realize is the importance of the relationship between beach grass and the Lake Huron shoreline. Without the stabilizing qualities that beach grass provides to the shoreline, and with the increasing impacts of climate change, it is likely that in the future, there will be very little beach left to be enjoyed by the public. For example, according to Doody (2013), the sacrificing of environmental integrity for affluence leads to major sand dune loss and eventually, structural and safety issues. In the past, this has caused many shoreline development sites to become abandoned and economically non-viable (Doody, 2013).

Therefore, when focusing on the short-term, it could appear as though beach grass may decrease the material well-being of community members and beach visitors, in terms of property value and enjoyment of the beach. Looking in the long-term, material well-being increases immensely with conservation of the integrity of the shoreline and reducing property damage costs.

Table 7.6 *Interview data pertaining to material well-being.*

Interview Participant	Quotation	Indicator(s) and ES(s) cited
1	"If [beach grass] is already present and being removed, that could have a negative effect financially. It could lead to increased erosion or flooding. If it's being deliberately introduced, it's going to have positive effect.	Current financial situation Erosion prevention
	"The person's well-being is predicated on how much of a threat there is to their property. They're going to lose their property through efforts and activities that are not good for the protection of their property. Their well-being is not going to be very good."	Property value
	"[…] people like to wiggle their toes and feet in the sand, build sandcastles. The beach, when you've got beach grass, is not conducive to that type of activity.	Enjoyment of the beach
2	"[…] without the resupply of sand and without the dynamic rebuilding, you'll run into a lot of structural problems.	Property value Current financial situation

		Erosion prevention
	"From a property value standpoint, it blocks people's view of the sunset and blocks people's access to the shoreline."	Property value Enjoyment of the beach Aesthetic enjoyment
	"It is not only providing the cohesion of the dunes, but the stability of the dunes provides the property owner with shore protection."	Property value Enjoyment of beach Weather and storm moderation
	"There is a financial impact, if the dune is removed, then when the water level comes back up, you'll get flooding around your home or cottage.	Current financial situation Weather and storm moderation
3	"Flood and erosion damages can have a big financial impact on a shoreline property owner. That could involve having to contract out some engineered solution in addition to a natural solution on their coast, especially if it's as severe as losing infrastructure or having to relocate a piece of infrastructure on the property."	Current financial situation Property value Erosion prevention
	"Beach grass' roots can grow up to 3m deep underground so that stabilization and prevention of flooding during storm events has a proactive piece to flooding. If you have turf grass with much shorter roots leading up from the lake to your property, the you're going to be at a much higher risk of flooding, especially if those dunes are not there in front of your house."	Current financial situation Property value Erosion prevention Weather and storm moderation
	"If you have a basement, flooding can then have negative effects on your septic system"	Current financial situation Property value
	"If you do get fined, dune restoration can cause from $5000 to $10 000."	Current financial situation
	"Dunes and dune grasses can provide natural services that equate to a value of about $2000 per linear metre."	Current financial situation
4	"In Southampton, walking along the concrete pathway, sometimes the sand is just blown right over onto everyone's property. This is about 100 feet from the water's edge."	Enjoyment of the beach
	"I think they would feel that the increase or decrease with the issues along the shoreline would cause a financial change to their properties, assessment wise. If they were families, they may have loss of income as a result."	Property value Current financial situation
	"That would go with high lake levels too if they haven't kept their dune grass and the dunes, then they could have erosion problems and then facing hazard issues of the lake, whether it's the wave uprush or the ice spray and the water spray during storm surges and winter or just the erosion and then loss of beach."	Enjoyment of the beach Erosion prevention Weather and storm moderation
	"I think consistently what we've heard in the last year's summer was the lack of beach-tell real-estate. […] Their enjoyment level has gone down. They can no longer lay down and have their groups and families come out and enjoy the beach as much or walk along the beach."	Property value Enjoyment of the beach

Material well-being is impacted by regulating and cultural beach grass ESs. In general, survey respondents reported medium-to-low levels of material well-being in relation to beach grass. Additionally, a significant positive correlation was found between beach grass changes and financial well-being impact, where most respondents reported that they were negatively impacted by the changes in beach grass that they experienced. Material well-being is thus supported through the maintenance of the quality of valued regulating and cultural beach grass ESs. However, when management decisions do not take this connection into account, shoreline communities will suffer material well-being losses from the loss of beach-dune systems. **Figure 7.3** illustrates these connections.

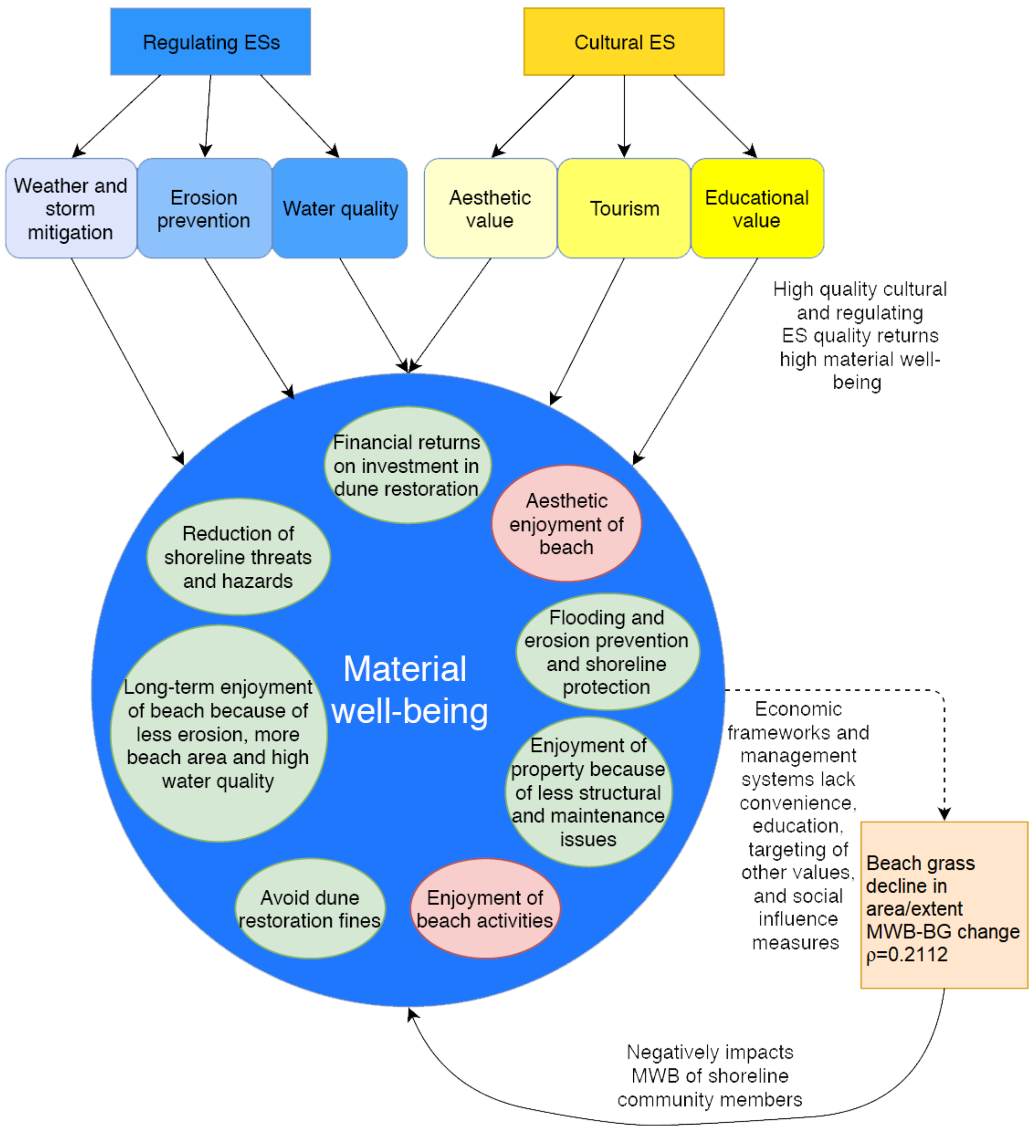

Figure 7.3 *In-depth interactions between regulating ESs, cultural ESs, material well-being and beach grass change. MWB= material well-being; BG= beach grass.*

7.1.2 *Relational well-being*

Relational well-being is defined by what people do and the interactions that they have with each other as well as the quality of those interactions (Britton & Coulthard, 2013; Larson, 1993). Survey participants were asked to respond to a series of statements (**Table 7.7**) relating to relational well-being and then had to choose from the options: "Strongly agree," "Agree," "Neither agree or disagree," "Disagree," "Strongly disagree," and "Not applicable/unsure" to state their level of agreement.

Table 7.7 *Relational well-being Likert-scale questions in the survey.*

Beach grasses contribute to your sense of place
Beach grasses contribute to your feeling of community belonging
Beach grass presence can be linked to your participation in community activities (e.g., restoration or clean up activities)
Beach grasses have negatively impacted your personal relationships (e.g., increased conflict with neighbours or other beach users to clear or restore)
Beach grasses have positively impacted your personal relationships (e.g., shared agreement to take an action)

These questions were used to establish a baseline of how the presence of beach grass affects the overall relational well-being of the respondents. The choices on the Likert scale were each valued exactly as described above for the material well-being questions. These scores were also categorized as described above for the material well-being questions. The results of this are presented below (**Figure 7.4**).

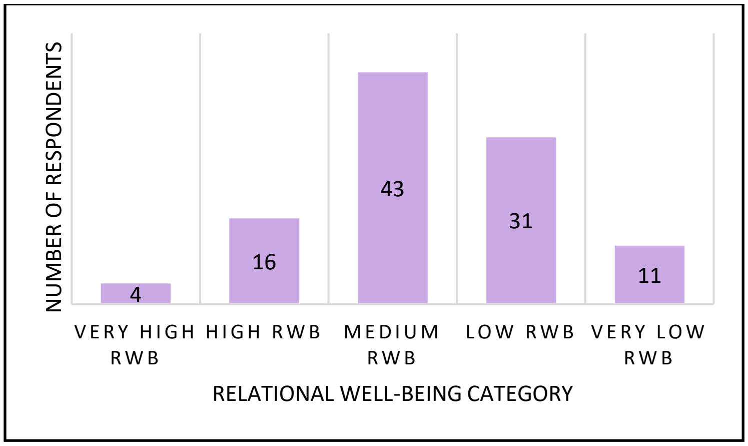

Figure 7.4 *Number of respondents in each of the relational well-being categories based on their answers pertaining to the relational well-being indicators in the survey. RWB= relational well-being. n=105.*

In the survey, participants were then presented with several relational well-being indicators and were asked to identify how the changes in beach grass they reported earlier in the survey[10], have impacted these specific indicators (**Table 7.8**).

Table 7.8 *Relational well-being indicators from the survey.*

Sense of place
Feeling of community belonging
Participation in community activities
Personal relationships

Here, respondents had to indicate whether the changes they reported "Very positively impacted," "Positively impacted," "Not impacted," "Negatively impacted," or "Very negatively impacted" that specific relational well-being indicator. Respondents also had the option to indicate if the specific statement was "Not applicable/unsure" to them. These responses were assigned a value from 1-5 as indicated in **Figure 4.2**. The total score across the four relational well-being indicators was calculated for each respondent and categorized as described in Section 4.3.1.1 (*Quantitative analysis*).

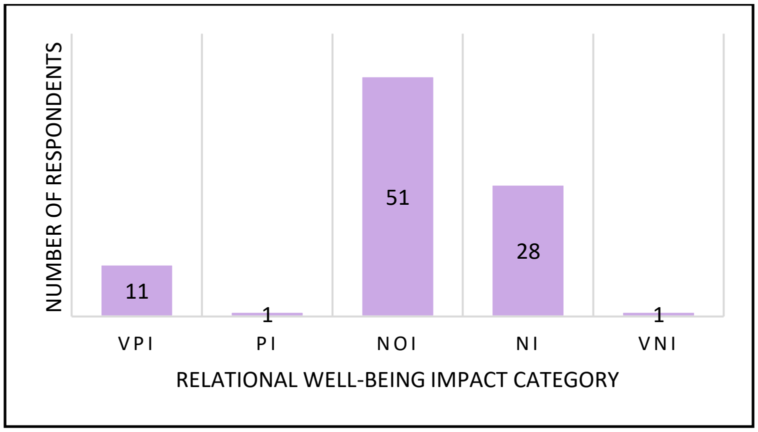

Figure 7.5 *Number of respondents in each of the relational well-being impact categories based on their answers pertaining to the relational well-being indicators in the survey. VPI= very positively impacted; PI= positively impacted; NOI= no impact; NI= negatively impacted; VNI= very negatively impacted; n=92.*

[10] This refers specifically to question 14 of the survey, addressing the specific types of changes in beach grass observed by respondents. The results of this question are presented in **Table 5.4.**

In general, the changes in beach grass have led to negative to no relational well-being impacts for survey respondents. To determine the specific types of beach grass changes leading to changes in relational well-being, the average value for each respondent's relational well-being impact score was taken and then correlated with the respective responses to the various dimensions of reported beach grass change for which the responses were converted from their original three-point scale values to five-point scale values as described in Section 7.1.1. The results for are presented in **Table 7.9**.

Table 7.9 *Relationship between dimensional changes of beach grass and relational well-being of survey respondents.*

Dimension of beach grass change correlated (x) with average relational well-being impact (y)	**Spearman correlation coefficient (ρ)**[11]	**p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)**	**Correlation strength**	**n**
Area/extent (x_1)	0.2350	0.0249, strong	Weak, positive	91
Density (x_2)	0.1861	0.0774, weak	Very weak, positive	91
Visual Health (x_3)	0.1865	0.0767, weak	Very weak, positive	91
Average (x_{avg})	0.1873	0.0754, weak	Very weak, positive	91

Of the three dimensions of beach grass change evaluated here, change in area/extent of beach grass has the greatest impact on the relational well-being of survey respondents. These results indicate that a general increase in beach grass area/extent leads to slightly increased relational well-being of survey respondents. Alternatively, the relationship between average beach grass changes reported by survey respondents and the various relational well-being indicators was evaluated using a Spearman correlation. Each variable was valued the same as described above in Section 7.1.1 and the results are presented below in **Table 7.10**.

Table 7.10 *Relationship between average changes of beach grass and relational well-being indicators.*

Indicator of relational well-being impact (y) correlated with average beach grass change (x)	**Spearman correlation coefficient (ρ)**[12]	**p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)**	**Correlation strength**	**n**
Sense of place (y_1)	0.2134	0.0423, strong	Weak, positive	91
Feeling of community belonging (y_2)	0.2795	0.0073, very strong	Weak, positive	91
Participation in community activities (y_3)	0.1601	0.1296, very weak to none	Very weak, positive	91
Personal relationships (y_4)	0.2718	0.0092, very strong	Weak, positive	91
Average impact (y_{avg})	0.1873	0.0754, weak	Very weak, positive	91

[11] Calculations for this were done using MATLAB R2018a and can be found in Section 15.5. Data used in these calculations can be found in Section 15.6. Participants who did not answer both questions were thus not counted in these calculations

[12] Calculations for this were done using MATLAB R2018a and can be found in Section 15.7. Data used in these calculations can be found in Section 15.8. Participants who did not answer both questions were thus not counted in these calculations

Of the four indicators of relational well-being evaluated here, average beach grass change has the greatest impact on feeling of community belonging. These results indicate that a general increase in beach grass coverage, density and health leads to a slight increase in the sense of place, feeling of community belonging, and personal relationships of survey respondents.

The relationship between relational well-being and beach grass ESs s important because efforts to support the beach grass ESs foster a sense of community belonging and encourage participation in community activities. Referring back to Becker's philosophy, that innately, all humans want to feel as though they are contributing to something greater than themselves, as though they are part of something meaningful (Becker, 1997). Efforts to restore beach grass, or just the natural shoreline environment in general, foster important personal relationships, bring people in the community together to work toward the conservation of a resource that is an integral part of their sense of place and belonging. This was mentioned by three interview participants. This was also observed in the field, for example, as depicted in **Figure 6.9**, in which the Goderich shoreline cleanup brought together many environmental stewards of the community who worked together to keep the shoreline clean.

In addition to this, personal conflicts tend to arise due to differing perceptions of beach grass. As depicted in Section 5.3 (*Perceptions of beach grass ecosystem services along the Lake Huron shoreline*), perception of beach grass is a great influencer of people's actions and behaviours toward it. This can negatively affect relational well-being. This was echoed by all interview participants (**Table 7.11**).

Table 7.11 *Interview data pertaining to relational well-being.*

Interview Participant	**Quotation**	**Indicator(s) and ES(s) cited**
1	"[…] you have to have a coordinated effort amongst neighbors. The benefits are not going to come through unless there is a community effort.	Feeling of community belonging Participation in community activities
	"If it's for [beach grass] removal, then you're going to upset somebody else, because they are going to think it's not the right things to do. […] If you're going to plant, to maximize the benefit, you have to get a broader support form the community that you're in."	Personal relationships Feeling of community belonging
	"Effective shore protection needs to be done on a group basis, not individual. They need to know that they are a part of it, but it is not only up to them alone."	Personal relationships Feeling of community belonging Erosion prevention Weather and storm moderation
2	"There is always conflict with neighbors and other beach users because not everyone has the same understanding of the importance of beach grass."	Personal relationships

	"There is always that type of community building, peer-to-peer aspect which can be a successful way to get the message across as well."	Feeling of community belonging
3	"[The relational well-being drawn from beach grass] will depend on how folks perceive the grass."	Sense of place
	"As someone that has been in this field as water resources fanatic, yes it brings a sense of place, a sense of calm, especially when you are on the shoreline and you see the wind blowing and see the seed heads flowing in the wind, it really is surreal."	Sense of place Biodiversity maintenance
	"[Education and awareness about beach grass] create a sense of belonging for the person, which can motivate an individual to move toward creating a healthy resilient coast and dune ecosystem because you feel that sense of belonging and importance for it."	Feeling of community belonging Sense of place Educational value
4	"You get that human impact again of battling with the municipal people who own the property, to push down the dunes because they're getting too high. […] So there is a bit of stress there between agencies and ourselves and the municipalities and the landowners."	Personal relationships
	"Empowering them to be able to have the knowledge as to what their actions are and what their actions shouldn't be. They can then share that with others in the community and share that with other resource users and also improve the shoreline aspects, the ecological services along there, and prevent the destruction of the area or help share, communicate information to others."	Sense of place Feeling of community belonging Participation in community activities Personal relationships Erosion prevention Weather and storm moderation

Relational well-being is impacted by regulating, supporting and cultural beach grass ESs. In general, survey respondents reported medium-to-low levels of relational well-being in relation to beach grass. Additionally, a significant positive correlation was found between changes in area/extent of beach grass and relational well-being impact, where most respondents reported that they were not or negatively impacted by the changes in beach grass that they experienced. Relational well-being is thus supported through the maintenance of the quality of valued regulating, supporting and cultural beach grass ESs, however when management decisions do not take this connection into account, shoreline communities will suffer relational well-being losses from the loss of beach-dune systems. **Figure 7.6** illustrates these connections.

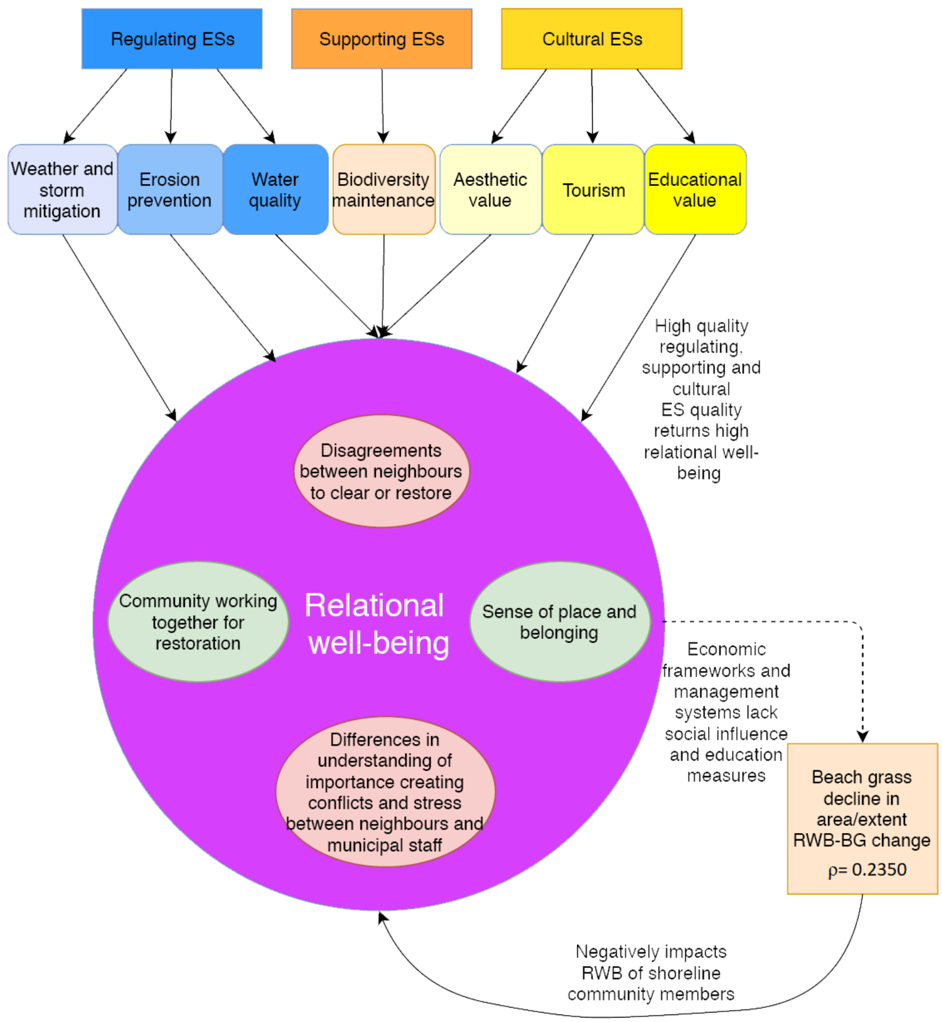

Figure 7.6 *In-depth interactions between regulating ESs, supporting ESs, cultural ESs, relational well-being and beach grass change. RWB = relational well-being; BG= beach grass.*

7.1.3 Subjective well-being

Subjective well-being is defined by people's own perceptions of how they feel and what their quality of life is (Britton & Coulthard, 2013). Survey participants were asked to respond to a series of statements (**Table 7.12**) relating to subjective well-being and then had to choose from the options: "Strongly agree," "Agree," "Neither agree or disagree," "Disagree," "Strongly disagree," and "Not applicable/unsure" to state their level of agreement.

Table 7.12 *Subjective well-being Likert-scale questions in the survey.*

Beach grass presence decreases your overall happiness
Beach grass presence increases your overall happiness
Beach grass presence increases your overall feeling of safety and security

These questions were used to establish a baseline of how the presence of beach grass affects the overall subjective well-being of the respondents. The choices on the Likert scale were each valued exactly as described above for the material and relational well-being questions. The total score across the three questions was calculated by adding up the score for each question, resulting in scores ranging from 0-15 points. These scores were then categorized as described in Section 4.3.1.1 (*Quantitative analysis*). The results are presented below (**Figure 7.7**).

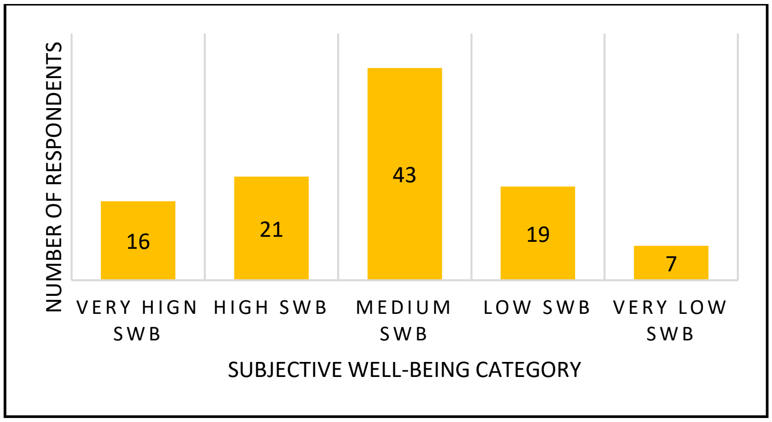

Figure 7.7 *Number of respondents in each of the subjective well-being categories based on their answers pertaining to the subjective well-being indicators in question 12 of the survey. SWB= subjective well-being. n=106.*

In the survey, participants were then presented with the several subjective well-being indicators and were asked to identify how the changes in beach grass they reported earlier in the survey[13], have impacted these specific indicators (**Table 7.13**).

Table 7.13 *Subjective well-being indicators from the survey.*

Overall happiness
Overall feeling of safety and security

Here, respondents had to indicate whether the changes they reported "Very positively impacted," "Positively impacted," "Not impacted," "Negatively impacted," or "Very negatively impacted" that specific subjective well-being indicator. Alternatively, respondents also had the option to indicate of the specific statement was "Not applicable/unsure" to them. These responses were assigned a value from 1-5 as indicated in **Figure 4.2**. The total score across the two subjective well-being indicators was calculated for

[13] This refers specifically to question 14 of the survey, addressing the specific types of changes in beach grass observed by respondents. The results of this question are presented in **Table 5.4.**

each respondent and categorized as described in Section 4.3.1.1 (*Quantitative analysis*). The results of this question are presented below (**Figure 7.8**).

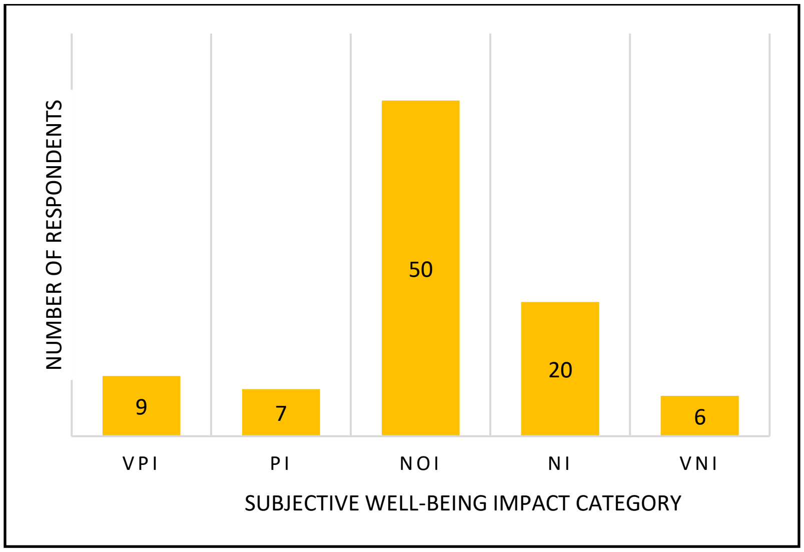

Figure 7.8 *Number of respondents in each of the subjective well-being impact categories based on their answers pertaining to the subjective well-being indicators in the survey. VPI= very positively impacted; PI= positively impacted; NOI= no impact; NI= negatively impacted; VNI= very negatively impacted; n=92.*

To determine the specific types of beach grass changes leading to changes in subjective well-being, the average value for each respondent's relational well-being impact score was taken and then correlated with the respective responses to the various dimensions of reported beach grass change for which the responses were converted from their original three-point scale values to five-point scale values as described in Section 7.1.1. The results are presented in **Table 7.14**.

Table 7.14 *Relationship between dimensional changes of beach grass and subjective well-being of survey respondents.*

Dimension of beach grass change (x) correlated with subjective well-being impact (y)	**Spearman correlation coefficient (ρ)**[14]	**p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)**	**Correlation strength**	**n**
Area/extent (x_1)	0.2520	0.0159, strong	Weak, positive	91
Density (x_2)	0.1349	0.2024, very weak to none	Very weak, positive	91
Visual Health (x_3)	0.1193	0.2600, very weak to none	Very weak, positive	91
Average (x_{avg})	0.1418	0.1799, very weak to none	Very weak, positive	91

[14] Calculations for this were done using MATLAB R2018a and can be found in Section 15.9. Data used in these calculations can be found in Section 15.10. Participants who did not answer both questions were thus not counted in these calculations

Of the three dimensions of beach grass change evaluated here, change in area/extent of beach grass has the greatest and only significant impact on the subjective well-being of survey respondents. These results indicate that a general increase in beach grass coverage, leads to slightly increased subjective well-being of survey respondents.

Alternatively, the relationship between average beach grass changes reported by survey respondents and the various relational well-being indicators was evaluated using a linear correlation. Each variable was valued the same as described above in Section 7.1.1 and the results are presented below in **Table 7.15**.

Table 7.15 *Relationship between average changes of beach grass and subjective well-being indicators.*

Indicator of subjective well-being impact (y) correlated with average beach grass change (x)	**Spearman correlation coefficient (ρ)[15]**	**p-value, evidence for rejecting H_0 when α=0.05 (where H_0: no correlation)**	**Correlation strength**	**n**
Overall happiness (y_1)	0.1772	0.0929, weak	Very weak, positive	91
Safety and security (y_2)	0.2002	0.0571, weak	Weak, positive	91
Average impact (y_{avg})	0.1418	0.1799, very weak to none	Very weak, positive	91

Of the two indicators of subjective well-being evaluated here, neither are significantly impacted by beach grass change, indicating that there is little-to-no connection between subjective well-being and beach grass changes for survey respondents.

The relationship between beach grass ESs and subjective well-being is complex and thus could not likely be represented appropriately in this study. Through the interviews with key informants, the depths of this complexity was explored. Having established dunes and beach grass along the shoreline provide great protection against various shoreline hazards as depicted in Section 6.2 (*Regulating ecosystem services*). Shoreline residents that are aware of the beach grass ESs, will therefore feel safer knowing that the beach grass is there to protect them and the beach. This was echoed by three interview participants (**Table 7.16**). Interview Participant 2 brought up an interesting new perspective about how some can perceive the shoreline dunes as being a public safety hazard, acting as a place for wrongdoers to hide. From this information, the relationship between the important beach grass ESs and subjective well-being becomes more complicated.

The relationship between overall happiness and beach grass ESs is equally complex. As addressed by several interview participants, some people may be happier when they know they are reaping the benefits of the dunes, however, others may be less happy with the dunes impeding their enjoyment of the beach. But

[15] Calculations for this were done using MATLAB R2018a and can be found in Section 15.11. Data used in these calculations can be found in Section 15.12. Participants who did not answer both questions were thus not counted in these calculations

they will also be unhappy if the beach is severely eroded by powerful storms or the local water quality diminishes, or a variety of other beach grass ESs are affected by the loss of the dunes.

Here the interplay, between the various dimensions of well-being, as discussed in Section 2.3 (*Social well-being*) (also see **Figure 2.9**) is made clearer.

Table 7.16 *Interview data pertaining to subjective well-being.*

Interview Participant	Quotation	Indicator(s) and ES(s) cited
1	"I think people have a feel-good thing with a lot of vegetation that they see. Whether it's beach grass or any other species growing, they generally feel good about it. I think that comes from the sense of security, knowing that there's a buffer between them and the lake. […] They sense there's other benefits going on that they should feel good about."	Overall happiness Overall feeling of safety and security Weather and storm moderation Erosion prevention
2	"I think people that understand the importance of dunes and dune grass have a feeling of safety when high water comes, and the dunes are there as their protection."	Overall feeling of safety and security Weather and storm moderation Erosion prevention
	"The contrary view is that having dunes on public beaches provides hiding areas where people can tuck away out of eyesight. […] There has always been a tug with regards to personal safety because some people see it just like planting trees. They provide space for people bound to doing no good to hide. They want to keep a clear view so that the police can keep a clear view on the activity on the beach."	Overall feeling of safety and security Aesthetic value
	"In terms of overall happiness, people that are aware of the importance of the dunes and the dune grass are probably much happier if they know that those are the benefits that they have with the type of ecosystem that they're living in harmony with."	Overall happiness
3	"I think it does bring folks a sense of calmness and security even. Being in their own place with their property so close to the lake. You have that buffer, knowing that the dunes are there to stabilize against potential flooding and provide retention capacity."	Overall feeling of safety and security Weather and storm moderation Erosion prevention
4	"They would be unhappy if they were losing their shoreline, more due to dune erosion and lake levels, invasive species. That would just change as the water level came down, however if we still have more invasive species, they would still be unhappy."	Overall happiness Erosion prevention Biodiversity maintenance

7.2 Results summary

Interactions between the valued beach grass ESs and dimensions of social well-being depicted throughout this chapter using the various social well-being indicators from the survey are visually summarized in **Figure 7.9**. Given these interacting forces, it is clear that the ways in which changes in beach grass coverage, density, and visual health impact social well-being are very complex. Shoreline community members, such as many of the survey respondents, play an important role in the conservation and management of beach grass along the Lake Huron shoreline, thus, are a driving force in the creation of their own well-being.

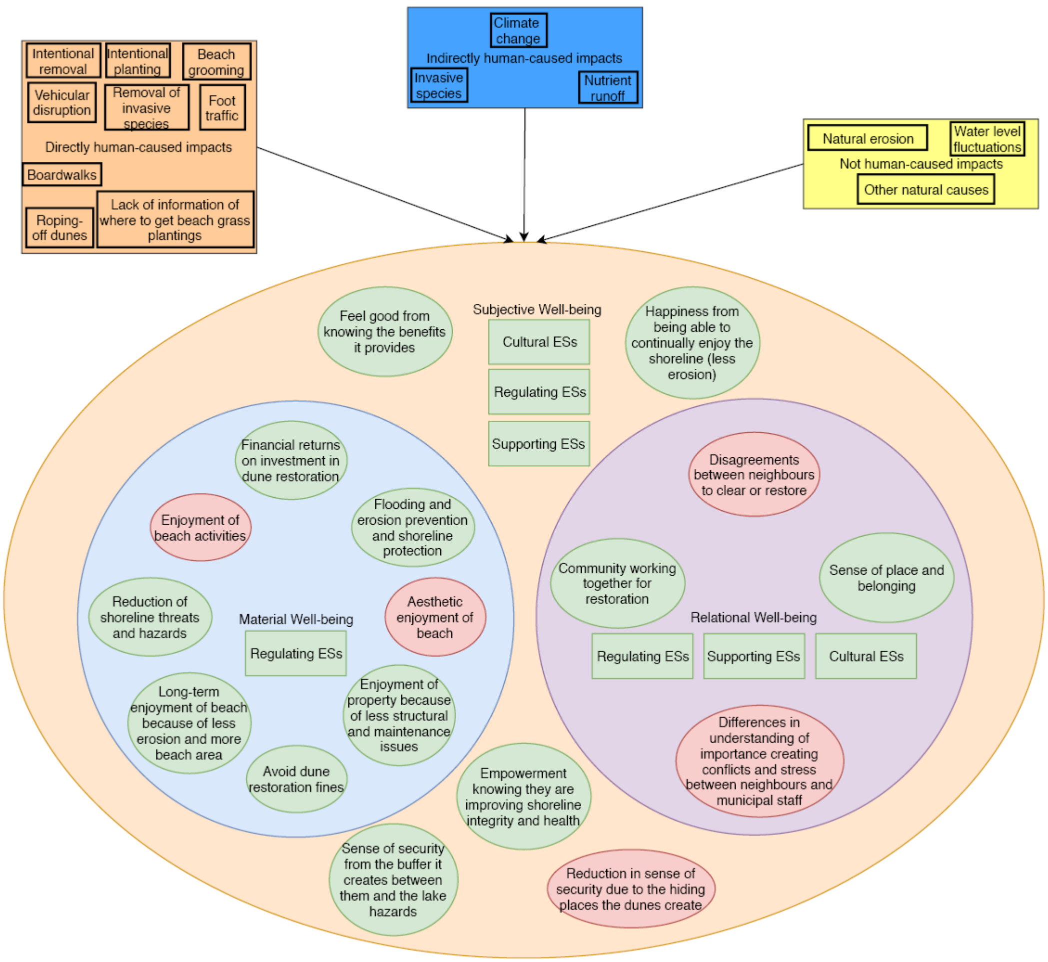

Figure 7.9 *Impacts of beach grass changes and beach grass ESs on the dimensions of social well-being. Results from the survey are combined with results from open and axial coding of semi-structured interviews. Green circles indicate a positive effect of beach grass ESs and red circles indicate a negative effect.*

Chapter 8 – Strategies to Enhance Coastal Action Planning Along the Southeastern Shoreline of Lake Huron

In the previous three chapters, I examined the changes in beach grass along the Lake Huron shoreline and drivers of change as perceived by survey respondents and interview participants, the beach grass ESs valued by survey respondents, and the linkages between these ESs and various dimensions of social well-being. In this chapter, I discuss how these findings are relevant to adopting an integrated approach to coastal planning for the southeastern shoreline of Lake Huron that enhances resilience and stability in the coastal ecosystem. This discussion on integrated coastal planning corresponds to Objective 5 of my research (**Table 8.1**). General management and other challenges for the shoreline were introduced in Chapter 3, such as human and environmental pressures, culturally unsustainable practices, and lack of cohesive shoreline management decision-making leading to perpetuation of environmentally destructive policies.

Table 8.1 *Research objectives.*

1.	Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors.
2.	Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.
3.	Identify beach grass ecosystem services of value by property owners and visitors along the shoreline
4.	Establish how beach grass changes are linked to social well-being from the perspective of property owners and shoreline visitors.
5.	**Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.**

8.1 Navigating troubled waters

Humans are deeply dependent on the their environments (Greer, 2011; Kosoy et al., 2012; Ponting, 2007; Postel & Carpenter, 1997; Raudsepp-Hearne et al., 2010; Schumacher, 1974), yet environmental policies and economic frameworks often perpetuate or even promote the destruction of natural systems (Beatley et al., 2002; Brown & Garver, 2009; Kosoy et al., 2012; Raworth, 2017; Schumacher, 1974). Ecosystem services serve as a basis of economic valuation of the environment (Steinman et al., 2017; Turner & Daily, 2008), but to incorporate them into an economy and management system that promote their exploitation and depletion, is fundamentally flawed, and implies that there is a miscommunication in terms of what people actually need (Kosoy et al., 2012; Raworth, 2017). This suggests that environmental management and economic valuation of the environment require an additional lens of scrutiny such that the value of an ES can always be weighed into the decisions that affect it (Greer, 2011). Environmental challenges (e.g., flooding, erosion, biodiversity loss) can impact many areas of human well-being such as economic security, basic needs, human health and safety and the quality of social interactions (Larson, 1993). Therefore, the value of an environmental service must reflect not only its value to human systems, but also the environmental systems humans are embedded in. Bringing this connection to the foreground demonstrates how potential decisions can affect human well-being by altering or restoring ecosystems, and how much these changes matter (Daily et al., 2009). It also sheds light on the role of people in the creation of their own well-being through conservation of important resources and improving environmental quality. Using an ES-well-being lens can thus serve to communicate the value of ESs in more ways than just the bare services they provide to people, providing a more cohesive and integrated approach to coastal planning.

8.2 Developing a greater steward-perception of the environment

The survey data regarding the interplay of beach grass perceptions and their actions/behaviours toward it, were able to give a better understanding of how the main drivers of survey respondents' actions and behaviours toward beach grass interact. It lined up with many of the emerging themes from the interview data. Both sources of data, as well as data collected through the literature review, point to increased knowledge of beach grass ESs, when paired with an increase in the importance of beach grass ESs to survey respondents has the most dramatic influence on actions and behaviour toward beach grass.

Through these changes in perception and behaviours/actions, people thus have the capacity to enhance their own social well-being. From this, it can be implied that conservation methods for beach grass should target the ESs that shoreline residents and beach visitors find most important, as this will have the biggest impact on their actions/behaviours toward beach grass. The five most valued beach grass ESs by survey participants are: erosion prevention, weather and storm mitigation, biodiversity maintenance, educational value, and aesthetic value (**Figure 8.1**).

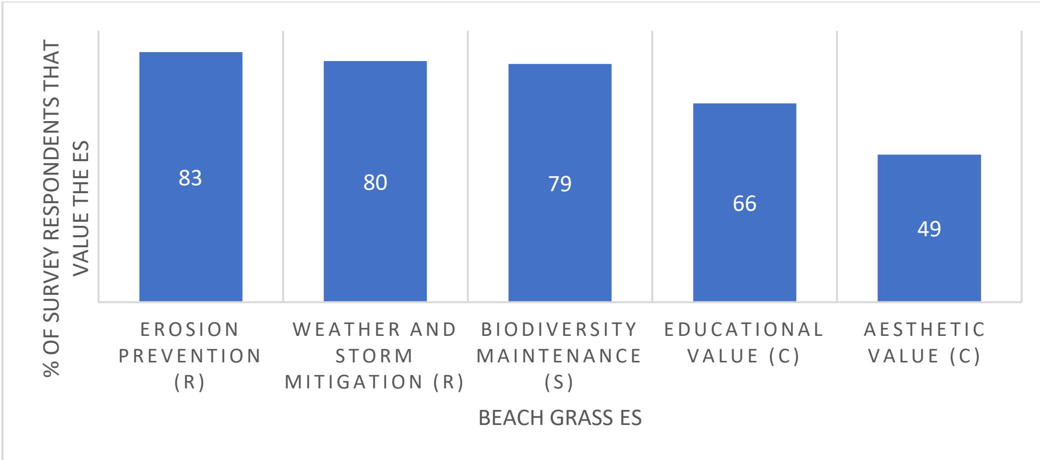

Figure 8.1 *Five most valued ESs by survey respondents. R= regulating; S= supporting; C= cultural.*

Targeting these ESs through the implementation of measures that seek to improve beach grass perception (convenience, the targeting of other values, education, and social influence) will not only bring about a large amount of positive change for ES quality, and the social well-being of shoreline communities. Moving forward from here, the best course of action in terms of shoreline management initiatives that will have the most impact on their actions/behaviours toward beach grass, as presented in the previous three chapters, would therefore be to target aspects of people's lives that are already important to them, and associate how beach grass enhances these, increasing the importance of beach grass to them, by association. Understanding the interplay of the various dimensions of perception of beach grass and how this impacts people's actions, is an important component of the human-environment interactions that impact beach grass along the Lake Huron shoreline. Once the value and importance that beach users place on various beach grass ESs is understood, then the complexities and drivers of human-environment interactions can also be understood.

8.3 Understanding what shoreline communities value

In Section 5.3, the various dimensions of perception and their effectiveness in changing actions/behaviour toward beach grass were discussed with relation to the survey and interview results. To maximize effectiveness of any shoreline management initiative in the instigation of behaviour change toward beach grass, it must foster a change in perception toward beach grass, by enhancing knowledge and importance of beach grass ESs through education, convenience, targeting other values, and social influence. In the survey, participants were asked their opinions on what should be done to enhance current coastal planning efforts with reference to beach grass. Each statement they were provided with alluded to education (**Figure 8.2**), targeting other values (**Figure 8.3**), convenience (**Figure 8.4**), or social influence (**Figure 8.5**).

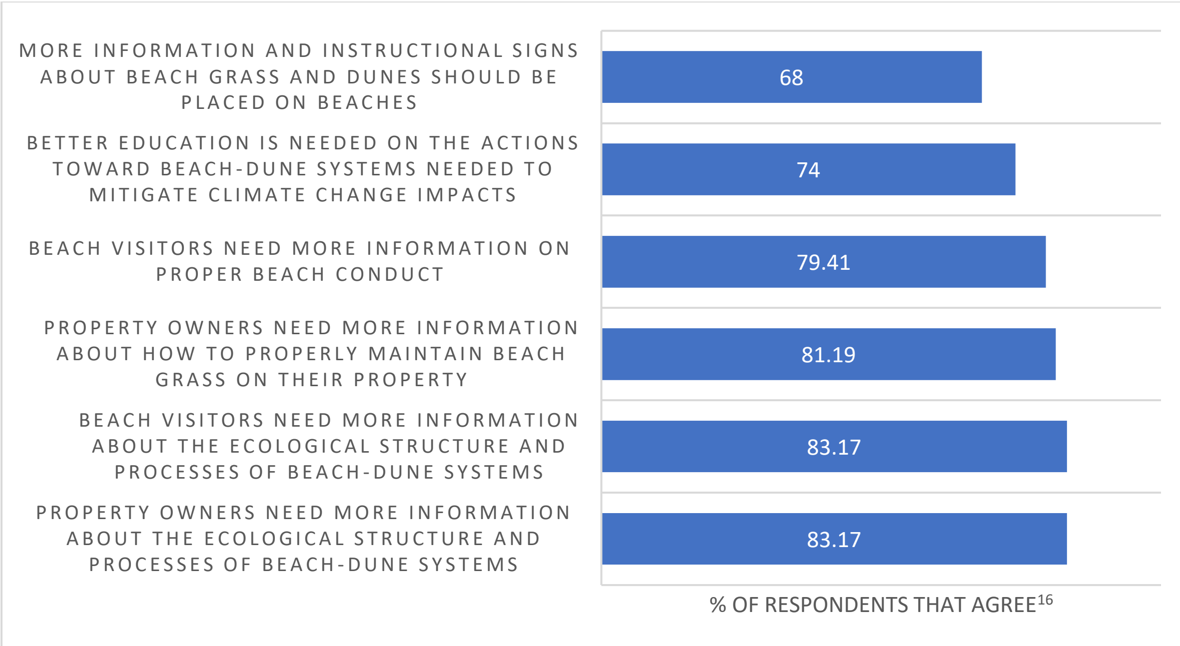

Figure 8.2 *Coastal planning initiatives relating to enhancing education.*

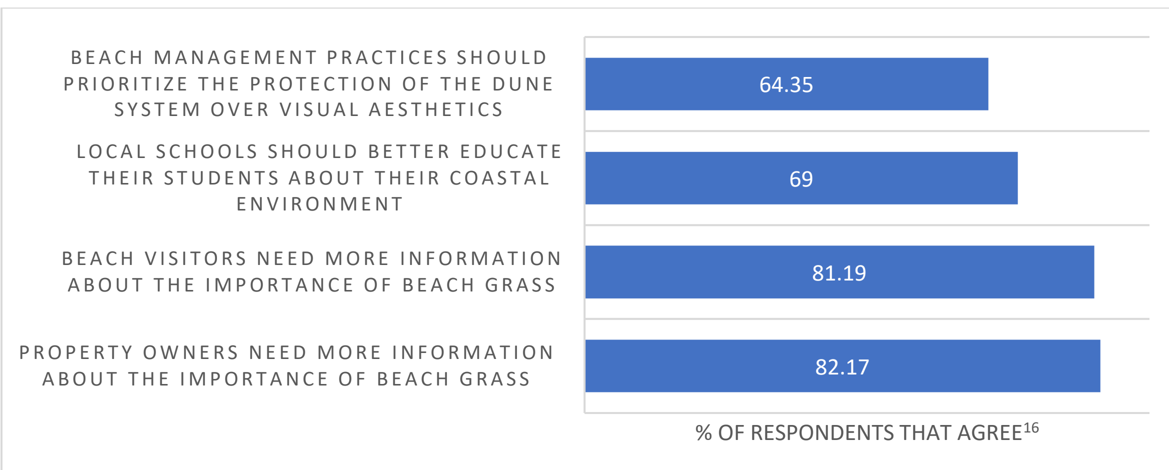

Figure 8.3 *Coastal planning initiatives relating to targeting other values.*

[16] If a participant answered “agree” or “strongly agree” to the statement regarding a specific beach grass initiative, then that was considered toward the final count presented

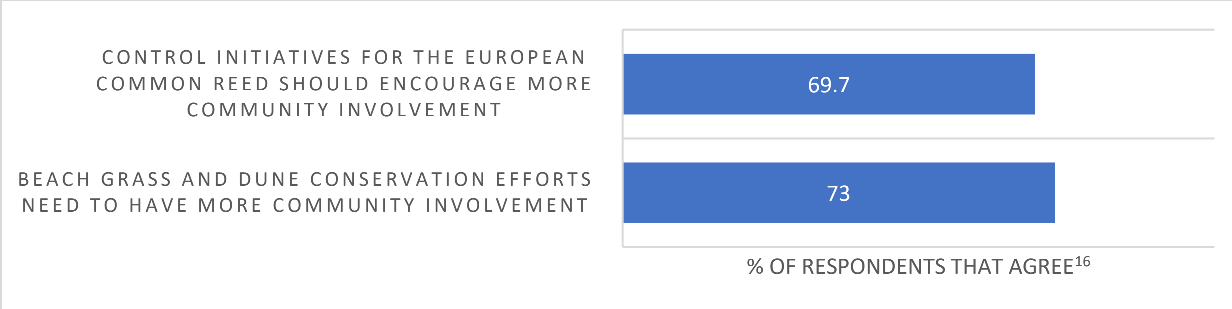

Figure 8.4 *Coastal planning initiatives relating to enhancing social influence.*

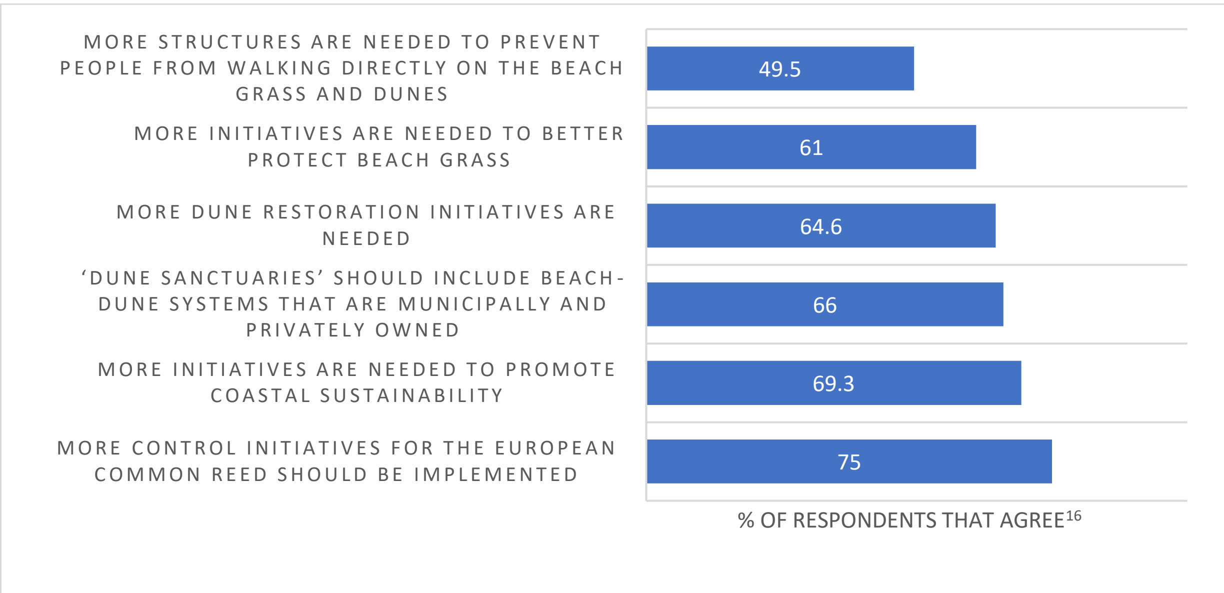

Figure 8.5 *Coastal planning initiatives relating to enhancing convenience.*

Here, as described in Chapter 3, it is important to understand that the shoreline is diverse in its topography and socio-economic activities. Therefore, the strategies that will work best for a given location or beach, will likely differ greatly from that of another nearby. Not taking this into account may lead to ineffective planning efforts, described well by a survey respondent:

"One challenge is that Conservation Authority and Coastal Centre 'experts' do not always understand (and incorporate into their advice) the reality that there are huge differences in the character of so many beach segments, and thus different strategies and advice are appropriate. [...] The result is advice is viewed as wrong by property owners, and can be ignored."

–Anonymous survey respondent

8.3.1 *Education and targeting other values*

Given the results presented in Section 5.3, and the opinions of survey respondents pertaining to initiatives of education and targeting other values for beach grass conservation, increasing these initiatives plays a crucial role the protection and maintenance of beach grass ESs, mainly due to their influence on perception of beach grass. Education and the targeting of other values can work synergistically for changing beach grass perceptions, as learning more about beach grass increases potential opportunities to learn about how beach grass interplays with other important aspects of one's life. These are important initiatives because it can be easy to observe one's environment, but not always easy to see one's place in it (Thoreau & Bode, 1967). This was described very well in a comment by a survey respondent when asked their opinion on what should be done to enhance current coastal planning efforts with reference to beach grass:

> *"Education is always important, especially as it pertains to such a fragile resource that is being tested by an ever-growing population ignorant of that on which they tread."*
>
> *–Anonymous survey respondent*

By learning more about human-environment interactions in terms of the ESs and contributions to social well-being provided by beach grass, one can begin to understand the important role one plays in the maintenance of one's own well-being. When resource users understand the role that they need to play in ecosystem maintenance, their well-being will be directly enhanced simply because they are the ones facilitating the improvement in quality of the ESs on which they rely.

Providing property owners and beach visitors with more information about the ecological structure and processes of beach-dune systems works to increase knowledge about beach grass and the ESs it provides, such as erosion prevention, mitigation of weather and storm damages. This initiative should focus primarily on the regulating and supporting beach grass ESs identified in **Figure 8.1**. To those who value the integrity of natural systems, this initiative would increase their knowledge of beach grass and the importance they place on the ESs it provides, thus, re-shaping their perceptions and actions toward beach grass in the direction of improving environmental stewardship. From here, not only does ES quality benefit, but all dimensions of social well-being are supported.

For those who are less inclined toward valuing natural systems, learning about the ecological processes of beach-dune systems will likely have little impact on their perceptions and actions toward beach grass. However, education initiatives for beach grass should not be limited to ecological processes, they should also target other values, such as their property, family, and finances. Here, focusing on the regulating and cultural ESs identified in **Figure 8.1** as well as all those identified in the survey (**Table 6.2**) would be beneficial to targeting these values, water quality, being one ES that could benefit from more targeted education initiatives. The interaction of beach grass and dunes on lake water quality is still a newly documented relationship in academia and presents a relatively unexplored opportunity to target legacy value, personal health and safety. Having safe drinking water and swimmable beaches represent values that could be of great importance to those living in Lake Huron's shoreline communities.

Providing property owners with more information on how to properly maintain the beach grass on their property will work to increase knowledge about beach grass, but accompanying this information with on why it is important that they maintain these dunes will likely have more impact on perception of beach grass and ultimately their actions toward it. Given that the majority of the southeastern shoreline is privately owned, the dunes and beach grass on private property are extremely important for conservation initiatives to target. Here it will also be important to focus on the regulating, supporting and cultural ESs that contribute to material and relational well-being (see **Table 6.2**). With a more cohesive and consistent understanding of the importance of the privately-owned dunes, conflicts with neighbors can be reduced, greater opportunities for community involvement can flourish, and relational well-being for shoreline residents can improve.

Providing beach visitors with more information on proper beach conduct must be done in such a way that will not only inform them of how to act toward the natural beach systems, but why they must follow the beach conduct guidelines. Those just visiting the Lake Huron shoreline for a short period of time, likely have much less invested in its environmental welfare. In order to shift the perceptions of beach visitors toward environmental stewardship, the simplest approach would likely be to target the reasons for why they are there (i.e. swim in the water, have a beach area to come back to year after year), targeting primarily regulating ESs, and thus all dimensions of social well-being. This takes the needs and values of both current and future beach users into account, as put firmly by a survey respondent:

"Preventing people from raking their beachfront for a reasonable seating area prevents enjoyment now, even though preservation is needed for future generations. Consideration needs to be given to both current beach users and future users."

–Anonymous survey respondent

Impacts of climate change will be challenging for shoreline communities, and sandy beach and dune systems are particularly vulnerable (Davidson-Arnott, 2016). Providing property owners and beach users with better education on the actions needed for mitigating climate change impacts should be an integral part of coastal planning initiatives involving education and the targeting of other values. The beach grass ESs that will be of the most importance for mitigating climate change impacts will be the ESs in

Figure 8.1. This supports all dimensions of social well-being, especially, material well-being as regulating and supporting ESs work to preserve the integrity and stability of the shoreline beaches.

Placing more instructional signs on beaches is an education initiative that is likely only to be needed on some beaches, as many beaches already have a significant amount (**Figure 6.6**, **Figure 6.7**, **Figure 6.8**, **Figure 6.12**, **Figure 6.11**). This could account for its relatively low agreement level. It is important that the signs on the beaches utilize the educational value (cultural ES) provided by the beach grass and dunes themselves. With a better visualization of the issue at hand, knowledge and importance of beach grass to the beach user can increase, influencing their actions and beach conduct. This initiative will likely be most effective at beaches where there are fewer or no instructional signs. Adding more to saturated beaches could potentially impede other beach grass ESs, along with material well-being:

"Signs are great, but too much fencing and too many signs will start to take away from the natural beauty."

–Anonymous survey respondent

Educating local schools about their coastal environment, contributes to education as well as the legacy value. This initiative has the potential to influence the next generation's perceptions toward environmental stewardship by increasing their knowledge and understanding of the important processes of the Lake Huron shoreline environment, especially those supported by beach grass ESs. From here, their place within their environment and the role they play in the creation of their own well-being can be better understood and carried through their actions and behaviours toward beach grass. This initiative should also utilize the education value (cultural ES) of the beach grass through the immersion of the school children in their local beach environment, for example:

"Port Franks Beach has in the past had students from local schools come to plant beach grass on the dunes."

–Anonymous survey respondent

Incorporation of the prioritization of the protection of the beach grass and dunes over the "flat beach" aesthetic into beach management practices targets other values of shoreline residents such as, avoiding flood damages, property value, and access to a healthy, stable beach area. This initiative also places the well-being of the shoreline communities at the forefront. Although this may anger some shoreline residents, ultimately, the safeguarding of the regulating and supporting beach grass ESs supports all dimensions of social well-being for shoreline residents, especially, material and subjective well-being, as demonstrated through the results presented in Chapter 7.

> *"I am ashamed of whatever you have done to destroy our wide beach. We have never had erosion and resent being forced to walk through this terrible [beach] grass [...]."*
>
> *–Anonymous survey respondent*

8.3.2 Increased community involvement

Enhancing community involvement in beach grass conservation and invasive species (particularly *Phragmites australis*) control efforts serves as a social influence initiative to influence the importance drawn from the presence of beach grass, and thus influences people's actions/behaviours toward it. This also serves to enhance relational well-being through the empowering of community members to work together to protect their environment that is important and meaningful to them (Becker, 1997). Relational well-being, is also improved through the conservation and invasive species control efforts themselves as they work to enhance regulating, supporting and cultural beach grass ESs.

Regarding *Phragmites australis* control specifically, education initiatives can also play a role in shifting perceptions of shoreline community members. As stated by Interview Participant 2: "A lot of the people that don't have the understanding of the different types of vegetation don't understand the difference between something that is native and critical to the beach-dune ecosystem and phragmites which is invasive and is a real threat. […] I think that is a huge problem because some people may be going in and thinking 'if this vegetation type is bad, we need to get rid of it all' and they're not sure what is what so they actually tear out some of the native and good vegetation that is there for a very important purpose and provides very important ecological services for that ecosystem. That is definitely a concern." Through greater social influence and education initiatives for invasive *Phragmites australis*, the regulating, supporting and cultural beach grass ESs are all supported, further enhancing all dimensions of social well-being.

8.3.3 Beach grass protection and restoration

Dune fencing, the creation of boardwalks, shuttle services and the butt-free beach are all convenience initiatives that protect beach grass and support an environmental steward perception by increasing people's knowledge about beach grass and other coastal processes when they learn why the initiatives are in place. The implementation of more convenience measures for some beaches would likely be beneficial, especially on those that lack them presently. In particular, a shuttle service may be a good idea for an area such as Sauble Beach that still allows parking directly on the beach sands, impeding natural dune growth and facilitating erosion. Improving convenience as well as beach grass restoration measures thus enhance primarily regulating beach grass ESs such as erosion prevention, water quality and weather and storm impact moderation, supporting material and subjective well-being.

8.3.4 Coastal sustainability

Enhancing the initiatives discussed above, in areas of the shoreline where they will be most beneficial and supporting of the valued beach grass ESs and social well-being, supports the cultural and coastal sustainability of the Lake Huron shoreline. While this conclusion may be straight forward in an academic context such as this one, it is not always clearly understood by important stakeholders with the right intentions, such as the resource users, who have a crucial responsibility to engage in beach stewardship activities that serve to maintain the integrity of the Lake Huron shoreline. A rather inquisitive and genuine comment by a survey participant highlights the nature of the work that needs to be done:

> *"What is coastal sustainability in a context where almost everything is modified by human activity?"*
>
> *–Anonymous survey respondent*

The concept of sustainability is entirely a human construct, defined by the Brundtland Commission as the use of natural resources in such a manner that the current needs of humans are met without compromising the needs of humans in the future (Robinson et al., 1990). It works with the environment in the sense that maintaining the natural elements of the environment is also beneficial for the people (Leopold, 1942), but this is actually more self-serving than self-less. Sustainability is for humans, more than the environment. This is neither a good nor bad thing, but it is an important distinction to make because coastal sustainability in the context of the Lake Huron shoreline is important because shoreline management has more to do with managing the people than the environment (Donnelly, 2018). Managing the people such that the environment is able to continue or resume its natural processes is supporting sustainability, and therefore, coastal planning initiatives that promote an environmental steward perception toward beach grass along the

Lake Huron shoreline support coastal sustainability through the maintenance of valued beach grass ESs and social well-being.

8.4 Toward an integrated model for coastal action planning

The use of a CBM base model for the management of the Lake Huron shoreline, is most desirable because of its emphasis on the involvement of the people that live in and interact with the resource system, in addition to the many actors from multiple sectors and scales within the policy-making cycle of ICM (Kearney et al., 2007; Patterson et al., 2015). As stated by Interview Participant 1, with current sectoral management, there is a lack of coordination and cohesiveness throughout the various levels of management:

> *"I think there are interrelationships happening between a variety of organizations and agencies. What's missing is the overarching umbrella piece. There are people trying to do good things here and there, but it's not coordinated by anybody for a large area. There are good planning efforts out there and it's just not cohesive."*
>
> *–Interview Participant 1, November 2018*

CBM is focused on managing at the local/community level and tailoring the management plan to their specific needs (Kearney et al., 2007). For this thesis, I defend a CBM-WEBs framework, that uses the CBM model as a basis to apply an ES-well-being lens to coastal planning for the Lake Huron shoreline. This entails understanding what and why specific ESs are valued by resource users, how these ESs impact social well-being, what drives human-environment interactions, and using this information to map out collaborative structures and social constellations between stakeholders, resource users and other interest groups, in the context of coastal action planning (Bennett et al., 2015; Wegner & Pascual, 2011). Interview Participant 4 outlines what this collaboration would look like in their view, emphasizing the need for management at the community level:

> "I would say that would have to start at the official plan level. The counties would have to establish the direction that they feel is important for their municipality along those areas that have beach grass, and identify the reasons why they would want to be restrictive along there to maintain those areas. Once the county level official plan has direction, then the municipalities then need to be more restrictive at their level. I think the issue becomes enforcement, so if the counties and the municipalities decide that they're behind maintaining the shoreline and beach grass areas, then they would have to have people monitoring that and enforcing that and educating about that. I think there would be an issue with that along the

shoreline. I don't think the Conservation Authorities Act would be the vehicle to do this, I think it is more of a local plan."

Adding to this, in CBM it is important to have high levels of management as well, but to ensure that management needs at the local level are not left out, compromised, or contradicted by these higher-level management bodies (Kearney et al., 2007). As Interview Participant 3 stated, federal and provincial policies are important to have in place, but cannot tackle the specific issues on the ground:

> *"Some of the higher-level stuff, like provincial and federal plans, they are broader and not necessarily focused on the resource user. They just explain, based on their assessment, the state of particular ecosystems in Lake Huron. The stuff from conservation authorities and at the Coastal Centre are focused on helping individual property owners."*
>
> *–Interview Participant 3, February 2019*

Incorporating resource users in the integrated management of the shoreline entails working toward the maintenance and protection of the quality of the ESs they value the most, and serves as a guide to key areas and issues that management initiatives should target. This therefore reflects societal values in the applied environmental governance strategies, gearing societal behaviour and planning efforts toward the preservation and conservation of nature, as opposed to its exploitation and domination. From here, the building of culturally sustainable societies is facilitated (Daily et al., 2009; Leopold, 1942). Interview Participant 2 explained how defining the role of the resource user in CBM promotes more culturally sustainable societies and ecocentric societal values:

> *"Understanding fragility and importance of the shoreline including dunes and the beach grass and then basically appealing to these people's understanding why that's why they need to play a role in protecting and restoring it."*
>
> *–Interview Participant 2, November 2018*

Using the 'WEBs' conceptual framework within CBM demonstrates how potential decisions can affect social well-being of community members through the alteration or restoration of valued ESs. A WEBs perspective also adds another layer of specificity within CBM, to further tailor management decisions to the specific needs of the community. Interview Participant 3 discussed how when management plans are developed at the local level, and support the well-being of the community, they are better received by the community members:

> *"Last year, we came out with a guide for sustainable shoreline properties in the township of Huron-Kinloss. It's been very well taken there. Very supported by the local government and community members. There has been quite a bit of positive feedback on this resource that was made for them. There has even been uptake from other local governments to do something similar."*
>
> *–Interview Participant 3, February 2019*

In the face of climate change, CBM is ideal because it is adaptive, leaving space for changes in external factors, and allowing for adaptation to unpredicted change (Ehler, 2003). This adaptive aspect of CBM is essential in coastal planning for the Lake Huron shoreline and all of the Great Lakes basin because the local impacts of climate change are unclear but are expected to include erratic and unpredictable weather patterns (Peach, 2016) as thoroughly described in Section 3.1.2 (*Human and environmental pressures facing the shoreline*). Interview Participant 2 described the current need for adaptive management in coastal planning for Lake Huron and the rapidly changing environment:

> *"Climate change adaptation is something that hasn't been a focus in the past. This is where coastal planning efforts need to be more inclusive and provide options and direction for folks so they can adapt to these new environments."*
>
> *–Interview Participant 2, November 2018*

Adding to this, a WEBs lens in CBM is able to highlight how social well-being is dependent on ES quality and is impacted by changes in the environment. This was explored in this thesis by examining impacts of beach grass change on material, relational and subjective well-being, the results of which are summarized in **Figure 7.3**, and **Figure 7.6**. A WEBs perspective also brings insight to the role of the resource user in the creation of their own well-being through ES protection and improving environmental quality. Interview Participant 3 described how engaging the resource user in CBM enhances well-being:

> *"A healthier shoreline creates a healthier person when you are more connected. When you know how something works, you feel more connected to your environment. Hopefully that creates a sense of wanting to work and keep it for the better and keep it from degrading."*
>
> *–Interview Participant 3, February 2019*

Another aspect of human-environment interactions included in this framework is that of perceptions and actions/behaviours. Understanding the drivers behind people's actions/behaviours toward their environment will potentially aid in the effectiveness of the implemented coastal management initiatives. The evidence for this collected in this thesis demonstrated that the knowledge someone has about beach grass and the ESs it provides, as well as the importance they attribute to these ESs, influences their actions/behaviours toward it. Knowing what methods influence action by the resource users has potential to increase effectiveness of coastal management initiatives through the application of these methods. The emerging themes of education and convenience were found to influence actions/behaviours toward beach grass by increasing knowledge about beach grass and beach grass ESs, as outlined in **Figure 5.9**, and by interview participants 4 and 2 respectively:

"If education were provided and guidance was given, we might have an increase in dune grass and dunes. So they can understand the need and what ability they get from the dunes protecting the shoreline and hold the sand back."

–Interview Participant 4, February 2019

"If the users are aware of the importance, then they can aid in […] practices like using the controlled access use, boardwalks and staircases that go over the dunes rather than cutting across them. They can provide that role."

–Interview Participant 2, November 2018

Additionally, the emerging themes of social influence and targeting other values were found to influence actions/behaviours toward beach grass by increasing the importance attributed to beach grass and beach grass ESs, as outlined in **Figure 5.9**, and by Interview Participant 2:

"The more people [using the boardwalks], the more peer pressure will correct that. In other words, people will hopefully call people out on not using the path. That will prevent damage and promote proper stewardship."

"[…] a healthy dune ecosystem, which means a healthy water quality nearby. That's an important connection that people can wrap their heads around and recognize that this is also another reason why you would want to keep the dune grass intact."

–Interview Participant 2, November 2018

The CBM-WEBs framework (**Figure 8.6**) that is central to this thesis begins with the physical system, containing the ICM policy cycle, the foundation of CBM. All levels of governments collaborate and contribute appropriately to each phase of the cycle, such that they are all on the same page and each level of government implements more and more locally tailored conservation initiatives. In the implementation phase, the CAP is indicated as a cohesive plan that is focused on the needs of the community members and supports their values. This is not to say that other regulating documents from the various levels of governments don't or shouldn't exist, it is indicating that all of these regulations should align with each other, work together, and not contradict each other as implementation of initiatives trickles down to the local level. Interview Participant 2 describes how the CAP supports cohesive decision-making and the well-being of Lake Huron shoreline communities:

> *"The CAP is more of a voluntary awareness initiative. […] the whole idea of what draws people to the shoreline, what types of things they are looking for to maintain property values, and enjoyment of their properties. Coastal planning is not something that has successfully captured all those aspects in the past. We are hoping that the CAP will cover and fill the gaps."*
>
> *–Interview Participant 2, November 2018*

As external actors, researchers and resource users play crucial roles in the CBM-WEBs framework, interacting with the resources and drivers of the system. The resource users are products of specific cultures and economic systems, which influence the ESs they value and why they value them, influencing the way in which they perceive, interact with and impact their surrounding environment. They also draw well-being from the quality of these ESs, therefore, resource users play a role in the creation of their own well-being through the ways they choose to treat their surrounding environment. The researchers gain understanding of the interacting forces between resource users and the environment, allowing them to feed into the decision-making process with the goal of creating more effective and locally tailored coastal planning initiatives.

The results of this thesis were able to better map out the complexities of the human-environment interactions with respect to beach grass at Lake Huron. These are presented in **Figure 8.6**, the CBM-WEBs framework. Using the insights from this research and the building of the CBM-WEBs framework, various recommendations for coastal action planning with regards to beach grass protection and conservation will be outlined in the following section.

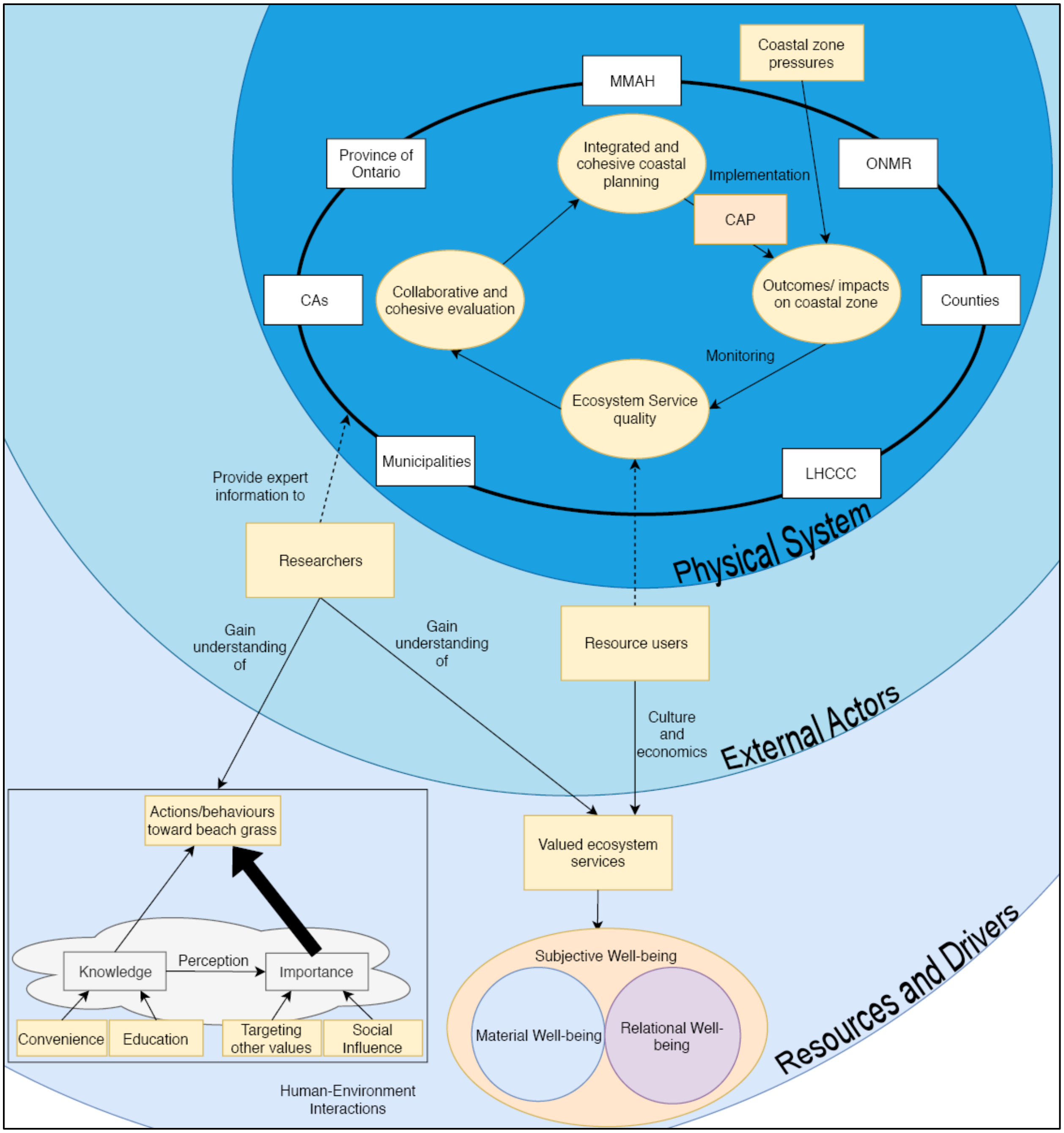

Figure 8.6 *Adding to the conceptual framework presented in Section 2.5, the complexities of the human-environment interactions regarding beach grass have been mapped out.*

8.5 Moving forward: recommendations for coastal action planning

Moving forward this thesis has presented opportunities for improvement in terms of education, on the ground action, and institutional practices.

Education initiatives should be community-based, targeting property owners primarily, and be geared toward the shifting of perceptions of beach grass toward stewardship through focusing on the ecological and anthropocentric importance of beach grass by explaining the ESs that beach grass provides (**Table 6.2**) and the connections they have to the social well-being of shoreline communities (**Figure 7.3**, and **Figure 7.6**). Additionally, they should also target other values of shoreline community members (e.g., having swimmable beaches, legacy value), play to social influence tactics, and convenience measures. Information on beach conduct should be presented to guests at accommodation establishments as well as visitors renting out shoreline properties. These education initiatives would be best carried out by the LHCCC as well as municipalities.

Beach grooming should be limited to sandy areas without beach grass, and it should be ensured that it does not interfere with its growth and extent. This should be organized at the municipal level. Parking should not be allowed directly on any beach along the shoreline. Currently, as depicted in **Figure 5.6**, Sauble Beach allows parking only a few metres landward of the lake. A few kilometres south of Sauble Beach, Station Beach in Kincardine (**Figure 8.7**), designated parking lots are located at a walkable distance from the beach. Boardwalks and other dune-protection measures (**Figure 6.11**) are also installed to connect the parking lot to the beach protect the dunes (Section 8.3.3). Here is a good example of beach management that supports important beach grass ESs, and social well-being through stewardship-driven initiatives.

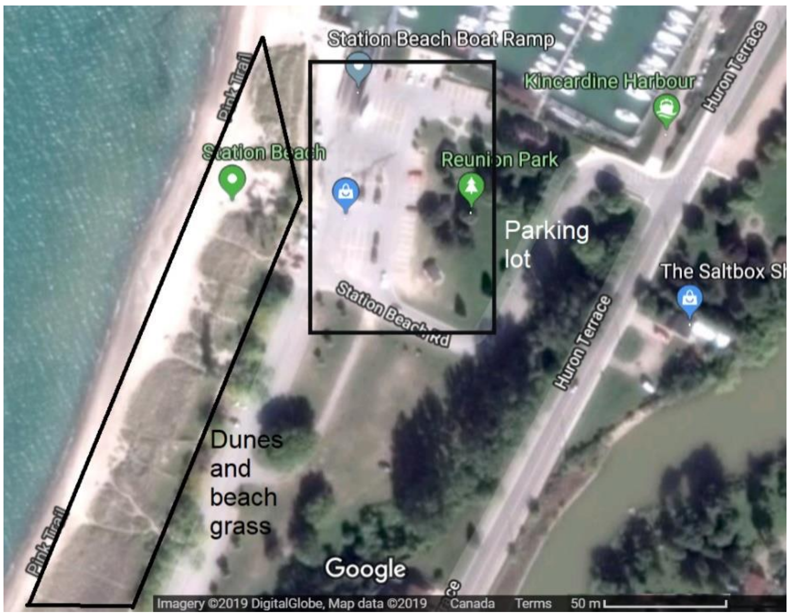

Figure 8.7 *Station Beach, Kincardine, ON. The parking lot is significantly large, and is removed from the beach itself, offering protection for the dunes and beach grass from vehicular and foot traffic while still allowing visitors to easily access the beach area (Google Maps, 2019g).*

The fight against the *P. australis* invasion is still ongoing. Measures to eradicate and control the invasion could be further enhanced by increasing community involvement in removal initiatives (Section 8.3.2). Additionally, planting beach grass in place of *P. australis* (where appropriate) would also be of value to maintaining the integrity of the shoreline and enhancing beach grass ESs. Through greater community involvement, *P. australis* removal, and beach grass restoration and protection can be more effective in addition to supporting relational well-being (**Figure 7.6**) and mitigating climate change impacts (Section 3.1.2, **Figure 3.8**). These initiatives should be organized by municipalities, the LHCCC and CAs.

At the institutional level, the valued beach grass ESs (**Table 6.2**) should be taken into account when implementing development or other types of policies that affect the beach-dune systems. This ensures that the value of the ESs are taken into account in the decisions that affect them. By ensuring that beach-dune systems are protected, the shoreline integrity can be maintained and all dimensions of social well-being can be supported (**Figure 7.3** and **Figure 7.6**). This consideration in decision-making is mainly important for stakeholders at the county and provincial levels.

Finally, to implement a CBM-WEBs approach to shoreline management, requires collaboration across all involved institutions at all stakeholder levels (Section 2.1.2.3). CBM-WEBs focuses on the needs of individual shoreline communities through the conservation and protection of the beach grass ESs that they value, and the supporting of social-well-being. It also requires maintaining ES-well-being linkages as the central focus of this collaboration, ensuring that all decisions line-up and don't contradict each other as they trickle down in management. Each level of management supports the one above it, but also takes into account the more specific issues pertaining to the area.

Chapter 9 – Conclusion

In this chapter, I offer a summary of my research findings, highlight key insights, contributions, and important areas for future research. I begin with a reviewing each objective in this thesis, outlining all relevant points from the chapters in which each objective was addressed. I emphasize key insights on ecosystem services, social well-being, and shoreline governance with reference to beach grass. Building on these insights, I present the contributions of this research, concluding with an examination of opportunities for future research.

9.1 Thesis context

The shoreline communities of Lake Huron are facing vast changes, which include the effects of climate change —decreased winter ice cover, water flow timing, flooding and storm frequency and intensity, and lake level fluctuations (Peach, 2016)—population increase, nutrient pollution from nearby agricultural fields, artificial shoreline modification and impacts of cultural unsustainability. The impacts of many of these changes can be mitigated through the protection of *Ammophila breviligulata*, beach grass, an important shoreline feature. Identification of the benefits (ESs) and well-being that shoreline community members draw from beach grass is important for the development of effective protection measures for beach grass and the Lake Huron shoreline (see Chapter 1). However, the sectoral management of the shoreline has led to some inconsistencies in planning and management of the shoreline's natural resources, and because of this, the needs of the communities are not always met.

A CBM-WEBs approach to shoreline management presents an opportunity to enhance stewardship, conserve, and protect beach grass, and improve the well-being of shoreline community members (see Chapter 2). This case study, the southeastern shoreline of Lake Huron, highlights coastal management in the context of beach grass (see Chapter 3). Through the application of ecosystem services (the benefits people get from the environment (Section 2.2)) and social well-being (material, relational, and subjective dimensions of well-being (Section 2.3)) as lenses in this research and in the application of a CBM approach to coastal planning at Lake Huron, this research aims to enhance opportunities for integrated coastal planning by assessing the underlying drivers of change with regard to beach grass, and understanding how coastal resource users perceive the value of the ecosystem services beach grass provides. Understanding the drivers of change and resource user perceptions is a critical step for implementing effective conservation measures for beach grass at Lake Huron. The Lake Huron Centre for Coastal Conservation is putting together the Coastal Action Plan for the Southeastern Shoreline of Lake Huron that puts the resource users at the centre of the framework to maximize well-being without compromising environmental soundness.

Thus, the results of this research can have application for implementing this CBM-WEBs approach to improve resilience of the system, influence more sustainable societal values (environmental stewardship) in Lake Huron shoreline communities and conserve valuable and important coastal resources.

9.2 Thesis summary

In this section, I summarize the main findings for each research objective addressed in this thesis. To address these objectives, this research took a qualitative case study approach incorporating inductive and deductive analysis. Specifically, the methods used included: 1) literature review, 2) surveys with property owners and beach visitors, and 3) semi-structured interviews with key informants (see Chapter 4).

Table 9.1 *Research objectives, paired with the chapter where each objective is addressed.*

Objective	Chapter where addressed
1. Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors.	5
2. Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.	5
3. Identify beach grass ecosystem services of value to property owners and visitors along the shoreline.	6
4. Establish how beach grass changes are linked to social well-being from the perspective of property owners and shoreline visitors.	7
5. Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.	8

9.2.1 Objective one

Examine how beach grass along the shoreline is changing and reasons for those changes from the perspective of property owners and shoreline visitors

In terms of area/extent of beach grass, 60% of survey respondents observed an increase, 3% did not observe change, and 31% observed a decrease. For density of beach grass, 54% of survey respondents observed an increase, 20% did not observe change, and 19% observed a decrease. Finally, in terms of visual health of beach grass, 32% of survey respondents observed an increase, 43% did not observe change, and 15% observed a decrease (Section 5.2). The nature of the changes to beach grass indicated by survey respondents was most frequently described as significant/substantial (64), poses challenges (27), and sudden (18) (Section 5.2.1). The drivers behind these were perceived by survey respondents as primarily "not human-caused" (23) as opposed to "indirectly human-caused" (22) or "directly human-caused" (15) (Section 5.2.2). When asked more detail on this front, many survey respondents indicated erosion (27) as the main cause of beach grass changes, as well as invasive species (19), and intentional removal (7). Still, the results were consistently indicating that most survey respondents perceive changes in beach grass to be not human-caused (Section 5.2.2). A different story is told through the semi-structured interviews with key informants. They were asked explicitly about the ecological and human driven changes to beach grass, therefore all interview participants discussed both ecological and human caused changes to beach grass, but significantly more emphasis was placed on human-caused drivers of beach grass change (Section 5.2.2).

Given that that the survey respondent pool consists of individuals with a strong ability to identify changes to the shoreline and that key informants have extensive background knowledge about the shoreline as well as significant experience working with shoreline communities (see Section 5.1), these findings suggest that it is easy to observe one's environment, but not always easy to see one's place in it. People are likely having a larger effect on their environment that they think they are, indicating a need for more education and awareness initiatives on this front.

9.2.2 Objective two

Understand how perceptions of beach grass affect property owners and shoreline visitors' behaviours and actions toward beach grass.

The perception of beach grass by survey respondents was determined by their self-reported knowledge levels and importance ratings of beach grass ESs. The way people perceive beach grass influences their actions/behaviours toward it. Overall, 85% percent of survey respondents consider themselves to be knowledgeable of beach grass (Section 5.3). The beach grass ESs that survey respondents considered to be most important to them are: erosion prevention, water quality, and biodiversity maintenance, which were identified as important by 94%, 92% and 89% of survey respondents respectively (Section 5.3). Generally, the majority of survey respondents are knowledgeable about beach grass and consider the regulating and supporting ESs it provides as important, indicating an overall positive perception of beach grass. On average, the correlation found here between survey respondents' knowledge about beach grass and the importance they attribute to it, is $\rho=0.2077$ ($p<0.05$), which is a weak, but significant positive relationship (Section 5.3.1).

In terms of actions toward beach grass, 57% of survey respondents said that they "leave it be/take no action," and 27% said that they "maintain/try to augment it," both of which are generally positive/desirable actions (Section 5.3). The correlation found between average importance ratings of beach grass ESs and people's actions and behaviours toward it is $\rho=0.3467$ ($p<0.05$), which is a moderate and significant positive correlation (Section 5.3.2). The correlation found between people's self-reported knowledge levels of beach grass and their actions/behaviours toward it is $\rho=0.2631$ ($p<0.05$), which is a weak, but significant positive correlation (Section 5.3.2).

Through the semi-structured interviews with key informants, the emerging themes that can influence perception of beach grass are: convenience, education (both contribute to knowledge of beach grass), targeting other values, and social influence (both contribute to the importance attributed to beach grass ESs) (Section 5.3.2).

These findings suggest that to influence positive actions/behaviours toward beach grass by resource users, implementing conservation initiatives that are geared toward prompting a stewardship perception of beach grass would be most effective.

9.2.3 Objective three

Identify beach grass ecosystem services of value to property owners and beach visitors.

Out of regulating, supporting and cultural beach grass ESs, property owners and beach visitors identified supporting and regulating ESs as the most valued categories. The beach grass ES that was most notable for property owners and beach visitors was erosion prevention, which was valued by 83% of survey respondents and mentioned by all interview participants (sections 6.1,6.2). The benefits drawn from preventing shoreline erosion are reduction of shoreline threats and hazards, long-term enjoyment of the beach, enjoyment of property, and sense of security. Other ESs that were valued by property owners and beach visitors were weather and storm moderation (regulating ES), biodiversity maintenance (supporting ES) and educational value (cultural ES), which were identified by 80%, 79% and 66% of survey respondents respectively (see Section 6.1). The beach grass ES of Weather and storm moderation was mentioned by all interview participants, biodiversity maintenance was mentioned by 3 of the 4 interview participants, and educational value was not mentioned by any interview participants. None of the interview participants mentioned any cultural ESs of beach grass, however, they were also not explicitly asked about any beach grass ESs.

Less than half of the survey respondents (49%) identified the aesthetic value of beach grass (cultural ES) as a valued ES, and even less (47%) identified water quality (regulating ES). Only half of the interview participants also identified water quality as a valuable beach grass ES. The ES that was identified as valuable by the least number of survey respondents was tourism (cultural ES), which is likely due to the fact that 94% of survey respondents are property owners and not tourists (Section 5.1).

These findings suggest that to better support beach grass conservation and protection along the shoreline, consideration of important regulating, supporting and cultural ESs should be taken into consideration by decision-makers because these ESs are valued by property owners and beach visitors.

9.2.4 Objective four

Establish how beach grass changes are linked to social well-being from the perspective of property owner and shoreline visitors.

In terms of material well-being, the indicators used in this thesis were: current financial situation, property value, and enjoyment of the beach. From here a basis for survey respondents' material well-being could be established. The majority of survey respondents reported high (38) to medium (35) levels of material well-being. Survey respondents also indicated how the beach grass changes they reported impact their material well-being. The majority of survey respondents reported negative (43) to no impact (31) to their material well-being. Through analysis of the correlations between dimensions of beach grass change and average material well-being impact (across indicators), it was found that change in area/extent of beach grass was most strongly correlated to material well-being impact average ($\rho=0.2112$, $p<0.05$)). Through analysis of the correlations between material well-being indicators and average beach grass change, it was found that current financial situation was the indicator most strongly correlated to average beach grass change ($\rho=0.4262$, $p<0.05$). In the semi-structured interviews, all interview participants acknowledged as strong contribution of valued beach grass regulating ESs to material well-being, and one interview participant acknowledged the contribution of aesthetic value (cultural ES) to material well-being.

In terms of relational well-being, the indicators used in this thesis were: sense of place, feeling of community belonging, participation in community activities, and personal relationships. From here a basis for survey respondents' relational well-being could be established. The majority of survey respondents reported medium (43) to low (31) levels of relational well-being. Survey respondents also indicated how the beach grass changes they reported impact their relational well-being. The majority of survey respondents reported no (51) to negative impact (28) to their relational well-being. Through analysis of the correlations between dimensions of beach grass change and average relational well-being impact (across indicators), it was found that area/extent of beach grass change was most strongly correlated to relational well-being impact average ($\rho=0.2350$, $p<0.05$). Through analysis of the correlations between relational well-being indicators and average beach grass change, it was found that feeling of community belonging was the indicator most strongly correlated to average beach grass change ($\rho=0.2795$, $p<0.05$). In the semi-structured interviews, two interview participants acknowledged the contribution of valued beach grass regulating ESs to relational well-being, and one interview participant acknowledged the contribution of aesthetic value (cultural ES) and biodiversity maintenance (supporting ES) to relational well-being.

In terms of subjective well-being, the indicators used in this thesis were: overall happiness, and overall feeling of safety and security. From here a basis for survey respondents' subjective well-being could be established. The majority of survey respondents reported medium (43) to high (21) levels of subjective well-being. Survey respondents also indicated how the beach grass changes they reported impact their subjective well-being. The majority of survey respondents reported no (50) to negative impact (20) to their subjective well-being. Through analysis of the correlations between dimensions of beach grass change and average subjective well-being impact (across indicators), and it was found that area/extent of beach grass change was the only significant correlation to subjective well-being impact average (ρ=0.2520, $p<0.05$)). Through analysis of the correlations between subjective well-being indicators and average beach grass change, no significant correlations were found ($p>0.05$ for all). In the semi-structured interviews, two interview participants acknowledged the contribution of valued beach grass regulating ESs to relational well-being, and one interview participant acknowledged the contribution of aesthetic value (cultural ES) and biodiversity maintenance (supporting ES) to relational well-being. These findings suggest that all dimensions of social well-being are impacted by changes to beach grass ESs. Initiatives that support the conservation of beach grass ESs will also support social well-being.

9.2.5 Objective five

Use insights from the research to support and enhance current coastal planning efforts along the southeastern shoreline of Lake Huron.

Through the results of this research, the connection between humans and their environment, has been brought to the foreground when examining the ES-well-being linkages with respect to beach grass and the Lake Huron shoreline. Understanding these linkages demonstrates how potential decisions can affect human well-being by altering or restoring ecosystems. Shoreline community members, play an important role in the conservation and management of beach grass along the Lake Huron shoreline, and are thus a driving force in the creation of their own well-being. Using a CBM-WEBs approach to shoreline management, will thus engage the resource users in the creation of their own well-being, while enhancing culturally sustainable and environmental stewardship values.

9.3 Outcomes and contributions

In this section, I discuss the broader conceptual contributions and specific insights of this research to literature. Then, I examine the applications of this research to action on the ground.

9.3.1 *Conceptual framework*

The conceptual framework generated for this thesis can be applied to other shoreline and coastal communities in order to build toward coastal sustainability (see Section 8.4). This framework illustrates how people interact with their environment, and that putting a lens on valued ESs and social well-being enables the formation of a viable pathway toward coastal sustainability.

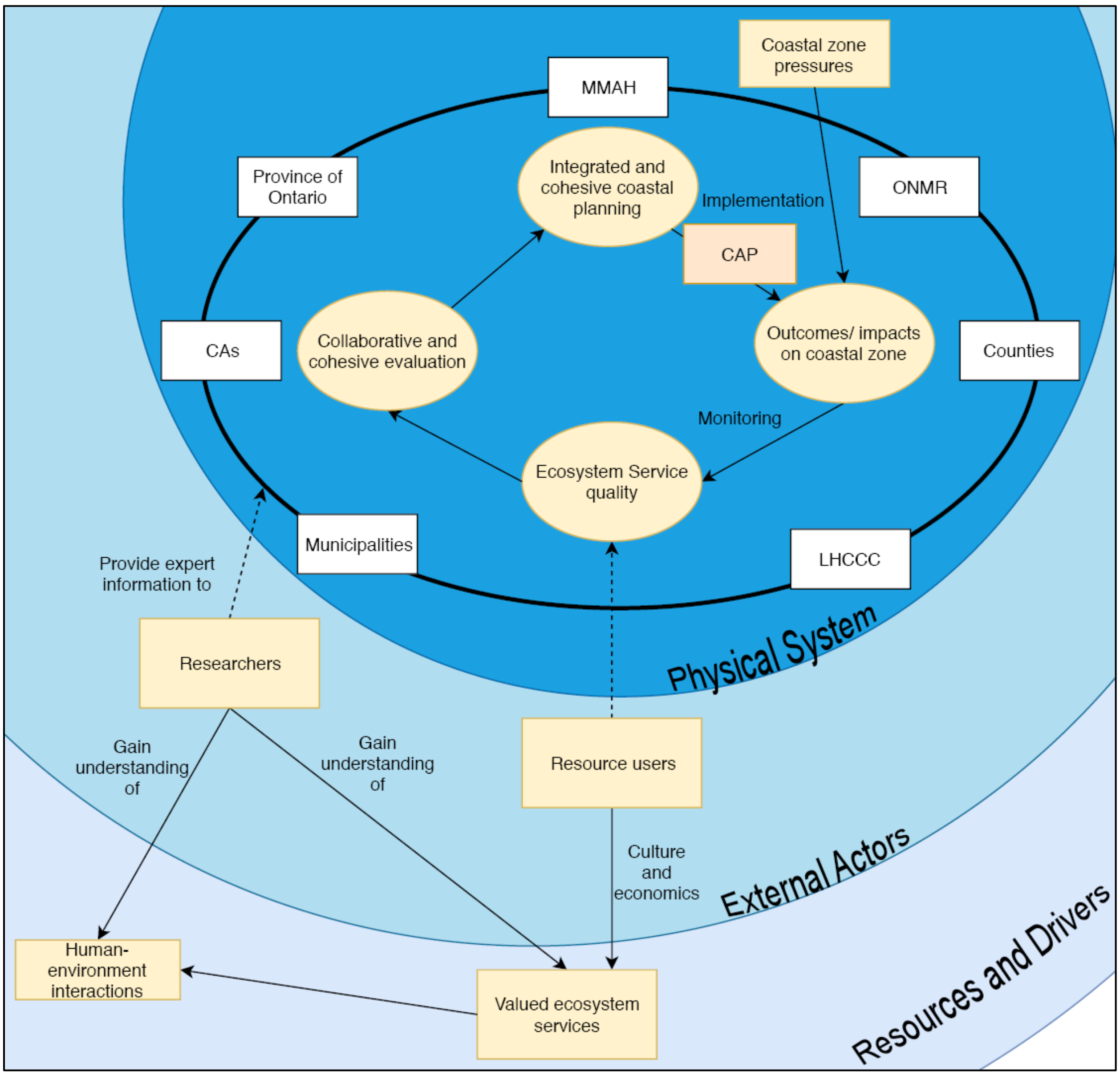

Figure 9.1 *Conceptual framework.*

As demonstrated in this thesis, analyzing ES and social well-being linkages dives into the complex nature of human-environment interactions and surfaces with opportunities may for more context-specific and locally tailored approaches to coastal resource management.

9.3.2 *Key insights*

In addition to the empirical findings summarized in Section 9.2, this thesis offers three key insights to coastal resource management:

1. Conservation initiatives that support the formation of a coastal stewardship perception can support effective change (Chapter 5);
2. Resource users play a key role in the integrated management of the shoreline and their values should offer guidance as to what the targeted areas and issues of management initiatives are; and
3. A CBM-WEBs management approach highlights the improvement of social-well-being, with the improvement in the quality of ecosystem service quality and environmental resources.

Firstly, coastal planning initiatives that promote an environmental steward perception toward beach grass along the Lake Huron shoreline support coastal sustainability through the maintenance of valued beach grass ESs and social well-being. To maximize effectiveness of any shoreline management initiative in the instigation of behaviour change toward beach grass, it must foster a change in perception toward beach grass, by enhancing knowledge and importance of beach grass ESs through education, convenience, targeting other values, and social influence.

Secondly, resource users also draw well-being from the quality of these ESs, therefore, resource users play a role in the creation of their own well-being through the ways they choose to treat their surrounding environment. Incorporating resource users in the integrated management of the shoreline entails will ensure that management initiatives reflect societal values, gearing societal behaviour and planning efforts toward the preservation and conservation of coastal resources.

Thirdly, using a CBM-WEBs framework demonstrates how management decisions can affect social well-being of community members through the alteration or restoration of valued ESs. It is also able to highlight how social well-being is dependent on ES quality and is impacted by changes in the environment, bringing insight to the role of the resource user in the creation of their own well-being through ES protection and improving environmental quality.

9.3.3 *Practical action on the ground*

The CAP will outline a localized and community-based approach for the management of beach grass and other coastal resources. Localization of coastal resource management would promote cultural and environmental sustainability because it promotes ecologically-based administrative boundaries, ecological literacy and use of local knowledge (Gibson, 2017). Local scales are extremely important for resilience and ICM/CBM, as it is the scale at which people and ecosystems are most strongly connected (Walker & Salt, 2012). Since these human-environment interactions and ESs are at the core of this thesis, localization of management strategies would indicate progress toward social-ecological sustainability of the coastal ecosystems of Lake Huron because managing resources at the local scale ensures that social well-being and environmental resilience can both be maximized (Walker & Salt, 2012).

The research in this thesis contributes to the CAP in the sense that it offers guidance to effective education and management initiatives that are tailored to the needs and values of the local population. By understanding the beach grass ESs valued by shoreline communities, and how changes in these ESs impacts their social well-being, the CAP can set appropriate conservation priorities that aim to maximize well-being without compromising environmental soundness. Implementing this localized, bottom-up framework will thus work to improve resilience of the system, influence more sustainable societal values in coastal communities and conserve valuable and important coastal resources.

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<u>Appendix A</u>

11.1 Survey questions

Interviewer Name:
Interviewee Code:
Date:
Location:

Section 1: Respondent Information

1. What statement describes you most accurately:
   a) A landowner/property owner with adjacent beach
   b) A landowner/property owner with beach access (public or private)
   c) An occasional beach visitor (non-landowner/property owner)

2. How often do you access the beach?
   a) Daily
   b) 2-3 times per week
   c) Once per week
   d) Once per month
   e) Less than once per month

3. I am knowledgeable about beach grass

Strongly disagree	**Disagree**	**Agree**	**Strongly Agree**

4. Do you have beach grass on or around your property or is it on the beach you normally visit?
   YES
   NO

5. *If yes*:
   a) Do you maintain it / try and augment it)
   b) Try to get rid of it (i.e., consider it a nuisance)
   c) Leave it be / take no action

6. Has the area/extent of beach grass on the beach you visit changed in the past 5-10 years?
   YES
   NO

7. *If yes*: In your view, what is the main reason for the change?

a) It naturally died out
b) Intentional removal
c) Impacted by invasion of European Common Reed (*Phragmites australis*)
d) Other (if so, specify) ____________
e) Unsure

Section 2: Perceived benefits of beach grass (ecological)

8. State your level of agreement with the following statements:

The presence of beach grass in general serves:

	Strongly Agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Disagree**	**Unsure**
to maintain the shoreline wildlife and biodiversity						
to stabilize and/or maintain the beach (eg., prevent erosion)						
to moderate the effects of flooding and storm events						
to improve the lake water quality						
to improve the aesthetic enjoyment of the frequented public/private beaches along the Lake Huron Shoreline						
to improve the enjoyment of touristic activities involving Lake Huron						
as a reminder of coastal processes						
Other:						
Other:						
Other:						

9. How important are these services to you?

	Not important at all	**Not important**	**Neutral**	**Important**	**Very important**	**Not applicable**
the maintenance of shoreline wildlife and biodiversity						
the stability and maintenance of the beach						
the moderation of the effects of flooding and storm events						
the improvement of lake water quality						
the aesthetic enjoyment of the frequented public/private beaches along the Lake Huron Shoreline						
enjoyment of touristic activities involving Lake Huron						
coastal processes						
Other:						
Other:						
Other:						

Section 3: Perceived benefits of beach grass (social)

10. Indicate your level of agreement with the following statements.

	Strongly Disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly Agree**	**Not applicable/Unsure**
Beach grasses have costed you money in past (e.g., for removal)						
Beach grasses presently cost you money (e.g., for removal)						
Beach grass presence decreases your property value						
Beach grass presence has compromised your ability to enjoy the beach						
Beach grass presence has increased your overall financial well-being (e.g., increased your property value)						
Beach grasses contribute to your sense of place						
Beach grasses contribute to your feeling of community belonging						
Beach grass presence can be linked to your participation in community activities (e.g., restoration or clean up activities)						
Beach grasses have negatively impacted your personal relationships (e.g., increased conflict with neighbours or						

other beach users to clear or restore)						
Beach grasses have positively impacted your personal relationships (e.g., shared agreement to take an action)						
Beach grass presence decreases your overall happiness						
Beach grass presence increases your overall happiness						
Beach grass presence increases your overall feeling of safety and security						

Section 4: Changes in ecosystem services and beach grass

16. Have you observed any changes in the presence of beach grasses in general along the Lake Huron shoreline with which you are most familiar?
    YES

    NO

17. If yes, what are some of the important changes? (specify increase or decrease in choices)
    a) Increase/Decrease in beach grass coverage
    b) Increase/Decrease in beach grass density
    c) Increase/Decrease in beach grass health (visually)
    d) Other (if so, specify) ____________

18. How would you describe the nature of the changes you have explained above? Select all that Apply
    a) Sudden / abrupt
    b) Significant / substantial
    c) Pose significant challenges to local communities, managers, others

19. Are the changes you mentioned above:
    a) Directly Human-caused (e.g. physical removal of beach grass)
    b) Indirectly human-caused (e.g. European Common Reed invasion)
    c) Not Human-caused (e.g. die out)
    d) Unsure

20. Regarding the changes you reported in question 17, how have they impacted:

	Very negatively impacted	**Negatively impacted**	**No impact**	**Positively impacted**	**Very positively impacted**	**Not applicable/ unsure**
Your current financial situation						
Current financial situation						
Property value						
Enjoyment of the beach area you access						
Your sense of place						
Your feeling of community belonging						
Your participation in community activities						
Your personal relationships						
Your overall happiness						
Your overall feeling of safety and security						

Section 5: Insights for better management practices

21. State your level of agreement with the following statements in reference to the Lake Huron shoreline

	Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly Agree**	**Not applicable/Unsure**
Property owners need more information about the importance of beach grass						
Property owners need more information about the ecological						

structure and processes of beach-dune systems						
Property owners need more information about how to properly maintain beach grass on their property						
Beach visitors need more information about the importance of beach grass						
Beach visitors need more information about the ecological structure and processes of beach-dune systems						
Beach visitors need to more information on proper beach conduct						
More initiatives are needed to better protect beach grass						
More structures are needed to prevent people from walking directly on the beach grass and dunes (e.g. fences and designated pathways)						
More initiatives are needed to promote coastal sustainability						
Beach grass and dune conservation efforts need to have more community involvement						
Local schools should better educate their students about their coastal environment						
More information and instructional signs about beach grass and dunes should be placed on beaches						

More dune restoration initiatives are needed						
Beach management practices should prioritize the protection of the dune system over visual aesthetics (e.g. stop raking the beach near the dunes)						
Community members should be better educated on what actions should be taken to ameliorate local impacts of climate change with regards to the beach-dune systems						
'Dune sanctuaries' should include beach-dune systems that are municipally and privately owned						
More control initiatives for the European common reed should be implemented						
Control initiatives for the European common reed should encourage more community involvement						

11.2 Interview Guide

Research objective: Examine how beach grass is changing and reasons for those changes

1. Changes in beach grass (*Ammophila breviligulata)* XYZ (to be determined from survey data) were reported by people living along the shoreline/ beach visitors etc.
   a) To your knowledge, what natural or ecological factors are influencing the above changes, and to what extent?
   b) To your knowledge, what human-caused factors are influencing these changes, and to what extent?
2. How do you expect beach grass will change over the next 10 years?
   - *Follow-up:* What is your reasoning for this?

3. Do you foresee any new causes (drivers) of change that may play a key role in future changes of beach grass?

Research objective: Establish how these changes are linked to well-being

4. To your knowledge, what impacts can these changes have on the well-being of community members:
   a) Financially? (e.g. intentional removal or flood damages)
   b) Relationally? (e.g. conflict with neighbours or other beach users to clear or restore)
   c) Subjectively/in general? (e.g. overall happiness, feeling of safety)

Research objective: Contribute to the transformation of the current coastal planning efforts such that it will promote sustainable resource use while maintaining social well-being

5. Are there any gaps in current coastal planning efforts that could have allowed for these natural and human-caused factors to lead to the changes that they have?

Elaboration: Are the laws/policies in place sufficient for protecting and conserving beach grass to community members?

6. Given the changes to beach grass outlined in the survey done by community members, how can coastal planning efforts be modified in ways to better conserve and manage beach grass?
7. Do the current coastal planning efforts support the overall well-being of community members?
   - *Follow-up:* (depending on answer) How do they do this? OR How can they be further modified such that they can do this?
8. Do the current coastal planning efforts support coastal sustainability?
   - *Follow-up:* (depending on answer) How do they do this? OR How can they be further modified such that they can do this?
9. Do the current costal planning efforts aim to resolve issues that are deeply rooted in societal values, are they more remedial/maintenance efforts, or something in between?
   - *Follow-up:* (depending on answer) How do they do this? OR How can they be further modified such that they can do this?
10. Is the role of the resource user in the conservation and management of beach grass defined in current coastal planning efforts?

Elaboration: The resource user in this context refers to people who use the beaches with beach grass and/or own beachfront property with beach grass and/or use any ecosystem services provided by beach grass.

11. In you view, is defining the role of the resource user in the conservation and management of these ecosystem services is important?
    - *Follow-up:* (depending on answer) Why is it important? OR Why is it not important?

12. How can defining (or a clearer definition of) the role of the resource user:
    a) Aid in conserving beach grass in general?
    b) Prevent future detrimental changes to beach grass?/ Promote sustainable resource use?
    c) Promote more culturally sustainable societies?/ Promote ecocentric societal values?
    d) Benefit the coastal environment?
    e) Improve the well-being of community members?
13. Are there any important issues we have not discussed?
14. Would you like a summary of the research findings?

If yes:

E-mail address: ____

OR other preferred method of contact: __________________________________

Appendix B

$$\%\ total\ category\ A = \frac{\#\ respondents\ in\ category\ A}{n\ (specific\ to\ the\ question)}\ x\ 100$$

Equation 12.1 *Percentage calculation for respondent pool distribution.*

$$\%\ respondents\ that\ value\ beach\ grass\ ES = \frac{\#\ \text{agree responses} + \#\ \text{strongly agree responses}}{n\ of\ beach\ grass\ ES}\ x\ 100$$

Equation 12.2 *Percentage calculation for respondent pool distribution.*

$$\%\ respondents\ in\ agreement\ level\ A = \frac{\#respondents\ that\ chose\ agreement\ level\ A}{n} x100$$

Equation 12.3 *Calculations for self-reported knowledge level of survey respondents.*

$$\%\ respondents\ in\ importance\ category\ A\ for\ ES\ A = \frac{\#respondents\ that\ chose\ importance\ level\ A\ for\ ES\ A}{n\ of\ beach\ grass\ ES}\ x\ 100$$

Equation 12.4 *Calculations for beach grass ES importance levels of survey respondents.*

$$\%\ respondents\ of\ action\ type\ A = \frac{\#respondents\ that\ chose\ action\ type\ A}{n} x100$$

Equation 12.5 *Calculations for actions/behaviours of survey respondents.*

$$\%\ repondents\ observed\ change\ type\ A = \frac{\#\ of\ respondents\ that\ chose\ change\ type\ A}{n} x\ 100$$

Equation 12.6 *Calculations for observed change types by survey respondents.*

Appendix C

13.1 Calculations used for correlation coefficients of self-reported knowledge and importance levels of ecosystem services

```
% Correlation coefficient for self-reported knowledge and importance of
% the maintenance of shoreline wildlife and biodiversity
xB=table2array(knoBio); % converting the data imported from excel into a readable array
yB=table2array(impBio); % converting the data imported from excel into a readable array
alpha=0.05;
[HknoBio, pknoBio, WknoBio]= swtest(xB,alpha); % Normality test for knowledge data set
[HimpBio, pimpBio, WimpBio]= swtest(yB,alpha); % Normality test for importance data set
[rhoB,tB,pB]=spear(xB,yB);                     % Calculation of Spearman rank correlation coefficient of
                                               % self-reported knowledge and importance of the maintenance
                                               % of shoreline wildlife and biodiversity, t value and p value

% Correlation coefficient for self-reported knowledge and importance of
% erosion prevention

xPE=table2array(knoPE); % each 'kno' variable is specific to the ES
                        % importance variable because the respondent pool
                        % is different for each. Only those that answered
                        % both self-reported knowledge and listed an
                        % importance level for the specific ES are
                        % included in the r calculation.
yPE=table2array(impPE);
[HknoPE, pknoPE, WknoPE]= swtest(xPE,alpha); % Normality test for knowledge data set
[HimpPE, pimpPE, WimpPE]= swtest(yPE,alpha); % Normality test for importance data set
[rhoPE,tPE,pPE]=spear(xPE,yPE);              % Calculation of Spearman rank correlation coefficient of
                                             % self-reported knowledge and importance of erosion
                                             % prevention, t value and p value

% Correlation coefficient for self-reported knowledge and importance of
% the moderation of the effects of flooding and storm events

xMF=table2array(knoMF);
yMF=table2array(impMF);
[HknoMF, pknoMF, WknoMF]= swtest(xMF,alpha); % Normality test for knowledge data set
[HimpMF, pimpMF, WimpMF]= swtest(yMF,alpha); % Normality test for importance data set
[rhoMF,tMF,pMF]=spear(xMF,yMF);              % Calculation of Spearman rank correlation coefficient of
                                             % self-reported knowledge and importance of the moderation of
                                             % the effects of flooding and storm events, t value and p value

% Correlation coefficient for self-reported knowledge and importance of
% the improvement of lake water quality
```

```
xWQ=table2array(knoWQ);
yWQ=table2array(impWQ);
[HknoWQ, pknoWQ, WknoWQ]= swtest(xWQ,alpha); % Normality test for knowledge data set
[HimpWQ, pimpWQ, WimpWQ]= swtest(yWQ,alpha); % Normality test for importance data set
[rhoWQ,tWQ,pWQ]=spear(xWQ,yWQ);              % Calculation of Spearman rank correlation coefficient of
                                             % self-reported knowledge and importance of the improvement
                                             % of lake water quality, t value and p value

% Correlation coefficient for self-reported knowledge and importance of
% the aesthetic enjoyment of the frequented public/private beaches along the Lake Huron Shoreline

xA=table2array(knoA);
yA=table2array(impA);
[HknoA, pknoA, WknoA]= swtest(xA,alpha); % Normality test for knowledge data set
[HimpA, pimpA, WimpA]= swtest(yA,alpha); % Normality test for importance data set
[rhoA,tA,pA]=spear(xA,yA);               % Calculation of Spearman rank correlation coefficient of
                                         % self-reported knowledge and aesthetic enjoyment,
                                         % t value and p value

% Correlation coefficient for self-reported knowledge and importance of
% the enjoyment of touristic activities involving Lake Huron

xT=table2array(knoT);
yT=table2array(impT);
[HknoT, pknoT, WknoT]= swtest(xT,alpha); % Normality test for knowledge data set
[HimpT, pimpT, WimpT]= swtest(yT,alpha); % Normality test for importance data set
[rhoT,tT,pT]=spear(xT,yT);               % Calculation of Spearman rank correlation coefficient of
                                         % self-reported knowledge and importance of enjoyment of
                                         % touristic activities, t value and p value

% Correlation coefficient for self-reported knowledge and importance of
% reminder of coastal processes

xCP=table2array(knoCP);
yCP=table2array(impCP);
[HknoCP, pknoCP, WknoCP]= swtest(xCP,alpha); % Normality test for knowledge data set
[HimpCP, pimpCP, WimpCP]= swtest(yCP,alpha); % Normality test for importance data set
[rhoCP,tCP,pCP]=spear(xCP,yCP);              % Calculation of Spearman rank correlation coefficient of
                                             % self-reported knowledge and importance of reminder of
                                             % coastal processes, t value and p value

% Correlation coefficient for self-reported knowledge and average
% importance level. This includes all respondents that answered both
% questions to any capacity.

xAvg=table2array(knoAvg);
yAvg=table2array(impAvg);
[HknoAvg, pknoAvg, WknoAvg]= swtest(xAvg,alpha); % Normality test for knowledge data set
[HimpAvg, pimpAvg, WimpAvg]= swtest(yAvg,alpha); % Normality test for importance data set
[rhoAvg,tAvg,pAvg]=spear(xAvg,yAvg);             % Calculation of Spearman rank correlation coefficient of
                                                 % self-reported knowledge and importance level average,
                                                 % t value and p value

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

13.2 Data used for correlation coefficients' calculations of self-reported knowledge and importance levels of ecosystem services

SURVEY #	CODE #		IMPORTANCE						
		Knowledge	Biodiversity	Erosion Prevention	Moderation of Flooding and Storm Events	Water quality	Aesthetic	Enjoyment of Touristic Activities	Coastal Processes
PHONE 1	0001	3.6666667	5	5	4	4	5	4	5
PHONE 2	0002	3.6666667	4	4	4	4	2	2	4
2	0008	5	5	5	5	5	5	2	5
3	0009	5	3	4	NA	NA	2	2	NA
4	0010	5	5	5	2	5	4	3	4
5	0011	5	5	5	3	3	5	5	3
7	0012	5	5	5	5	5	5	5	5
8	0013	3.6666667	4	5	5	5	5	3	4
9	0014	5	5	5	5	5	5	5	5
11	0016	3.6666667	4	5	4	5	5	5	4
12	0017	5	4	4	4	5	5	5	NA
14	0019	3.6666667	5	5	5	5	4	5	4
16	0021	5	2	2	2	4	4	4	NA
17	0022	3.6666667	4	4	4	4	4	4	4
19	0024	5	5	5	5	5	5	5	4
22	0026	3.6666667	3	5	4	5	5	5	NA
23	0027	3.6666667	4	5	5	5	4	4	5
24	0028	2.3333333	4	4	4	4	4	4	4
25	0029	3.6666667	4	4	4	4	4	4	4
26	0030	5	4	5	5	5	5	5	5
27	0031	2.3333333	5	5	5	4	5	4	5
28	0032	3.6666667	5	5	5	5	5	5	5
29	0033	3.6666667	4	4	4	5	4	3	3
30	0034	3.6666667	2	NA	NA	5	4	4	3
31	0035	3.6666667	5	5	5	4	4	3	5
32	0036	5	5	5	5	5	5	5	5
35	0037	3.6666667	5	5	5	5	3	3	5
37	0039	3.6666667	3	3	3	4	3	3	3
38	0040	5	3	5	2	5	5	4	4
39	0041	3.6666667	5	5	5	5	5	5	5
40	0042	3.6666667	4	4	4	4	5	5	4
41	0043	5	5	5	5	5	5	3	5

43	0045	5	5	5	5	5	5	5	3
44	0046	3.6666667	5	5	5	5	5	4	5
45	0047	3.6666667	5	4	5	5	4	4	5
46	0048	2.3333333	5	5	5	5	5	5	5
47	0049	3.6666667	4	5	3	4	4	2	4
50	0052	3.6666667	5	5	4	NA	4	3	5
51	0053	2.3333333	2	5	5	4	2	2	NA
52	0054	5	4	5	5	5	4	5	5
53	0055	3.6666667	5	5	5	5	5	5	5
54	0056	3.6666667	5	5	5	5	3	3	5
55	0057	5	5	5	5	5	5	5	5
56	0058	5	5	5	5	5	5	3	5
58	0060	2.3333333	5	5	5	5	4	4	5
59	0061	2.3333333	4	5	5	5	4	4	4
61	0063	2.3333333	4	5	5	5	5	5	5
62	0064	3.6666667	4	5	5	5	4	4	5
63	0065	3.6666667	4	5	5	5	5	5	4
64	0066	3.6666667	5	5	5	5	4	4	NA
65	0067	3.6666667	4	4	5	5	3	4	4
66	0068	3.6666667	5	5	5	5	4	4	5
68	0070	3.6666667	5	5	4	5	5	5	3
69	0071	5	5	5	5	5	1	1	5
70	0072	2.3333333	5	5	5	5	5	5	5
71	0073	2.3333333	5	5	5	5	5	5	5
72	0074	3.6666667	5	5	5	5	3	3	4
73	0075	3.6666667	5	5	4	5	3	3	4
74	0076	5	5	5	5	5	5	5	5
75	0077	5	5	5	5	5	5	5	5
76	0078	5	3	3	1	3	5	5	3
77	0079	5	5	5	5	5	5	5	5
78	0080	3.6666667	5	5	5	5	5	3	5
79	0081	3.6666667	3	5	3	5	5	5	4
80	0082	3.6666667	5	5	4	5	5	4	NA
81	0083	3.6666667	NA	5	NA	NA	NA	NA	NA
82	0084	3.6666667	4	4	4	4	2	1	3
83	0085	3.6666667	5	5	5	5	5	5	5
84	0086	2.3333333	5	5	5	5	5	5	5
85	0087	5	5	5	5	5	5	5	5
87	0089	2.3333333	5	5	5	5	3	3	4
88	0090	3.6666667	NA	NA	NA	1	NA	NA	NA
90	0092	3.6666667	5	5	5	5	5	5	5
91	0093	5	5	5	3	3	4	2	3
92	0094	3.6666667	5	5	4	5	4	2	5
93	0095	3.6666667	4	5	4	4	5	5	NA

94	0096	3.6666667	5	5	5	5	5	4	5
95	0097	3.6666667	5	5	5	5	5	5	5
96	0098	3.6666667	5	5	5	5	4	3	5
97	0099	3.6666667	4	4	4	4	3	2	3
98	0100	2.3333333	2	3	2	3	3	3	3
99	0101	2.3333333	5	5	4	3	3	3	3
100	0102	3.6666667	5	5	5	5	3	3	5
101	0103	3.6666667	5	5	5	5	5	5	5
102	0104	5	5	5	5	5	5	5	3
103	0105	5	5	5	5	5	4	3	5
104	0106	3.6666667	5	5	5	5	5	5	3
105	0107	2.3333333	4	4	4	4	5	5	4
106	0108	3.6666667	5	5	5	5	5	2	5
107	0109	2.3333333	5	5	5	5	5	4	5
108	0110	3.6666667	4	4	4	4	4	3	4
109	0111	5	5	5	4	5	4	2	3
110	0112	3.6666667	5	5	5	5	5	4	5
111	0113	5	5	5	5	5	4	3	5
113	0115	3.6666667	5	4	4	5	4	4	5
115	0117	3.6666667	5	5	5	5	5	3	5
116	0118	5	5	5	5	5	5	5	5
117	0119	5	5	5	5	5	5	2	5
118	0120	3.6666667	5	5	5	5	4	3	5
119	0121	5	5	5	5	5	5	4	5
120	0122	5	5	5	5	5	5	5	4
121	0123	3.6666667	5	5	5	4	3	3	5
122	0124	3.6666667	5	5	5	5	5	4	5
125	0127	5	5	5	5	5	5	5	5

13.3 Calculations used for correlation coefficients of average importance levels of ecosystem services and actions/behaviour

```
% Calculations used for correlation coefficient of average importance
% levels and actions/behaviour
x=table2array(imp);                      % Converting table of average importance to usable array
y=table2array(act);                      % Converting table of actions to usable array
alpha=0.05;
[Himp, pimp, Wimp]= swtest(x,alpha);     % Normality test for importance data set
[Hact, pact, Wact]= swtest(y,alpha);     % Normality test for actions data set
[rho,tval,pval]=spear(x,y);              % Calculation of Spearman rank correlation coefficient of
                                         % average importance levels and actions/behaviour
function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...           % Function definition (Leontitsis, 2002)
```

13.4 Data used for correlation coefficient calculation of average importance levels of ecosystem services and actions/behaviour

SURVEY #	CODE #		
		Importance average	Actions
PHONE 1	0001	4.571428571	5
PHONE 2	0002	3.428571429	3
2	0008	4.571428571	5
3	0009	2.75	3
4	0010	4	1
5	0011	4.142857143	1
7	0012	5	1
8	0013	4.428571429	3
9	0014	5	5
11	0016	4.571428571	5
12	0017	4.5	3
14	0019	4.714285714	3
16	0021	3	1
17	0022	4	5
19	0024	4.857142857	3
22	0026	4.5	1
23	0027	4.571428571	3
24	0028	4	3
25	0029	4	1
26	0030	4.857142857	5
27	0031	4.714285714	3
28	0032	5	3
29	0033	3.857142857	3
30	0034	3.6	3
31	0035	4.428571429	5
32	0036	5	5
35	0037	4.428571429	5
37	0039	3.142857143	5
38	0040	4	1
40	0042	4.285714286	1
41	0043	4.714285714	3
43	0045	4.714285714	1
44	0046	4.857142857	1
46	0048	5	3
47	0049	3.714285714	3
51	0053	3.333333333	1

52	0054	4.714285714	5
53	0055	5	5
54	0056	4.428571429	3
55	0057	5	5
56	0058	4.714285714	3
58	0060	4.714285714	3
59	0061	4.428571429	3
61	0063	4.857142857	3
62	0064	4.571428571	3
63	0065	4.714285714	5
64	0066	4.666666667	3
65	0067	4.142857143	3
66	0068	4.714285714	3
68	0070	4.571428571	3
69	0071	3.857142857	3
70	0072	5	3
71	0073	5	3
72	0074	4.285714286	5
73	0075	4.142857143	5
75	0077	5	3
76	0078	3.285714286	3
78	0080	4.714285714	3
79	0081	4.285714286	3
80	0082	4.666666667	3
81	0083	5	5
82	0084	3.142857143	3
83	0085	5	3
84	0086	5	3
85	0087	5	3
87	0089	4.285714286	3
88	0090	1	1
90	0092	5	3
91	0093	3.571428571	3
92	0094	4.285714286	3
93	0095	4.5	1
95	0097	5	3
97	0099	3.428571429	3
98	0100	2.714285714	3
99	0101	3.714285714	3
100	0102	4.428571429	5
101	0103	5	3
102	0104	4.714285714	3
103	0105	4.571428571	5
104	0106	4.714285714	3

105	0107	4.285714286	3
106	0108	4.571428571	3
107	0109	4.857142857	5
108	0110	3.857142857	3
109	0111	4	3
110	0112	4.857142857	5
111	0113	4.571428571	5
113	0115	4.428571429	3
115	0117	4.714285714	1
116	0118	5	5
117	0119	4.571428571	3
118	0120	4.571428571	5
119	0121	4.857142857	5
120	0122	4.857142857	5
121	0123	4.285714286	5
122	0124	4.857142857	5
123	0125	4.285714286	3
125	0127	5	5

13.5 Calculations for self-reported knowledge levels and actions/behaviour

```
%Calculations for correlation coefficient of self-reported knowledge levels
%and actions/behaviour of survey respondents
x=table2array(kno); % Converting the imported data for self-reported
                    % knowledge levels into a useable array
y=table2array(act); % Converting the imported data for actions/behaviour
                    % into a useable array
alpha=0.05;
[Hkno, pkno, Wkno]= swtest(x,alpha);          % Normality test for knowledge dataset
[Hact, pact, Wact]= swtest(y,alpha);          % Normality test for actions dataset
[rho,tval,pval]=spear(x,y);                   % Calculation of Spearman rank correlation coefficient of
                                              % self-reported knowledge levels and actions/behaviour
function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

13.6 Data used for correlation coefficient calculation of self-reported knowledge levels and actions/behaviour

SURVEY #	**CODE #**		
		Knowledge	Actions
PHONE 1	0001	3.6666667	5
PHONE 2	0002	3.6666667	3
2	0008	5	5
3	0009	5	3
4	0010	5	1
5	0011	5	1
7	0012	5	1
8	0013	3.6666667	3
9	0014	5	5

11	0016	3.6666667	5
12	0017	5	3
14	0019	3.6666667	3
16	0021	5	1
17	0022	3.6666667	5
19	0024	5	3
22	0026	3.6666667	1
23	0027	3.6666667	3
24	0028	2.3333333	3
25	0029	3.6666667	1
26	0030	5	5
27	0031	2.3333333	3
28	0032	3.6666667	3
29	0033	3.6666667	3
30	0034	3.6666667	3
31	0035	3.6666667	5
32	0036	5	5
35	0037	3.6666667	5
37	0039	3.6666667	5
38	0040	5	1
40	0042	3.6666667	1
41	0043	5	3
43	0045	5	1
44	0046	3.6666667	1
46	0048	2.3333333	3
47	0049	3.6666667	3
51	0053	2.3333333	1
52	0054	5	5
53	0055	3.6666667	5
54	0056	3.6666667	3
55	0057	5	5
56	0058	5	3
58	0060	2.3333333	3
59	0061	2.3333333	3
61	0063	2.3333333	3
62	0064	3.6666667	3
63	0065	3.6666667	5
64	0066	3.6666667	3
65	0067	3.6666667	3
66	0068	3.6666667	3
68	0070	3.6666667	3
69	0071	5	3
70	0072	2.3333333	3
71	0073	2.3333333	3

72	0074	3.6666667	5
73	0075	3.6666667	5
75	0077	5	3
76	0078	5	3
78	0080	3.6666667	3
79	0081	3.6666667	3
80	0082	3.6666667	3
81	0083	3.6666667	5
82	0084	3.6666667	3
83	0085	3.6666667	3
84	0086	2.3333333	3
85	0087	5	3
87	0089	2.3333333	3
88	0090	3.6666667	1
90	0092	3.6666667	3
91	0093	5	3
92	0094	3.6666667	3
93	0095	3.6666667	1
95	0097	3.6666667	3
97	0099	3.6666667	3
98	0100	2.3333333	3
99	0101	2.3333333	3
100	0102	3.6666667	5
101	0103	3.6666667	3
102	0104	5	3
103	0105	5	5
104	0106	3.6666667	3
105	0107	2.3333333	3
106	0108	3.6666667	3
107	0109	2.3333333	5
108	0110	3.6666667	3
109	0111	5	3
110	0112	3.6666667	5
111	0113	5	5
113	0115	3.6666667	3
115	0117	3.6666667	1
116	0118	5	5
117	0119	5	3
118	0120	3.6666667	5
119	0121	5	5
120	0122	5	5
121	0123	3.6666667	5
122	0124	3.6666667	5
125	0127	5	5

Appendix D

14.1 Comment categorization for main drivers of change (online survey)

Comments of participants that chose to not be anonymously quoted in this thesis have been removed.

#	Category	OTHER (PLEASE SPECIFY)	DATE
1	Natural causes	natural causes The previous owner mowed some of the beach vegetation between the dune and the sandy shore. I think the dune might be higher now that the vegetation hasn't been mowed in about 5 years.dune is better now	12/13/2018 8:10 PM
2	Erosion	Erosion high water level Some loss due to higher water levels in past several years on lake huron	11/21/2018 5:40 PM
3	Erosion	Erosion high water level Erosion from the high water levels	11/19/2018 9:57 PM
4	Erosion	Erosion high water level Erosian from high water waves	11/19/2018 1:53 PM
5	Erosion	Erosion Lost to water erosion	11/19/2018 8:42 AM
6	Erosion	Erosion high water level Lake level fluctuations have caused significant erosion of the beach and adjacent dunes.	11/18/2018 1:02 PM
7	Erosion	Erosion high water level rising water levels in lake	11/17/2018 11:36 PM
8	Erosion	Erosion high water level erosion, what levels are high	11/17/2018 3:39 PM
9	Erosion	Erosion high water level High lake levels/excessive wave action has removed a huge swath of sand and growing dune grass.	11/17/2018 12:52 PM
10	Erosion	Beach grass has increased Erosion high water level intentional planting planted by neighbours so now in areas where never was before and in last 2 years washed out by high water erosion	11/14/2018 12:23 PM
11	Intentional planting	Beach grass has increased intentional planting planted by neighbours	11/14/2018 12:17 PM
12	Erosion	Erosion high water level higher lake levels mean less beach width for dune grass	11/12/2018 11:04 AM
13	Erosion	Erosion nearshore wave erosion of beach sand	11/11/2018 9:25 PM
14	Unsure	Beach grass has increased unsure It has always been on the beach but in recent years it has increased exponentially.	11/8/2018 12:43 PM
15	Erosion	Erosion high water level intentional planting We have a great combination of weeds and grasses. We are encouraging the blue-green "Huron" grasses but digging out everything else so that we have a good seating area but also erosion protection. Last year the water was so high as to pull out the weeds left in front of our seating area, so now we expect more erosion to come. Thankfully the blue-green grasses in front of our path to the beach have remained. I'd like to encourage them to grow.	10/31/2018 5:02 PM
16	Intentional planting	Beach grass has increased intentional planting It grows and spreads over the years. My family planted the grass on the advice of the ministry of natural resources and in the last ca. 40 years it has spread with the prevailing north winds all the way to the Bayfield river. (1.6 km)	10/31/2018 4:44 PM
17	Unsure	Beach grass has increased unsure my impression is it is increasing, not sure if we have the common reed invasion	10/31/2018 5:32 AM
18	Erosion	Erosion high water level Rising lake levels have removed some of the dunes containing beach grass	10/29/2018 6:35 AM
19	Low water levels	Beach grass has increased low water levels the water level is up, and therefore we have more sand to support the growth of the beach grass	10/26/2018 7:59 PM
20	Unsure	Beach grass has increased unsure It has come back	10/24/2018 5:28 PM
21	Intentional planting	intentional planting There has been a concerted effort by local conservationists and the committee overseeing the beach to plant indigenous grasses and protect the planting sites.	10/24/2018 2:37 PM
22	Unsure	Beach grass has increased unsure It grew and multiplied so much that there is almost no beach left to sit at. Too invasive.	10/24/2018 2:06 PM
23	Unsure	Beach grass has increased unsure Much more beach grass than in previous years. Have been told this is common along all Lake Huron beaches in Ontario.	10/23/2018 1:55 PM
24	Low water levels	Beach grass has increased low water levels Low water levels has allowed the beach grass to spread on to more of the beach area	10/23/2018 8:43 AM

25	Invasive species	choked out by MarramGrass other invasive species Marram grass should never have been planted-- our native (original) beach grass is being choked out	10/22/2018 8:02 PM
26	Unsure	Beach grass has increased unsure There seems to be more?	10/22/2018 7:56 PM
27	Erosion	Erosion Natural erosion from Lake	10/22/2018 6:14 PM
28	Erosion	Erosion Impacted by erosion	10/22/2018 5:28 PM
29	Discounted	intentional removal natural die out Phragmites Many of the above	10/22/2018 4:33 PM
30	Low water levels	Beach grass has increased high water level low water levels Grass has increased because dunes have grown higher and due to high water beach has more grass	10/22/2018 4:27 PM
31	Erosion	Beach grass has increased Erosion The assumption is that it has declined when in fact it has not, erosion has removed some but most of us just want the sandy beach back. Given the choice between a sandy beach and dune grass I would pick the sandy beach.	10/22/2018 3:25 PM
32	Intentional planting	Beach grass has increased intentional planting Beach grass has taken over the beach. As a long term resident, we never had beach grass until it was planted to protect the shore.	10/22/2018 8:22 AM
33	Erosion	Erosion high water level low water levels Phragmites rise and fall of lake levels has a big impact on vegetation along the shore. Plus phragmites is often outcompeting other invasive species	10/18/2018 9:17 PM
34	Invasive species	choked out by MarramGrass other invasive species Phragmites All of the above and introduction of marram grass; while switch grass was the dominant native grass typically on the beach	10/17/2018 9:03 AM
35	Invasive species	choked out by MarramGrass other invasive species Phragmites Invasive species are impacting (phrag, sweet clover, etc.), planting of different kinds of grasses, all of the above	10/17/2018 8:43 AM
36	Unsure	Beach grass has increased unsure It had grown/spread - not diminished.	10/14/2018 1:23 PM
37	Natural causes	Beach grass has increased natural causes Natural propagation	10/14/2018 10:35 AM
38	Unsure	Beach grass has increased unsure It has increased	10/4/2018 7:11 AM
39	Unsure	Beach grass has increased unsure The beach grass has increased substantially on Port Franks Beach over the last 20 years.	10/2/2018 10:24 AM
40	Erosion	Erosion high water level The lake is currently high so at lot of sand has come in and covered it. Beach grass still exists further away from the water to help protect the shoreline.	9/27/2018 11:19 AM
41	Erosion	Erosion high water level Erosion from the higher waters	9/25/2018 3:36 PM
42	Erosion	Erosion foot traffic erosion by natural/ foot traffic	9/20/2018 5:00 PM
43	Erosion	Erosion high water level storm High water levels complicated by extreme storms	9/18/2018 1:40 PM
44	Unsure	Beach grass has increased unsure It actually has grown more	9/17/2018 6:01 PM
45	Erosion	Beach grass has increased Erosion high water level storm The beach and the beach grass/dunes undergo highs and lows over time. I have been a Bruce Beach resident for nearly 60 years. Some years there is all beach and little vegetation, then slowly the vegetation grows up again. One big storm, or summer of high water levels (1982??) or crazy winter can take all the vegetation out though, and then we start over again. Vegetation has been strengthening over the last ten (?) years which has resulted in a small beach (at least in front of our cottage)	8/31/2018 11:19 PM
46	Unsure	Beach grass has increased unsure Beach grass has covered a previously open (no grass) sand beach	8/28/2018 8:15 AM
47	Unsure	Beach grass has increased unsure The grass is creeping into the sandy area where we sit	8/27/2018 3:06 PM
48	Erosion	Erosion Erosion by wave action from Lake Huron	8/27/2018 1:35 PM
49	Erosion	Erosion high water level increased when water levels in L Huron went down, and has decreased with recent increase in L Huron water levels. In other words, natural increase and decrease which is the nature of the beach.	8/25/2018 8:08 AM
50	Nutrient runoff	high nutrient runoff Higher nutrient levels in the lake have made the grasses much thicker than they use to be.	8/25/2018 7:26 AM
51	Nutrient runoff	high nutrient runoff More fertile land due to runoff from farmers fields	8/25/2018 1:07 AM
52	Intentional removal	intentional removal Enlightened property understand the value and importance of grasses in preserving the lakeshore ecosystem and leave it in place. A diminishing number of uncaring owners persist in destroying the grasses. They should be prosecuted.	8/24/2018 9:04 PM
53	Intentional planting	Beach grass has increased intentional planting Increase where I transplanted	8/24/2018 8:38 PM

54	Unsure	Beach grass has increased unsure increased for unclear reasons	8/24/2018 5:10 PM
55	Low water levels	Beach grass has increased low water levels Lower water levels equals more grass	8/24/2018 4:07 PM
56	Intentional removal	Beach grass has increased intentional removal I have left more grass than I used to and only clear a large sitting area	8/24/2018 2:37 PM
57	Discounted	intentional removal natural die out Phragmites all of the above accept unsure	8/24/2018 9:41 AM
58	Low water levels	Beach grass has increased	8/24/2018 9:24 AM
59	Nutrient runoff	Beach grass has increased high nutrient runoff High nitrates from Hog farms is making grass grow where it's never been before	8/24/2018 9:15 AM
60	Erosion	Erosion high water level other invasive species season to season wave action, high water levels has removed some invasive willows and certain weeds at shore, in addition, one grass species has nearly overtaken (pushed) out another grass species	8/24/2018 9:00 AM
61	Nutrient runoff	high nutrient runoff other invasive species Unchecked agricultural runoff which includes phosphates and nitrates. Invasive species released into the great lakes.	8/24/2018 8:25 AM
62	Erosion	Beach grass has increased Erosion high water level low water levels When the lake level was low the grass marched slowly towards the shoreline. When the lake level rose the wave action removed a great deal of grass and returned the sand it had held into the lake bed near the shore.	8/23/2018 7:44 PM

14.2 *Comment categorization for main drivers of beach grass change (phone survey)*

7. *If yes*: In your view, what is the main reason for the change?
   a) It naturally died out
   b) Intentional removal
   c) Impacted by invasion of European Common Reed (*Phragmites australis*)
   d) Other (if so, specify) Rising water levels → Category: Erosion
   e) Unsure

14.3 *Comment categorization for nature of beach grass change (online survey)*

#	OTHER (PLEASE SPECIFY)	DATE
1	Slight Looks like beach grass area on Port Elgin beach is bigger than it used to be. Near my property there is now a slightly bigger area of beach grass. In the fall I divided some plants and planted them to expand the area.	12/13/2018 8:30 PM
2	Gradual Gradual increase in thickness and range along foredune in front of my seasonal lakefront cottage since aggressively planted 30+ years ago.	11/21/2018 5:59 PM
3	Constant Cyclical Gradual Natural Sig./substantial Sudden/abrupt Since the record-high water levels of Lake Huron in 1987 began to recede, our beach grasses (both naturally occurring and transplanted by local dune stewards) have served to capture the beach sand. Gradually, over the course of two decades, the beach widened and the adjacent dune grew to create a gradual sandy shoreline slope to the water's edge. Three years of rising lake levels have dramatically changed the coastline as the water scoured away 20 more feet of beach each year, leaving behind a stony beach and an abrupt bluff of sand that drops 14 feet to the shore. The grasses will reestablish themselves as the water recedes and the cycle will begin again.	11/18/2018 1:42 PM
4	Natural Natural forces - removal by wave action/ high water	11/17/2018 12:56 PM
5	Pose challenges Through the last 60 years I have seen lake Huron rise to high levels 3 times betseen 3 significan low levels. Having also reviewed the graph of the last 100 years of water levels it seems apparent to me that Mother Nature has her own agenda. During the past low water and the present high water I have had the chance to observe and experience the effects of beach grass. In my opinion, in times of low water and wide beaches it is a nuiance. It is not pleasant to walk thru, I personally don't find it pretty, and I have not seen any effect on wild life. I would like to learn more about the relationship between beach grass & wild life to verify my assessment. In times of high water it is not effective in stablizing this sandy beach.	11/14/2018 12:53 PM
6	Natural loss of sand to take hold and regenerate	11/11/2018 9:47 PM
7	Gradual The growth of the grasses is slow. The growth of the weeds is too fast.	10/31/2018 5:13 PM

8	Gradual Pose challenges gradual changes, concern that they cause elevated sand dunes that obstruct views of the lake and shore, birds etc	10/31/2018 5:51 AM
9	Pose challenges I was appalled by the action of our neighbour; and concerned about what would happen to the shoreline in front of our cottage as a result.	10/29/2018 10:05 AM
10	Cyclical Natural A natural part of the cycle of the lake	10/29/2018 6:42 AM
11	Natural Slight Minor changes due to high water level and wave action. Mainly confined to 5 metres from water's edge.	10/26/2018 7:29 AM
12	Sig./substantial significant is not a positive thing. It changed our beach for the worse.	10/22/2018 8:20 PM
13	Natural Erosion has removed some of the grass	10/22/2018 6:05 PM
14	Important Natural dune grass holds the sand around my cottage on my property	10/22/2018 4:33 PM
15	Cyclical Natural cyclical: eg during the low lake levels in the mid 1960s willows established themselves along the shore: storms with later higher lake levels washed the willows away.	10/18/2018 9:34 PM
16	Natural natural shoreline changes	10/16/2018 12:27 PM
17	Gradual Moderate Slow and moderate.	10/14/2018 1:27 PM
18	Gradual Sig./substantial Slow gradual, I rarely go to Sauble so I saw huge changes	10/11/2018 11:09 AM
19	Pose challenges The Port Franks Beach Association has been criticized by beach growers because the grass is close to the waters edge there is no room for beach blankets.	10/2/2018 10:32 AM
20	Cyclical Natural This is the normal cycle as the lake water level changes.	9/27/2018 11:26 AM
21	in #16 i would like today both directly and indirectly human caused	9/26/2018 10:41 PM
22	Sig./substantial The phragmites has significantly changed some areas of French Bay and the beach grass coverage in general has supported the growth of small shrubs and the start of trees on areas where we had mostly sand mixed with some beach grass.	9/20/2018 4:34 PM
23	Natural Changes are because of high water levels, not intentional	9/18/2018 1:49 PM
24	Gradual Natural long process of beach grasses increasing height of dunes	9/17/2018 6:06 PM
25	Constant Relentless Relentless and constant	9/4/2018 3:26 PM
26	Constant Gradual Pose challenges Sig./substantial In front of our cottage the grasses continually sent out 'shoot's in the sand and encroach on the area where we sit causing us to dig and pull it out to prevent it from 'taking' over the area where we sit. This area was completely sandy when I was a youth - 1950s and 1960s.	8/27/2018 3:15 PM
27	Constant Beach grass has been cleared by some adjacent owners for the 60 years that I have had the opportunity to observe.	8/27/2018 11:51 AM
28	Gradual Natural The long low water periodmseemed to facilitate the establishment of non-grass species (horsetail, some flower 'weeds"?) as well as willows, that have overpowered the original and typical American Beach Grass in some sections of shoreline.ach	8/25/2018 8:31 AM
29	Gradual Sudden/abrupt on our personal beach space, changes are gradual with water levels. On neighboring properties, people engage in clearing beach grass which is abrupt. not sure what you are asking	8/25/2018 8:21 AM
30	Gradual The changes have been gradual. People need to adapt and accept the restoration of grasses along the Lake Huron shore. This isn't Waikiki!	8/24/2018 9:15 PM
31	Pose challenges destroy use of beach for recreation and walkability.	8/24/2018 8:53 PM
32	Pose challenges Sig./substantial The inability to walk for extended distances or use the beach as a social corridor have created a greater sense of isolation and decreased human access to the Beach. It has adversely affected non property owners who previously would have parked at concession roads and enjoyed access to the full extent of the Beach.	8/24/2018 9:35 AM
33	Pose challenges unwelcome and resented.	8/24/2018 9:19 AM

Appendix E

15.1 Calculations used for correlation coefficients of beach grass change dimensions and material well-being impact

```
% Calculations for correlation coefficient of dimensional beach grass changes
% and material well-being (MWB)impact as reported by survey respondents.
xcov=table2array(cov);       % Converting imported data for beach grass
                             % area/extent changes into a useful array.

y=table2array(MWB);          % Converting the imported data for MWB impact into
                             % a useful array.

alpha=0.05;
[Hcov, pcov, Wcov]= swtest(xcov,alpha);% Normality test for area/extent changes dataset
[HMWB, pMWB, WMWB]= swtest(y,alpha);   % Normality test for MWB impact dataset
[rhocov,tvalcov,pvalcov]=spear(xcov,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass area/extent changes and MWB impact.


xden=table2array(den);       % Converting the imported data for beach grass density
                             % change into a useful array.

[Hden, pden, Wden]= swtest(xden,alpha);% Normality test for density changes dataset
[rhoden,tvalden,pvalden]=spear(xden,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass density change and MWB impact.

xvis=table2array(vis);       % Converting the imported data for beach grass visual health
                             % change into a useful array.

[Hvis, pvis, Wvis]= swtest(xvis,alpha);% Normality test for visual health changes dataset
[rhovis,tvalvis,pvalvis]=spear(xvis,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass visual health change and MWB impact.


xavg=table2array(avg);       % Converting the imported data for average beach grass change
                             % into a useful array.

[Havg, pavg, Wavg]= swtest(xavg,alpha);% Normality test for average beach grass changes dataset
[rhoavg,tvalavg,pvalavg]=spear(xavg,y);% Calculation of Spearman rank correlation coefficient of
                                       % average beach grass change and MWB impact.

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

15.2 Data used for correlation coefficients of beach grass change dimensions and material well-being impact

SURVEY #	CODE #	Area/extent	Density	Visual Health	Average Change Value	MWB Impact Average
PHONE 1	0001	5	5	5	5	3.333333333
PHONE 2	0002	5	5	5	5	3.333333333
2	0008	1	1	1	1	2.666666667

3	0009	5	1	3	3	3
4	0010	1	1	1	1	3.333333333
5	0011	1	1	1	1	3.666666667
7	0012	1	1	3	1.666666667	3.666666667
8	0013	3	3	5	3.666666667	3
9	0014	1	3	1	1.666666667	3.666666667
11	0016	1	1	3	1.666666667	3.666666667
12	0017	1	1	0	0.666666667	5
16	0021	1	1	3	1.666666667	4
17	0022	1	1	3	1.666666667	3.333333333
19	0024	0	0	0	0	1.666666667
22	0026	1	1	1	1	4
23	0027	5	5	0	3.333333333	2
25	0029	1	1	3	1.666666667	2.333333333
26	0030	1	0	3	1.333333333	0.333333333
28	0032	1	1	1	1	2.666666667
29	0033	1	1	3	1.666666667	3.333333333
30	0034	1	1	1	1	3.666666667
31	0035	0	3	3	2	2.666666667
35	0037	5	3	3	3.666666667	3
37	0039	5	3	3	3.666666667	4
38	0040	1	1	1	1	2.666666667
39	0041	1	1	1	1	3.666666667
40	0042	1	1	3	1.666666667	4
43	0045	1	1	3	1.666666667	3.333333333
44	0046	1	1	1	1	3.666666667
45	0047	1	1	0	0.666666667	1.333333333
46	0048	5	5	5	5	2.333333333
47	0049	1	1	3	1.666666667	2.666666667
48	0050	1	1	1	1	2
50	0052	5	5	5	5	4
51	0053	1	1	3	1.666666667	3.666666667
52	0054	5	1	1	2.333333333	3
53	0055	1	3	3	2.333333333	3.666666667
54	0056	5	5	5	5	1.333333333
55	0057	1	1	5	2.333333333	3
59	0061	5	5	5	5	3
61	0063	5	5	3	4.333333333	3
62	0064	5	5	5	5	3.333333333
63	0065	5	3	3	3.666666667	3
64	0066	1	1	3	1.666666667	3.333333333
65	0067	5	3	3	3.666666667	3.666666667
66	0068	1	1	3	1.666666667	3.333333333
68	0070	0	0	1	0.333333333	3.333333333

69	0071	1	1	3	1.666666667	1
70	0072	1	1	1	1	3.333333333
71	0073	5	0	0	1.666666667	3
73	0075	1	0	0	0.333333333	1
74	0076	0	0	0	0	3
75	0077	1	1	5	2.333333333	4
79	0081	1	0	0	0.333333333	1.333333333
80	0082	3	3	3	3	3
82	0084	1	1	1	1	3.333333333
83	0085	1	1	1	1	3
84	0086	1	1	3	1.666666667	2.666666667
85	0087	5	5	5	5	3.666666667
87	0089	1	3	3	2.333333333	3.333333333
88	0090	1	1	1	1	5
90	0092	1	1	3	1.666666667	3.333333333
91	0093	1	1	1	1	3.666666667
93	0095	1	1	0	0.666666667	4
94	0096	1	1	1	1	0.333333333
95	0097	1	1	1	1	0.666666667
96	0098	1	1	1	1	3
97	0099	1	1	1	1	3.333333333
99	0101	1	1	1	1	3.333333333
100	0102	3	5	5	4.333333333	2.333333333
101	0103	5	3	1	3	1
102	0104	1	3	3	2.333333333	3.333333333
103	0105	5	3	3	3.666666667	2.333333333
104	0106	5	5	0	3.333333333	3.333333333
105	0107	1	1	3	1.666666667	3.333333333
106	0108	1	3	3	2.333333333	2.333333333
107	0109	1	1	1	1	3
108	0110	1	1	3	1.666666667	3
109	0111	1	3	3	2.333333333	3.333333333
110	0112	5	5	3	4.333333333	3.333333333
111	0113	5	5	3	4.333333333	3.333333333
113	0115	5	1	3	3	3.333333333
115	0117	0	0	0	0	2.666666667
116	0118	5	3	1	3	4.333333333
117	0119	5	5	3	4.333333333	3
118	0120	5	3	3	3.666666667	3
119	0121	5	3	3	3.666666667	4.333333333
120	0122	5	3	1	3	5
121	0123	5	1	3	3	5
122	0124	5	5	5	5	3.333333333
123	0125	1	1	1	1	2

125	0127	1	0	1	0.666666667	2.333333333

15.3 *Calculations used for correlation coefficients of average beach grass change and material well-being indicator impact*

```
% Calculations for correlation coefficient of average beach grass changes
% and material well-being (MWB)indicator impact as reported by survey respondents.
x=table2array(chg);         % Converting imported data for beach grass
                            % average changes into a useful array.

yfin=table2array(fin);      % Converting the imported data for MWB indicator impact into
                            % a useful array (financial situation).

alpha=0.05;
[Hchg, pchg, Wchg]= swtest(x,alpha);    % Normality test for average changes dataset
[Hfin, pfin, Wfin]= swtest(yfin,alpha);% Normality test for MWB indicator impact dataset (financial situation).
[rhofin,tvalfin,pvalfin]=spear(x,yfin);% Calculation of Spearman rank correlation coefficient of
                                        % beach grass average changes and MWB indicator (financial situation).


ypv=table2array(pv);        % Converting the imported data for MWB indicator impact into
                            % a useful array (property value).

[Hpv, ppv, Wpv]= swtest(ypv,alpha);     % Normality test for MWB indicator impact dataset (property value).
[rhopv,tvalpv,pvalpv]=spear(x,ypv);     % Calculation of Spearman rank correlation coefficient of
                                        % beach grass average changes and MWB indicator (property value).

yeb=table2array(eb);        % Converting the imported data for MWB indicator impact into
                            % a useful array (enjoyment of beach).

[Heb, peb, Web]= swtest(yeb,alpha);     % Normality test for MWB indicator impact dataset (enjoyment of beach).
[rhoeb,tvaleb,pvaleb]=spear(x,yeb);     % Calculation of Spearman rank correlation coefficient of
                                        % beach grass average changes and MWB indicator (enjoyment of beach).


yavg=table2array(avg);      % Converting the imported data for MWB impact average
                            % into a useful array.

[Havg, pavg, Wavg]= swtest(yavg,alpha);% Normality test for MWB impact average dataset
[rhoavg,tvalavg,pvalavg]=spear(x,yavg);% Calculation of Spearman rank correlation coefficient of
                                        % average beach grass change and MWB impact average.

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

15.4 *Data used for correlation coefficients of average beach grass change and material well-being indicator impact*

SURVEY #	**CODE #**	Financial Situation	Property Value	Enjoyment of Beach	MWB impact average	BG change average
PAPER 1	0001	3	3	4	3.333333333	5
PAPER 2	0002	3	3	4	3.333333333	5
2	0008	3	3	2	2.666666667	1
3	0009	3	3	3	3	3

4	0010	3	3	4	3.333333333	1
5	0011	3	4	4	3.666666667	1
7	0012	3	4	4	3.666666667	1.666666667
8	0013	3	3	3	3	3.666666667
9	0014	3	3	5	3.666666667	1.666666667
11	0016	3	4	4	3.666666667	1.666666667
12	0017	5	5	5	5	0.666666667
16	0021	3	4	5	4	1.666666667
17	0022	3	4	3	3.333333333	1.666666667
19	0024	0	0	5	1.666666667	0
22	0026	3	4	5	4	1
23	0027	3	0	3	2	3.333333333
25	0029	3	0	4	2.333333333	1.666666667
26	0030	0	0	1	0.333333333	1.333333333
28	0032	3	3	2	2.666666667	1
29	0033	3	3	4	3.333333333	1.666666667
30	0034	3	4	4	3.666666667	1
31	0035	3	3	2	2.666666667	2
35	0037	3	3	3	3	3.666666667
37	0039	4	4	4	4	3.666666667
38	0040	3	3	2	2.666666667	1
39	0041	3	3	5	3.666666667	1
40	0042	3	4	5	4	1.666666667
43	0045	3	3	4	3.333333333	1.666666667
44	0046	3	3	5	3.666666667	1
45	0047	0	0	4	1.333333333	0.666666667
46	0048	3	2	2	2.333333333	5
47	0049	3	3	2	2.666666667	1.666666667
48	0050	3	0	3	2	1
50	0052	3	4	5	4	5
51	0053	3	4	4	3.666666667	1.666666667
52	0054	3	3	3	3	2.333333333
53	0055	4	3	4	3.666666667	2.333333333
54	0056	0	0	4	1.333333333	5
55	0057	3	3	3	3	2.333333333
59	0061	3	3	3	3	5
61	0063	3	3	3	3	4.333333333
62	0064	3	3	4	3.333333333	5
63	0065	3	3	3	3	3.666666667
64	0066	3	3	4	3.333333333	1.666666667
65	0067	3	4	4	3.666666667	3.666666667
66	0068	3	3	4	3.333333333	1.666666667
68	0070	3	3	4	3.333333333	0.333333333
69	0071	0	0	3	1	1.666666667

70	0072	3	3	4	3.333333333	1
71	0073	3	3	3	3	1.666666667
73	0075	0	0	3	1	0.333333333
74	0076	3	3	3	3	0
75	0077	3	4	5	4	2.333333333
79	0081	0	0	4	1.333333333	0.333333333
80	0082	3	3	3	3	3
82	0084	3	3	4	3.333333333	1
83	0085	3	3	3	3	1
84	0086	3	3	2	2.666666667	1.666666667
85	0087	3	4	4	3.666666667	5
87	0089	3	3	4	3.333333333	2.333333333
88	0090	5	5	5	5	1
90	0092	3	3	4	3.333333333	1.666666667
91	0093	3	4	4	3.666666667	1
93	0095	3	4	5	4	0.666666667
94	0096	0	0	1	0.333333333	1
95	0097	0	0	2	0.666666667	1
96	0098	3	3	3	3	1
97	0099	3	3	4	3.333333333	1
99	0101	3	3	4	3.333333333	1
100	0102	3	0	4	2.333333333	4.333333333
101	0103	1	1	1	1	3
102	0104	3	3	4	3.333333333	2.333333333
103	0105	3	2	2	2.333333333	3.666666667
104	0106	3	3	4	3.333333333	3.333333333
105	0107	3	3	4	3.333333333	1.666666667
106	0108	2	2	3	2.333333333	2.333333333
107	0109	3	3	3	3	1
108	0110	3	3	3	3	1.666666667
109	0111	3	3	4	3.333333333	2.333333333
110	0112	3	3	4	3.333333333	4.333333333
111	0113	3	3	4	3.333333333	4.333333333
113	0115	3	3	4	3.333333333	3
115	0117	0	4	4	2.666666667	0
116	0118	5	3	5	4.333333333	3
117	0119	3	3	3	3	4.333333333
118	0120	3	3	3	3	3.666666667
119	0121	4	4	5	4.333333333	3.666666667
120	0122	5	5	5	5	3
121	0123	5	5	5	5	3
122	0124	3	3	4	3.333333333	5
123	0125	3	3	0	2	1
125	0127	3	2	2	2.333333333	0.666666667

15.5 Calculations used for correlation coefficients of beach grass change dimensions and relational well-being impact

```
% Calculations for correlation coefficient of dimensional beach grass changes
% and relational well-being (RWB)impact as reported by survey respondents.
xcov=table2array(cov);       % Converting imported data for beach grass
                             % area/extent changes into a useful array.

y=table2array(RWB);          % Converting the imported data for RWB impact into
                             % a useful array.

alpha=0.05;
[Hcov, pcov, Wcov]= swtest(xcov,alpha);% Normality test for area/extent changes dataset
[HRWB, pRWB, WRWB]= swtest(y,alpha);   % Normality test for RWB impact dataset
[rhocov,tvalcov,pvalcov]=spear(xcov,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass area/extent changes and RWB impact.


xden=table2array(den);       % Converting the imported data for beach grass density
                             % change into a useful array.

[Hden, pden, Wden]= swtest(xden,alpha);% Normality test for density changes dataset
[rhoden,tvalden,pvalden]=spear(xden,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass density change and RWB impact.

xvis=table2array(vis);       % Converting the imported data for beach grass visual health
                             % change into a useful array.

[Hvis, pvis, Wvis]= swtest(xvis,alpha);% Normality test for visual health changes dataset
[rhovis,tvalvis,pvalvis]=spear(xvis,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass visual health change and RWB impact.


xavg=table2array(avg);       % Converting the imported data for average beach grass change
                             % into a useful array.

[Havg, pavg, Wavg]= swtest(xavg,alpha);% Normality test for average beach grass changes dataset
[rhoavg,tvalavg,pvalavg]=spear(xavg,y);% Calculation of Spearman rank correlation coefficient of
                                       % average beach grass change and RWB impact.

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

15.6 Data used for correlation coefficients of beach grass change dimensions and relational well-being impact

SURVEY #	Code #	Area/extent	Density	Visual Health	Average Change Value	RWB impact average
PHONE 1	0001	5	5	5	5	3
PHONE 2	0002	5	5	5	5	2.75
2	0008	1	1	1	1	2.25
3	0009	5	1	3	3	3

4	0010	1	1	1	1	3
5	0011	1	1	1	1	3
7	0012	1	1	3	1.666666667	3.25
8	0013	3	3	5	3.666666667	3.25
9	0014	1	3	1	1.666666667	3.25
11	0016	1	1	3	1.666666667	3
12	0017	1	1	0	0.666666667	0
16	0021	1	1	3	1.666666667	4
17	0022	1	1	3	1.666666667	3
19	0024	0	0	0	0	2.75
22	0026	1	1	1	1	3.25
23	0027	5	5	0	3.333333333	3
25	0029	1	1	3	1.666666667	3
26	0030	1	0	3	1.333333333	1
28	0032	1	1	1	1	0.75
29	0033	1	1	3	1.666666667	0
30	0034	1	1	1	1	3
31	0035	0	3	3	2	2.75
35	0037	5	3	3	3.666666667	3.75
37	0039	5	3	3	3.666666667	3
38	0040	1	1	1	1	2.75
39	0041	1	1	1	1	5
40	0042	1	1	3	1.666666667	3.25
43	0045	1	1	3	1.666666667	3.25
44	0046	1	1	1	1	3
45	0047	1	1	0	0.666666667	1.75
46	0048	5	5	5	5	3
47	0049	1	1	3	1.666666667	3
48	0050	1	1	1	1	3.25
50	0052	5	5	5	5	3
51	0053	1	1	3	1.666666667	3.25
52	0054	5	1	1	2.333333333	3
53	0055	1	3	3	2.333333333	3
54	0056	5	5	5	5	0
55	0057	1	1	5	2.333333333	3
59	0061	5	5	5	5	3
61	0063	5	5	3	4.333333333	3
62	0064	5	5	5	5	3.25
63	0065	5	3	3	3.666666667	3
64	0066	1	1	3	1.666666667	3.25
65	0067	5	3	3	3.666666667	2.75
66	0068	1	1	3	1.666666667	3
68	0070	0	0	1	0.333333333	3.25
69	0071	1	1	3	1.666666667	0

70	0072	1	1	1	1	3
71	0073	5	0	0	1.666666667	3
73	0075	1	0	0	0.333333333	2.75
74	0076	0	0	0	0	3
75	0077	1	1	5	2.333333333	3.5
79	0081	1	0	0	0.333333333	3
80	0082	3	3	3	3	2.75
82	0084	1	1	1	1	3
83	0085	1	1	1	1	3.25
84	0086	1	1	3	1.666666667	2.75
85	0087	5	5	5	5	3.75
87	0089	1	3	3	2.333333333	3
88	0090	1	1	1	1	1
90	0092	1	1	3	1.666666667	3
91	0093	1	1	1	1	3
93	0095	1	1	0	0.666666667	3.5
94	0096	1	1	1	1	0
95	0097	1	1	1	1	0.5
96	0098	1	1	1	1	3
97	0099	1	1	1	1	3
99	0101	1	1	1	1	3
100	0102	3	5	5	4.333333333	1
101	0103	5	3	1	3	1
102	0104	1	3	3	2.333333333	3
103	0105	5	3	3	3.666666667	2.25
104	0106	5	5	0	3.333333333	3.25
105	0107	1	1	3	1.666666667	3.25
106	0108	1	3	3	2.333333333	3
107	0109	1	1	1	1	2.75
108	0110	1	1	3	1.666666667	3
109	0111	1	3	3	2.333333333	3.25
110	0112	5	5	3	4.333333333	3.25
111	0113	5	5	3	4.333333333	3
113	0115	5	1	3	3	3.25
115	0117	0	0	0	0	3.75
116	0118	5	3	1	3	3.5
117	0119	5	5	3	4.333333333	3
118	0120	5	3	3	3.666666667	3
119	0121	5	3	3	3.666666667	3
120	0122	5	3	1	3	3.5
121	0123	5	1	3	3	3.5
122	0124	5	5	5	5	3.25
125	0127	1	0	1	0.666666667	2.25

15.7 Calculations for correlation coefficient of average beach grass change and relational well-being indicator impact

```
% Calculations for correlation coefficient of average beach grass changes
% and relational well-being (RWB)indicator impact as reported by survey respondents.
x=table2array(chg);          % Converting imported data for beach grass
                             % average changes into a useful array.

ysop=table2array(sop);       % Converting the imported data for RWB indicator impact into
                             % a useful array (sense of place).

alpha=0.05;
[Hchg, pchg, Wchg]= swtest(x,alpha);    % Normality test for average changes dataset
[Hsop, psop, Wsop]= swtest(ysop,alpha);% Normality test for RWB indicator impact dataset (sense of place).
[rhosop,tvalsop,pvalsop]=spear(x,ysop);% Calculation of Spearman rank correlation coefficient of
                                        % beach grass average changes and RWB indicator (sense of place).


ycb=table2array(cb);         % Converting the imported data for RWB indicator impact into
                             % a useful array (community belonging).

[Hcb, pcb, Wcb]= swtest(ycb,alpha);     % Normality test for RWB indicator impact dataset (community belonging).
[rhocb,tvalcb,pvalcb]=spear(x,ycb);     % Calculation of Spearman rank correlation coefficient of
                                        % beach grass average changes and RWB indicator (community belonging).

ypca=table2array(pca);       % Converting the imported data for RWB indicator impact into
                             % a useful array (participation in community activities).

[Hpca, ppca, Wpca]= swtest(ypca,alpha);% Normality test for RWB indicator impact dataset (participation in
                                        % community activities).
[rhopca,tvalpca,pvalpca]=spear(x,ypca);% Calculation of Spearman rank correlation coefficient of
                                        % beach grass average changes and RWB indicator (participation in
                                        % community activities).
ypr=table2array(pr);         % Converting the imported data for RWB indicator impact into
                             % a useful array (personal relationships).

[Hpr, ppr, Wpr]= swtest(ypr,alpha);     % Normality test for RWB indicator impact dataset (personal relationships)
[rhopr,tvalpr,pvalpr]=spear(x,ypr);     % Calculation of Spearman rank correlation coefficient of beach grass
                                        % average changes and RWB indicator
                                        % (personal relationships).

yavg=table2array(avg);       % Converting the imported data for RWB impact average
                             % into a useful array.

[Havg, pavg, Wavg]= swtest(yavg,alpha);% Normality test for RWB impact average dataset
[rhoavg,tvalavg,pvalavg]=spear(x,yavg);% Calculation of Spearman rank correlation coefficient of
                                        % average beach grass change and RWB impact average.

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

15.8 Data used for correlation coefficient of average beach grass change and dimensional relational well-being impact

SURVEY #	CODE #	Sense of Place	Community Belonging	Participation in Community Activities	Personal Relationships	Average RWB impact	BG change average
PHONE 1	0001	4	3	2	3	3	5
PHONE 2	0002	3	3	2	3	2.75	5
2	0008	2	2	2	3	2.25	1
3	0009	3	3	3	3	3	3

4	0010	3	3	3	3	3	1
5	0011	3	3	3	3	3	1
7	0012	3	3	4	3	3.25	1.666666667
8	0013	4	3	3	3	3.25	3.666666667
9	0014	4	3	3	3	3.25	1.666666667
11	0016	3	3	3	3	3	1.666666667
12	0017	0	0	0	0	0	0.666666667
16	0021	4	3	5	4	4	1.666666667
17	0022	0	4	4	4	3	1.666666667
19	0024	4	4	0	3	2.75	0
22	0026	4	3	3	3	3.25	1
23	0027	3	3	3	3	3	3.333333333
25	0029	3	3	3	3	3	1.666666667
26	0030	4	0	0	0	1	1.333333333
28	0032	0	0	0	3	0.75	1
29	0033	0	0	0	0	0	1.666666667
30	0034	3	3	3	3	3	1
31	0035	2	3	3	3	2.75	2
32	0036	4	4	3	4	3.75	3.666666667
37	0039	4	3	2	3	3	3.666666667
38	0040	2	3	3	3	2.75	1
39	0041	5	5	5	5	5	1
40	0042	4	3	3	3	3.25	1.666666667
43	0045	4	3	3	3	3.25	1.666666667
44	0046	4	4	2	2	3	1
45	0047	2	2	3	0	1.75	0.666666667
46	0048	3	3	3	3	3	5
47	0049	3	3	3	3	3	1.666666667
48	0050	4	3	3	3	3.25	1
50	0052	3	3	3	3	3	5

51	0053	4	3	3	3	3.25	1.666666667
52	0054	3	3	3	3	3	2.333333333
53	0055	3	3	3	3	3	2.333333333
54	0056	0	0	0	0	0	5
55	0057	3	3	3	3	3	2.333333333
59	0061	3	3	3	3	3	5
61	0063	3	3	3	3	3	4.333333333
62	0064	4	3	3	3	3.25	5
63	0065	3	3	3	3	3	3.666666667
64	0066	3	3	3	4	3.25	1.666666667
65	0067	3	3	2	3	2.75	3.666666667
66	0068	3	3	3	3	3	1.666666667
68	0070	4	2	4	3	3.25	0.333333333
69	0071	0	0	0	0	0	1.666666667
70	0072	3	3	3	3	3	1
71	0073	3	3	3	3	3	1.666666667
73	0075	3	3	2	3	2.75	0.333333333
74	0076	3	3	3	3	3	0
75	0077	4	4	2	4	3.5	2.333333333
79	0081	3	3	3	3	3	0.333333333
80	0082	3	3	3	2	2.75	3
82	0084	3	3	3	3	3	1
83	0085	3	3	3	4	3.25	1
84	0086	2	3	3	3	2.75	1.666666667
85	0087	4	4	3	4	3.75	5
87	0089	3	3	3	3	3	2.333333333
88	0090	4	0	0	0	1	1
90	0092	3	3	3	3	3	1.666666667
91	0093	3	3	3	3	3	1

93	0095	4	3	4	3	3.5	0.666666667
94	0096	0	0	0	0	0	1
95	0097	1	1	0	0	0.5	1
96	0098	3	3	3	3	3	1
97	0099	3	3	3	3	3	1
99	0101	3	3	3	3	3	1
100	0102	4	0	0	0	1	4.333333333
101	0103	1	1	1	1	1	3
102	0104	3	3	3	3	3	2.333333333
103	0105	2	2	2	3	2.25	3.666666667
104	0106	3	4	3	3	3.25	3.333333333
105	0107	3	4	3	3	3.25	1.666666667
106	0108	3	3	3	3	3	2.333333333
107	0109	3	2	3	3	2.75	1
108	0110	3	3	3	3	3	1.666666667
109	0111	3	4	3	3	3.25	2.333333333
110	0112	4	3	3	3	3.25	4.333333333
111	0113	3	3	3	3	3	4.333333333
113	0115	4	3	3	3	3.25	3
115	0117	4	4	3	4	3.75	0
116	0118	5	3	3	3	3.5	3
117	0119	3	3	3	3	3	4.333333333
118	0120	3	3	3	3	3	3.666666667
119	0121	3	3	3	3	3	3.666666667
120	0122	5	3	3	3	3.5	3
121	0123	5	3	3	3	3.5	3
122	0124	4	3	3	3	3.25	5
125	0127	1	2	3	3	2.25	0.666666667

15.9 Calculations used for correlation coefficients of beach grass change dimensions and subjective well-being impact

```
% Calculations for correlation coefficient of dimensional beach grass changes
% and subjective well-being (SWB)impact as reported by survey respondents.
xcov=table2array(cov);        % Converting imported data for beach grass
                              % area/extent changes into a useful array.

y=table2array(SWB);           % Converting the imported data for SWB impact into
                              % a useful array.

alpha=0.05;
[Hcov, pcov, Wcov]= swtest(xcov,alpha);% Normality test for area/extent changes dataset
[HSWB, pSWB, WSWB]= swtest(y,alpha);   % Normality test for SWB impact dataset
[rhocov,tvalcov,pvalcov]=spear(xcov,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass area/extent changes and SWB impact.


xden=table2array(den);        % Converting the imported data for beach grass density
                              % change into a useful array.

[Hden, pden, Wden]= swtest(xden,alpha);% Normality test for density changes dataset
[rhoden,tvalden,pvalden]=spear(xden,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass density change and SWB impact.

xvis=table2array(vis);        % Converting the imported data for beach grass visual health
                              % change into a useful array.

[Hvis, pvis, Wvis]= swtest(xvis,alpha);% Normality test for visual health changes dataset
[rhovis,tvalvis,pvalvis]=spear(xvis,y);% Calculation of Spearman rank correlation coefficient of
                                       % beach grass visual health change and SWB impact.


xavg=table2array(avg);        % Converting the imported data for average beach grass change
                              % into a useful array.

[Havg, pavg, Wavg]= swtest(xavg,alpha);% Normality test for average beach grass changes dataset
[rhoavg,tvalavg,pvalavg]=spear(xavg,y);% Calculation of Spearman rank correlation coefficient of
                                       % average beach grass change and SWB impact.

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

15.10 Data used for correlation coefficients of beach grass change dimensions and subjective well-being impact

SURVEY #	Code #	Area/extent	Density	Visual Health	Average Change Value	SWB impact average
PHONE 1	0001	5	5	5	5	3
PHONE 2	0002	5	5	5	5	3
2	0008	1	1	1	1	2.5

3	0009	5	1	3	3	3
4	0010	1	1	1	1	3
5	0011	1	1	1	1	3
7	0012	1	1	3	1.666666667	3.5
8	0013	3	3	5	3.666666667	3
9	0014	1	3	1	1.666666667	3
11	0016	1	1	3	1.666666667	3
12	0017	1	1	0	0.666666667	0
16	0021	1	1	3	1.666666667	3
17	0022	1	1	3	1.666666667	3
19	0024	0	0	0	0	4
22	0026	1	1	1	1	4
23	0027	5	5	0	3.333333333	1.5
25	0029	1	1	3	1.666666667	3
26	0030	1	0	3	1.333333333	1
28	0032	1	1	1	1	0
29	0033	1	1	3	1.666666667	0
30	0034	1	1	1	1	3
31	0035	0	3	3	2	2.5
35	0037	5	3	3	3.666666667	3.5
37	0039	5	3	3	3.666666667	4
38	0040	1	1	1	1	2.5
39	0041	1	1	1	1	5
40	0042	1	1	3	1.666666667	3.5
43	0045	1	1	3	1.666666667	4
44	0046	1	1	1	1	3
45	0047	1	1	0	0.666666667	0
46	0048	5	5	5	5	3
47	0049	1	1	3	1.666666667	2.5
48	0050	1	1	1	1	4
50	0052	5	5	5	5	3
51	0053	1	1	3	1.666666667	3.5
52	0054	5	1	1	2.333333333	3.5
53	0055	1	3	3	2.333333333	3
54	0056	5	5	5	5	2
55	0057	1	1	5	2.333333333	3
59	0061	5	5	5	5	3
61	0063	5	5	3	4.333333333	3
62	0064	5	5	5	5	3
63	0065	5	3	3	3.666666667	3
64	0066	1	1	3	1.666666667	3.5
65	0067	5	3	3	3.666666667	3
66	0068	1	1	3	1.666666667	3
68	0070	0	0	1	0.333333333	4.5

69	0071	1	1	3	1.666666667	0
70	0072	1	1	1	1	3
71	0073	5	0	0	1.666666667	3
73	0075	1	0	0	0.333333333	3
74	0076	0	0	0	0	3
75	0077	1	1	5	2.333333333	3.5
79	0081	1	0	0	0.333333333	3
80	0082	3	3	3	3	1
82	0084	1	1	1	1	3
83	0085	1	1	1	1	3
84	0086	1	1	3	1.666666667	2.5
85	0087	5	5	5	5	4
87	0089	1	3	3	2.333333333	3
88	0090	1	1	1	1	2.5
90	0092	1	1	3	1.666666667	3
91	0093	1	1	1	1	3
93	0095	1	1	0	0.666666667	4.5
94	0096	1	1	1	1	0
95	0097	1	1	1	1	2
96	0098	1	1	1	1	3.5
97	0099	1	1	1	1	3
99	0101	1	1	1	1	3
100	0102	3	5	5	4.333333333	2
101	0103	5	3	1	3	1
102	0104	1	3	3	2.333333333	3
103	0105	5	3	3	3.666666667	2.5
104	0106	5	5	0	3.333333333	3.5
105	0107	1	1	3	1.666666667	3
106	0108	1	3	3	2.333333333	2
107	0109	1	1	1	1	2.5
108	0110	1	1	3	1.666666667	3
109	0111	1	3	3	2.333333333	3.5
110	0112	5	5	3	4.333333333	3.5
111	0113	5	5	3	4.333333333	3
113	0115	5	1	3	3	3
115	0117	0	0	0	0	3.5
116	0118	5	3	1	3	5
117	0119	5	5	3	4.333333333	3
118	0120	5	3	3	3.666666667	3
119	0121	5	3	3	3.666666667	4
120	0122	5	3	1	3	5
121	0123	5	1	3	3	5
122	0124	5	5	5	5	3.5
125	0127	1	0	1	0.666666667	2

15.11 Calculations for correlation coefficient of average beach grass change and dimensional subjective well-being impact

```
% Calculations for correlation coefficient of average beach grass changes
% and subjuective well-being (SWB)indicator impact as reported by survey respondents.
x=table2array(chg);          % Converting imported data for beach grass
                             % average changes into a useful array.

yoh=table2array(oh);         % Converting the imported data for SWB indicator impact into
                             % a useful array (overall happiness).

alpha=0.05;
[Hchg, pchg, Wchg]= swtest(x,alpha);   % Normality test for average changes dataset
[Hoh, poh, Woh]= swtest(yoh,alpha);    % Normality test for SWB indicator impact dataset (overall happiness).
[rhooh,tvaloh,pvaloh]=spear(x,yoh);    % Calculation of Spearman rank correlation coefficient of
                                       % beach grass average changes and SWB indicator (overall happiness).


yss=table2array(ss);         % Converting the imported data for SWB indicator impact into
                             % a useful array (safety and security).

[Hss, pss, Wss]= swtest(yss,alpha);    % Normality test for SWB indicator impact dataset (safety and security).
[rhoss,tvalss,pvalss]=spear(x,yss);    % Calculation of Spearman rank correlation coefficient of
                                       % beach grass average changes and SWB indicator (safety and security).


yavg=table2array(avg);       % Converting the imported data for SWB impact average
                             % into a useful array.

[Havg, pavg, Wavg]= swtest(yavg,alpha);% Normality test for SWB impact average dataset
[rhoavg,tvalavg,pvalavg]=spear(x,yavg);% Calculation of Spearman rank correlation coefficient of
                                       % average beach grass change and SWB impact average.

function[H, pValue, W] = swtest(x, alpha)...  % Function definition(Saida, 2014)
function [r,t,p]=spear(x,y)...                % Function definition (Leontitsis, 2002)
```

15.12 Data used for correlation coefficient of average beach grass change and dimensional subjective well-being impact

SURVEY #	**CODE #**	Overall Happiness	Safety and Security	SWB Impact Average	BG change average
PHONE 1	0001	3	3	3	5
PHONE 2	0002	3	3	3	5
2	0008	2	3	2.5	1
3	0009	3	3	3	3
4	0010	3	3	3	1
5	0011	3	3	3	1
7	0012	4	3	3.5	1.666
8	0013	3	3	3	3.666

9	0014	3	3	3	1.666
11	0016	3	3	3	1.666
12	0017	0	0	0	0.666
16	0021	3	3	3	1.666
17	0022	3	3	3	1.666
19	0024	4	4	4	0
22	0026	4	4	4	1
23	0027	0	3	1.5	3.333
25	0029	3	3	3	1.666
26	0030	2	0	1	1.333
28	0032	0	0	0	1
29	0033	0	0	0	1.666
30	0034	3	3	3	1
31	0035	3	2	2.5	2
35	0037	4	3	3.5	3.666
37	0039	4	4	4	3.666
38	0040	2	3	2.5	1
39	0041	5	5	5	1
40	0042	4	3	3.5	1.666
43	0045	4	4	4	1.666
44	0046	3	3	3	1
45	0047	0	0	0	0.666
46	0048	3	3	3	5
47	0049	2	3	2.5	1.666
48	0050	4	4	4	1
50	0052	3	3	3	5
51	0053	4	3	3.5	1.666
52	0054	3	4	3.5	2.333
53	0055	3	3	3	2.333
54	0056	4	0	2	5
55	0057	3	3	3	2.333
59	0061	3	3	3	5

61	0063	3	3	3	4.333
62	0064	3	3	3	5
63	0065	3	3	3	3.666
64	0066	4	3	3.5	1.666
65	0067	4	2	3	3.666
66	0068	3	3	3	1.666
68	0070	5	4	4.5	0.333
69	0071	0	0	0	1.666
70	0072	3	3	3	1
71	0073	3	3	3	1.666
73	0075	3	3	3	0.333
74	0076	3	3	3	0
75	0077	4	3	3.5	2.333
79	0081	3	3	3	0.333
80	0082	2	0	1	3
82	0084	3	3	3	1
83	0085	3	3	3	1
84	0086	2	3	2.5	1.666
85	0087	4	4	4	5
87	0089	3	3	3	2.333
88	0090	5	0	2.5	1
90	0092	3	3	3	1.666
91	0093	3	3	3	1
93	0095	5	4	4.5	0.666
94	0096	0	0	0	1
95	0097	2	2	2	1
96	0098	4	3	3.5	1
97	0099	3	3	3	1
99	0101	3	3	3	1
100	0102	4	0	2	4.333
101	0103	1	1	1	3
102	0104	3	3	3	2.333

103	0105	2	3	2.5	3.666
104	0106	3	4	3.5	3.333
105	0107	3	3	3	1.666
106	0108	2	2	2	2.333
107	0109	3	2	2.5	1
108	0110	3	3	3	1.666
109	0111	4	3	3.5	2.333
110	0112	3	4	3.5	4.333
111	0113	3	3	3	4.333
113	0115	3	3	3	3
115	0117	4	3	3.5	0
116	0118	5	5	5	3
117	0119	3	3	3	4.333
118	0120	3	3	3	3.666
119	0121	4	4	4	3.666
120	0122	5	5	5	3
121	0123	5	5	5	3
122	0124	4	3	3.5	5
125	0127	1	3	2	0.666

Appendix F

ORE Ethics Application System <OHRAC@uwaterloo.ca>
Thu 2018-08-02, 7:54 PM
Derek R Armitage; Prateep Nayak; +3 more

Reply all

Dear Researcher:

A Request for ethics review of a modification or amendment (ORE 104) to your ORE application:

Title: INTEGRATION OF SOCIAL WELLBEING AND ECOSYSTEM SERVICE BUNDLES FOR ADAPTIVE GOVERNANCE IN COASTAL SYSTEMS EXPERIENCING RAPID CHANGE
ORE #: 22119
Principal/Co-Investigator: Derek Armitage (derek.armitage@uwaterloo.ca)
Principal/Co-Investigator: Prateep Nayak (pnayak@uwaterloo.ca)
Principal/Co-Investigator: Graham Epstein (graham.epstein@uwaterloo.ca)
Student Investigator: Ana Carolina Estevez Diaz (ana.estevesdias@edu.uwaterloo.ca)
Student Investigator: Charlotte Hings (chings@uwaterloo.ca)

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together with a copy of relevant materials, was received in the Office of Research Ethics on:
7/24/2018 - 1) Modifications to the ongoing information letter and consent form are made to accommodate this research project in a Canadian context. 2) Add literature review. 3) Add new survey - context specific to Canadian content. 4) Change in selection criteria for the context-based survey; change in methods of recruitment as a result. 5) Add new study location - Canada. 6) Add Charlotte Hings.

The proposed modification request has been reviewed and has received full ethics clearance.

****

Note 1: This project must be conducted in accordance with the description in the application and modification for which ethics clearance has been granted. All subsequent modifications to the protocol must receive prior ethics clearance through the Office of Research Ethics.

Note 2: Researchers must submit a Progress Report on Continuing Human Research Projects (ORE Form 105) annually for all ongoing research projects. In addition, researchers must submit a Form 105 at the conclusion of the project if it continues for less than a year.

Note 3: Any events related to the procedures used that adversely affect participants must be reported immediately to the ORE using ORE Form 106.

Heather Root, PhD
Senior Manager
Office of Research Ethics
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