

PERCEPTIONS OF CLIMATE RISK AND EFFORTS TO ADAPT TO CLIMATE
CHANGE: AN EXAMPLE FOR TOURISM INDUSTRIES IN NORTHWEST MICHIGAN
USA

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Geography–Master of Science

2023

ABSTRACT

Current and projected future climate changes will threaten the tourism industry worldwide. However, little is known about perceptions of climate risk among key players in the tourism industry and the efforts they are taking to adapt to climate change. This research seeks to identify the climate change adaptation strategies and adaptive capacities of critical tourism industries in Northwest Michigan. This qualitative research 1) examines climate change projections for the region; 2) uses key informant interviews of 55 tourism managers within the region to identify the adaptation efforts for local agriculture, water, and winter-based tourism industries; 3) assesses implications and intervention options. Climate projections from the Great Lakes Integrated Sciences and Assessments (GLISA) for 2040-2060 and local industry perceptions show that changes in summer precipitation are most important for the water recreation sector, fall and summer precipitation is most crucial to the agritourism sector; and changes in average winter temperature is the winter recreation sector's greatest concern. Current adaptation efforts include altering agricultural practices, expanding the resilience of coastal formations and infrastructure, introducing and updating snowmaking technology, and using climate resilient plant varieties. Recently observed climatic change has resulted in various adverse impacts including increased erosion and invasive species decreasing yields. In response to these observed changes and potential future changes in climate, the tourism industry has applied numerous adaptation efforts that involve small-scale strategies such as increased communication and large projects involving infrastructure updates that will better position the region's tourism industry to cope with, and even benefit from climate change.

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Introduction

Michigan, known as the home of the Great Lakes (Longwoods International, 2020), offers many forms of tourism and recreation, including boating on the numerous freshwater lakes as well as skiing the glacial landforms synonymous with the state. There is an opportunity for all visitors, regardless of interest, to find an activity they will enjoy. Tourism remains one of the largest industries in the global economy, making up 10.4% of global GDP (9.2 trillion USD) and 10.6% of all employment - 334 million (WTTC, 2021). In Michigan, tourism accounts for more than 8% of all employment and nearly 26 billion dollars in revenues. In 2019, tourism contributed 6.3% of all employment and \$26.3 billion in revenues (Longwoods International, 2020). A disruption of any kind to this industry would be particularly damaging for the state's economy.

Climate change presents one potential significant disruptor that can pose various threats and can have adverse impacts on the tourism industry. Examples include coastal degradation of popular bike trails stemming from fluctuating water levels (Perkins, 2020), and a shrinking winter season resulting from an increase in average temperature that limits the profitability of winter recreation industries (Shih, et al., 2009). Numerous adaptation strategies and techniques have been utilized to mitigate the adverse impacts of climate change. However, impacts vary by tourism sub-sector. For instance, in addressing the observed and projected increases in temperature, winter tourism operators manufacture snow to make up for shortages in natural snowfall (Shih, et al., 2009). While winery operators increase their pest control efforts (Easterling, et al., 1997), and water tourism operators will increase coastal resilience efforts to prevent coastal degradation from temperature and precipitation linked to intensified fluctuations

of water levels (Perkins, 2020). This qualitative research will facilitate identification of the adaptive capacities of local tourism industries, and provide an in-depth look at tourism industries' adaptation plans and early outcomes.

0.1: Problem Statement

Most tourism spending and employment within Michigan is in the lodging and recreation sectors (Tourism Economics, 2020). In Northwest Michigan, water, agriculture, and winter-based tourism sub-sectors, with the addition of lodging and food and beverages, make up the majority of tourism spending in the region (Tourism Economics, 2020). This region is crucial to the tourism industry of the state, as it is one of the most visited areas, making up 8.4 million (16%) of the 52.4 million overnight visits in Michigan (Longwoods International, 2020). The main tourism activities at risk from a change in climate are water recreation, winery/brewery visitation, and winter recreation (Longwoods International, 2020).

The aforementioned activities are at risk as a result of damaging impacts from changes in climate. Climate change remains one of the most crucial issues to affect tourism and many other sectors adversely throughout the globe. Globally, climate change has contributed to various impacts including shortening of recreation seasons and increased costs for maintenance and tourism operations (Winkler, et al. 2014; Kovacs & Barrett, 2020; Dai, et al. 2006; Pryor, et al. 2009a). Still, as Scott et al. (2019) contend, there is significant research on climate change; however, there is a significant gap in research focused on the tourism industry's relationship with a changing climate. This situation is occurring in Michigan as well, as most of the research and public discourse surrounding climate change has been on the agricultural sector and the

hydrosphere (Winkler, et al. 2014; Kovacs & Barrett, 2020). The fundamental works informing this research include Winkler et al.'s 2019 report titled "Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment," and Kovacs & Barrett's 2020 work "Michigan Climate Assessment 2019: Considering Michigan's Future in A Changing Climate." In North America, there has been some work involving climate change assessments on tourism areas, but such work has largely been focused on urban areas such as Boston and New York City (Runsten, 2018). Given that, this thesis research seeks to contribute to the tourism industry's adaptation efforts by examining how changes in climate will impact tourism industries in the Northwest of Michigan, as well as identifying the methods currently being employed to address such changes. This is of importance as there is a need to identify and prioritize climate hazards and risks to guide adaptation planning and increase the resilience of this constantly growing portion of Michigan's economy to adverse impacts of climate change.

0.2: Research Objectives

The goal of this research is to identify what local tourism-sector stakeholders understand about observed and projected changes in climate and the risks that they pose, and how prepared they are to adapt to climate change. This was accomplished through three research objectives:

- 1.) To synthesize the observed and projected future changes in climate for Northwest Michigan. This was done through secondary data analysis of reported observations and projections from the literature.

- 2.) To identify perceived climate impacts for the tourism industries from the observed and projected changes in climate. Local stakeholders' perceptions of changes formed the basis of this identification and allowed the impact of said change on their businesses, especially focusing on temperature and precipitation to be identified.
- 3.) To assess and identify the adaptation efforts and preparedness of local agritourism, water recreation, and winter recreation operators and stakeholders throughout Northwest Michigan.

0.3: Study Organization

In the next section, relevant previous research that contextualizes observed and projected climate change and the previously applied research processes are presented and discussed. Once these fundamental works that inform this research are discussed, the research and data analysis methods for this study are explained. Following this, climate projections for Northwest Michigan are identified and discussed, including in relation to previously identified impacts from changes in climate. Once climate projections have been identified and discussed, interview findings focused on perceptions of climate risks to the agriculture, water and winter-based tourism industry, observed climate changes, and adaptation efforts that are being implemented will be identified and explained. These results are organized by season because of its importance in capturing the disparate climate change impacts on the individual sub-industries under study, and in shaping the adaptive responses. Discussion of the findings and their implications for the industry follows, and then overall conclusions are presented.

Chapter 1: Literature Review

To adequately synthesize relevant information from the literature that provides the basis for this study, this section is organized as follows: 1) description of the projected change in climate and their benefits and vulnerabilities; 2) climate change and the tourism industry focusing on climate risks and vulnerabilities, impacts, and adaptation approaches in Michigan, the USA and around the world; and 3) a synthesis of commonly used indicators and their application to the tourism industry.

1.1: Observed Changes in Climate in the Midwest

This research focuses on impacts of climate change on the local tourism industry. Winkler, et al. (2014) identified the impacts from climate change in the Midwestern United States based on the Coupled Model Intercomparison Project (CMIP) 5 projections. Many temperature variables and patterns affect the tourism industry. Winkler, et al. (2014) indicated that temperature and weather changes can be major determinants for travel to the area. They also highlighted the skiing and snowmobiling industries as particularly vulnerable to snowfall and temperature fluctuations.

Cutter & Finch (2008) stated that the vulnerabilities to projected climate change are minor in the Midwest as compared to other regions of the country in a general sense. Agriculture remains the most vulnerable, as weather is the greatest variable affecting production (Winkler, et al. 2014; Kovacs & Barrett, 2020). Other climate-related vulnerabilities related to human health can also affect the tourism industry. For instance, changing air quality and heat transfers in urban centers can cause ill health and undermine tourism travel (Winkler, et al. 2014; Kovacs & Barrett, 2020). Various vulnerabilities from extreme weather events are important to note, as they have a

severe impact on air and surface transportation (Winkler, et al. 2014). Observed changes in climate, by no way exhaustive, are discussed below.

1.1.1: Temperature

Throughout the greater Midwest, various climate changes have already been observed. The first and one of the most important is the steady increase in average temperature since 1900 (Brohan, et al. 2006). Temperature increases affect evaporation and precipitation rates (Kovacs & Barrett, 2020). Aurer, et al. (2010) indicate that these fluctuations can allow algae and invasive species to flourish in the water. Bush, et al. (2014) state that such algal blooms can lead to beach closings from unsafe water conditions. Winkler, et al. (2014) state that temperature fluctuations and their associated weather events can undermine crop quality and yields, including those crops crucial to wine production (grapes & maple trees).

1.1.2: Growing Season

The growing season has increased throughout the last 100 years. Skaggs and Baker (1985) found that it increased by an average of 14 days from 1899 to 1992. This extension of the growing season has increased further since 1992, averaging an additional 7 days to the aforementioned period, reaching the 170-day season as opposed to the 150s of the mid-19th century (Kunkel, et al. 2003; Wanyama, et al, 2020). This is a major change in climate with potentially significant impacts on the tourism industry. Winkler, et al. (2014) noted that this lengthening of the growing season is associated with earlier last freeze dates in the spring and later first freezes in the fall. This creates greater risks of freezing, particularly to fruit crops (Winkler, et al. 2013), but also allows previously unsuitable late-maturing crops to flourish in a longer growing

season (Winkler, et al. 2014; Kovacs & Barrett, 2020). For instance, Andresen, et al. (2001) state that the increases in temperature, coupled with the increase in precipitation, have reduced the threat of drought throughout the Midwest, creating crop yield increases and more favorable growing conditions.

1.1.3: Snow Cover

Snow cover has decreased throughout the Midwest in recent years (Dyer & Mote, 2006). Dyer and Mote (2006) state that overall snowfall totals have increased, but the increase in average temperature has caused earlier spring melts (Zhang, et al. 2000). Andresen (2012) states that the decrease in snow cover has a connection to milder winter temperatures resulting in faster snowmelt (Dyer & Mote, 2006). While Michigan experiences more frequent snowstorms than elsewhere in the Midwest, with six or more snowstorms each year (Changnon, et al. 2006), these storms are most frequent in early winter, leading to earlier spring melts (Winkler, et al. 2014).

1.1.4: Precipitation

The main observed changes in precipitation in Michigan since the 1970s are increases in the frequency of extreme rainfall events; increase in overall precipitation, and in cloudiness. Winkler, et al. (2014) found that water levels are impacted by fluctuations in precipitation and temperature, and will have large impacts on any water-dependent activities. Heavy precipitation is the greatest contributor to the overall increase in annual precipitation (Kunkel, et al. 2003). Andresen (2012) explains that heavy precipitation events are associated with an increase in the number of wet days, occurring 30% more since the 1930's. Findings from Pryor, et al. (2009a) show that a majority of the Midwest's precipitation occurs in the 10 largest precipitation events, with

85% of these events occurring in the summer months, from May through September (Winkler, et al. 2014). This heavy precipitation has impacts on river levels and can lead to flooding in small rivers and urban areas where drainage is not adequate (Winkler, et al. 2014; Kovacs & Barrett, 2020). Dai, et al. (2006) also identify a 1-3% increase in cloudiness per decade throughout the 1976-2004 period in the Midwest. Winkler, et al. (2014) acknowledge this increase in cloudiness is associated with the increase in precipitation.

1.1.4: Climate Variability

Variability between seasons and annually, as well as from location to location is important, as temperature and precipitation can vary greatly from north to south and between summer and winter (Dyer & Mote, 2006). Temperature has decreased in Michigan during the summer months (Pan, et al. 2004). This has been attributed to agricultural land cover change, as the reduction of forested area increases albedo and allows for more energy to be reflected or emitted (Pan, et al. 2004). Zhang, et al. (2000) noted that the largest increase in warming is throughout the winter and early spring. In certain seasons, precipitation has also increased, with the largest increase in spring, summer, and fall (Winkler, et al. 2014). Changnon, et al. (2006) highlight the varying nature of snowfall and a north/south distribution gradient, as southern portions of the Midwest experienced decreases in snowfall while the north has had substantial increases from 1901 through 2000.

1.1.5: Summary

In summary, the impacts of climate change in Michigan stem from observed increases in average temperature, as well as the increased variability in precipitation

patterns (Winkler, et al. 2014; Kovacs & Barrett, 2020). Consequently, a focus on the vulnerabilities of specific industries is important to assess and to enhance our understanding of observed and projected climate change impacts, and these vulnerabilities are analyzed below. Projected changes in climate and their impacts on local recreation industries of Michigan's northwest region are outlined below.

1.2: Projected Climate Change Impacts on Tourism

1.2.1: Agritourism

Brewery and winery visitation comprised 30% of the total recreation activities in Northwest Michigan in 2019 (Longwoods International, 2020). Much of this visitation was to wineries, making up 17% of all activities done in 2019 (Longwoods International, 2020). More than 42 wineries are located in the Grand Traverse Bay region, with the majority of these located on Leelanau and Old Mission Peninsulas (Traversecity.com, 2021). Little Traverse Bay boasts that it is "Northern Michigan's premier wine region," hosting 14 wineries (Petoskey.wine.com, 2021). Together these areas make up the majority of the 2,760-square-mile wine region located in the northern Lower Peninsula of Michigan, called the Tip of the Mitt American Viticultural Area (AVA) (Petoskey.wine.com, 2021). In this AVA, hybrid breeds of grapes are required due to the cold temperatures of the region, leading to the unique flavors and aromas for which the area is known (Wanyama, et al, 2020).

The region's viticulture industry is continually growing from its core area into Little Traverse Bay, which established wineries recently in 2016 (Petoskey.wine.com, 2021). The industry in Northwest Michigan is quite successful, despite being ranked lower (earning a medium to medium-high ranking) on suitability for viticulture than southern

Michigan (Wanyama, et al, 2020). The region is more suitable to white wine varieties than red (Wanyama, et al., 2020). The Leelanau and Old Mission peninsulas have the highest suitability in the region, comparable to the areas along the southwest shore of Lake Michigan (Wanyama, et al., 2020). The Michigan rotational fruit survey for 2014-2015 estimated that the northwest portion of the state contains over 86% of all the grape agriculture within the state, with the majority of that being in wine grapes (USDA, 2015).

Observed and predicted climate change is likely to increase the vulnerabilities of the viticulture industry, stemming mainly from the increase in temperature and precipitation (Andresen, et al. 2001; Winkler, et al. 2014). Easterling, et al. (1997) state that the increase in temperature will bring a heightened risk for disease and pest infestations for all agriculture. Winkler, et al. (2013) identify a heightened risk of freezing temperatures with the increase in growing season and weather variation.

The agritourism industry can also encounter various benefits from climate change, showing that not all impacts are negative. The greatest benefit will be in the extension of the growing season. Findings by Kunkel, et al. (2003) indicate that the growing season has advanced to over 170 days from 150 days in the 1950s. The associated increase in days with above freezing temperatures allows for crops that were unsuitable to be planted, as well as a greater chance to increase yields across the agriculture industry (Wanyama, et al. 2020; Winkler, et al. 2014). Further supporting the agritourism industry, warmer temperatures make for a more welcoming climate to those seeking warm weather (Winkler, et al. 2014; Sottini, et al. 2021).

1.2.2: Water Recreation

Water-based recreation activities are of particular importance to Northwest Michigan. In 2019, waterfront visitation represented 25% of all visitor activities within the region, with watercraft recreation making up 11% (Longwoods International, 2020). Grand Traverse Bay contains countless beaches, campgrounds, and waterfront parks. The majority of the coastal tourism occurs at Traverse City State Park, and the various private beaches along the coast (Allan, et al., 2015).

Water level fluctuations are considered to impact all associated recreation activities (Lofgren, et al., 2002; Winkler, et al., 2014). As Bush, et al. (2014) observe, beachfronts could be closed due to unsafe conditions such as unstable coastal formations (Lee, et al. 2012). Water level changes will have immense impacts on coastal areas, as fluctuating water levels threaten many coastal communities from an increase in erosion (Abdel-Fattah, et al. 2014; De Loë, 2001; Winkler, et al. 2014). There is also the risk of flooding from the increase in heavy precipitation events, particularly along river ways and low-lying areas (Winkler, et al. 2014). Dai, et al. (2006) specify that an increase in cloudiness will bring an increase in precipitation, which can have a negative impact on water recreation, as sunny clear days can be the most popular days to recreate near or in water. The main positive impacts to water recreation come from increases in temperature (Winkler, et al., 2014; Kovacs & Barrett, 2020), making the climate overall more welcoming to those seeking a day of water recreation.

1.2.3: Winter Recreation

Winter recreation makes up a significant portion of lodging expenditures, with much of this associated with large ski resorts (Longwoods International, 2020). The two

largest ski resorts in Michigan are Boyne Highlands and Boyne Mountain; both are located in the areas surrounding Little Traverse Bay (Boynemountain.com, 2021). Each resort contains a vertical change over 500 feet, with over 400 skiable acres boasting 115 trails across the two resorts (Boynemountain.com, 2021).

The skiing industry is particularly vulnerable to climate change. As noted in earlier research, the most extensive impacts will come from temperature increases (Shih, et al, 2009; Knowles, 2019). Zhang, et al. (2000) have found that the greatest warming occurred in winter months, which is especially damaging for an industry that has its main business period during the winter. Andresen (2012) explains how decreases in snow cover leads to earlier melt periods through greater solar radiation absorption by the surface, further exacerbating winter warming. Winkler, et al. (2014) found that the majority of snowfall in Michigan occurs in early winter, making the area more susceptible to early winter season melt periods. The impact of these changes is said to be of greatest concern in continental climates (Shih, et al, 2009). This agrees with Dyer and Mote's (2006) observations that snowfall has increased, but the accompanying increase in temperature offsets the snowfall, leading to shorter winters. This will be particularly damaging, as it will shorten the operating seasons of the skiing industry.

Now that the impacts of climate change on various recreation types have been identified, a brief review of indicator sources and previously utilized methods, and survey techniques to gauge a stakeholders' preparedness to climate changes are presented. This review informed development of the survey instruments used to seek views of the tourism industry.

1.3: Considerations, Processes and Indicators for Assessing Climate Adaptation

Given the rather recent rise in importance of climate change awareness and adaptation, there is an increased acknowledgment of impact identification as a necessary precursor for developing adaptation strategies (Runsten, 2018). However, there is broad acknowledgement of the difficulty of how to assess risk, as well as how to gauge success of adaptation strategies. A process that has been utilized before for vulnerability identification focuses on a change in means and a change in extremes (IPCC, 2007). As Zhang, et al. (2008) explained, a change in means stems from changes in precipitation, temperature, and water level, and can be more manageable (Zhang, et al., 2008; IPCC, 2007). A change in extremes will focus on storm surge, extreme rainfall, riverine floods, heat or cold waves, and drought, which present diverse management challenges (Zhang, et al., 2008; IPCC, 2007).

Economic risks also stem from changes in climate. Roger (2004) attributes these to economic system changes and monetary interaction changes, such as the way people spend money and what they purchase. This can occur when consumers' preferences are influenced by their perceptions of climate change and their contribution to it (Runsten, 2018). Multiple indicators focus on risk to property and businesses as markers of adaptation to climate change for the purpose of judging success, as well as various indicators for preparedness efforts (EPA, 2017).

Assessing preparedness for adaptation and impacts of adaptation efforts is also a complex process, and there is no single method or aggregate measure for assessing preparedness. The global climate change community is now grappling with the methodological challenges of measuring impacts of the adaptation efforts and projects

in order to assess the adequacy and effectiveness of adaptation and support under the global stock take (GST) of the 2016 Paris Agreement (Owen, 2020). The next section below, describes some processes and indicators for assessing impacts of adaptation, many of which are qualitative and were incorporated into our questionnaire.

1.3.1: Indicators for Tourism Adaptation

Considerations of indicators for the agritourism sector address such issues as condition degradation, preventive efforts, and economic disruptions. Assessment of condition degradation for agritourism includes indicators or perceptions stemming from crop disease and pest issues (Winkler, et al. 2014), changes in precipitation rates (ND-GAIN, 2018), and temperature fluctuations (ND-GAIN, 2018). To gauge preparedness for preventive efforts, indicators include levels of available funding (ND-GAIN, 2018), planning (ARUP, 2016), and infrastructure/property preparation (ARUP, 2016). This thesis research collected information at a qualitative level. Indicators for economic disruption include business interruptions (ARUP, 2016), economic loss (ND-GAIN, 2018), and planning (ARUP, 2016). Stakeholder views and perceptions on these were gathered during interviews.

Indicators for water recreation are mostly process based (operator's current operation system), and stem from adaptive capabilities, condition degradation, and economic disruptions. In regard to adaptive capabilities, the indicators focus on assessment efforts (EPA, 2017), funding (ND-GAIN, 2018), and planning (ARUP, 2016). To gather information on condition degradation, we collected stakeholder perceptions and actions mainly on coastal erosion or water issues, focusing on observed precipitation rates or trends (as in ND-GAIN, 2018), maintenance routines (ARUP,

2016), and water quality issues (EPA, 2017). In regard to economic disruptions the indicators vary, and include infrastructure degradation (ND-GAIN, 2018) as well as planning efforts (ARUP, 2016).

The types of indicators that make sense for the winter recreation sector also include adaptive capabilities, condition degradation, and economic disruptions. Available technology can indicate adaptive capabilities (ND-GAIN, 2018), as can funding (ND-GAIN, 2018) and planning (ARUP, 2016). Precipitation rates and trends can shed light on condition degradation (EPA, 2017), along with temperature fluctuations (ND-GAIN, 2018) and planning efforts (ARUP, 2016). For this research, the survey included questions on economic disruptions focused on planning efforts (ARUP, 2016), property degradation (ND-GAIN, 2018), and technological disruption (ND-GAIN, 2018).

In summary, the process of assessing the preparedness of the tourism industry can be complex and requires a plethora of indicators. However, for this exploratory study, we selected some indicators on which to seek views of the tourism industry through interviews to assess their climate impacts and adaptation efforts. Some of the indicators can then be used in future studies to assess impacts of their adaptation efforts.

Chapter 2: Methods

This qualitative research used a mixed methods approach focused on in-depth survey interviews supported by secondary data analysis. A mixed methods approach uses different sources of information to address the issues and questions from different perspectives, and therefore provides a more holistic picture of local stakeholders' understanding of climate risks and their preparedness to address them. This research used the following methods to address each of the three study objectives, summarized as follows, but described in further detail below:

- 1.) Objective 1, secondary data analysis: climate changes in the study region were identified utilizing past observations and future projections as described in Chapter 1.
- 2.) Objective 2, secondary data analysis and survey interviews: impacts identified by respondents were categorized based upon location, industry, and projected changes.
- 3.) Objective 3, survey interviews: in-depth interviews were conducted with stakeholders in the private and public sectors to gauge preparedness to adapt or increase resilience to the projected impacts of climate change.

2.1: Study Sites & Background

Northwest Michigan includes 10 counties: Antrim, Benzie, Charlevoix, Emmett, Grand Traverse, Kalkaska, Leelanau, Manistee, Missaukee, and Wexford. A map of the counties is shown in the region labeled 2, as well as its relation to Michigan is provided in Figure 1 below. The main tourism areas are the areas surrounding Grand Traverse

Bay and Little Traverse Bay. These areas are described in detail below, and their crucial tourism industries will be identified.

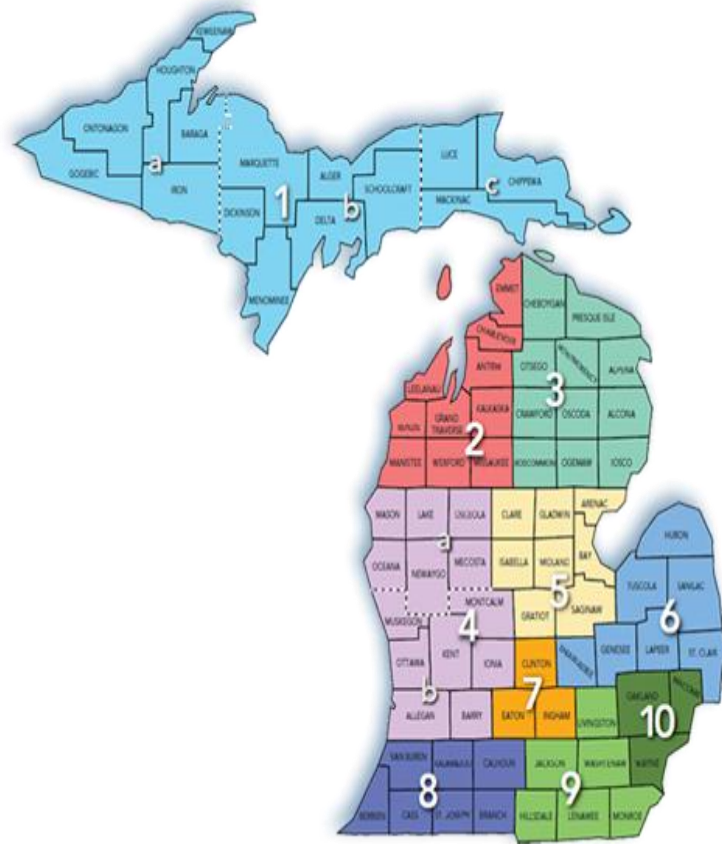


Figure 1: Michigan regions as defined by Michigan Economic Development Commission

2.1.1: Grand Traverse Bay

The Grand Traverse Bay area incorporates the counties Antrim, Grand Traverse, and Leelanau; with Antrim and Grand Traverse forming the main area visited by tourists. The makeup of the area is unique, containing access to more than five different bodies of water, the most popular of which are the East & West Arm of Grand Traverse Bay. The other bodies of water accessible are Elk Lake, Lake Leelanau, Lake Michigan, and Torch Lake. Furthermore, isthmuses and peninsulas, such as Old Mission

Peninsula provide attractive natural features. The predominant industries to the area are agritourism, water recreation, and winter recreation, and all have benefited from the geographic characteristics of the area.

2.1.2: Little Traverse Bay

While the main tourism industries are the same for the Little Traverse Bay area, it is a smaller area geographically, containing only two counties, Charlevoix and Emmett. Although smaller, the area boasts access to countless bodies of water, with the most popular being Burt Lake, Lake Charlevoix, Little Traverse Bay, and Walloon Lake. These water sources are surrounded by various moraines and rolling hills. These natural features contribute to its draw as a nature-based tourism destination.

2.2: Data Collection Methods

To adequately conduct this research, a mixed-methods approach was used. These combine key-informant interviews (perceptions on risk, impacts and adaptation efforts) and secondary data analysis (mainly for climate change trends and projections and literature review).

2.2.1: Climate Projections

The first guiding research question is “What are the projected changes in precipitation, and in temperature? ” To address this, we follow the projection process used by Kovacs & Barrett (2020). Kovacs & Barrett (2020) utilize projections from Great Lakes Integrated Sciences and Assessments (GLISA) that are provided at a spatially coarse 25 km resolution based on RCP 8.5 (Representative Concentration Pathway) for the 2040 - 2070 and 2071 - 2099 period. RCP 8.5 assumes continuous increase in greenhouse gas emissions, and is the highest or worst-case scenario in carbon

emissions among the four RCP types. For this research, we focused our analysis of the GLISA projections on the study region, with a focus on changes in precipitation and temperature. The projections utilized in this research were based on the mid-century period (2040 - 2059) for application purposes. The data for the Midwest was accessed through the GLISA website, (<https://glisa.umich.edu/summary-climate-information/>). These projections form the basis for identifying vulnerabilities and potential impacts for Northwest Michigan. However, it is important to note that at the spatial scales of the data, much detail and variability in projected climate across space is lost.

2.2.2: Sampling

To provide an accurate view of the current situation from climate change in Northwest Michigan, effective sampling must be done. To accomplish this, a stratified sampling approach was applied. This was done through first focusing on the NW region, then looking at the most visited areas (Grand & Little Traverse Bay), then finally by recreation type. We used three main strategies to identify potential subjects to sample and a sufficient sample pool for each sub-industry. These were Google searches, information from tourism bureau offerings, and snowball sampling by word of mouth from people we spoke with. Simple Google searches included keyword phrases such as "Skiing in Northern Michigan" or "Fun Summer Things in Northern Michigan." These searches were done to find organizations that might not be advertised well by local communities. Online tourism bureau offerings were the main initial sources for identifying potential respondents, and was done through accessing websites such as petoskeyarea.com and traversecity.com. We supplemented the two main sources of information for potential respondents with snowball sampling of tourism operators while

the study was underway. Through these three approaches, more than 100 organizations were identified as potential respondents.

2.2.3: Respondent Identification

Identification of adaptation efforts and strategies relied upon interviews with stakeholders associated with agritourism, water recreation, and winter recreation activities. Once potential organizations were identified, participant recruitment began. These potential interviewees were chosen based on their importance (economic & production) and representativeness of the region's tourism industry. Importance was based on numerous factors such as location, market share, industry type, size, and representative balance. To enhance representativeness, we incorporated a sample pool with diverse recreation experiences and offerings to provide a wholesome view of perceptions of climate change impacts and adaptation capabilities in the study area. This respondent pool formed the basis for this qualitative research.

Once potential respondents were identified, participation solicitation was conducted using two methods, email and over-the-phone solicitation. A combination of these methods was used depending on available information and responsiveness to first contact. Given this, response time to contact varied by respondent from one week to four months and resulted in staggered interview periods within the tourism sub-sectors. The interview process was designed to be flexible. This solicitation process is outlined in Appendix 1: Standard Operating Procedure.

2.2.3.1: Agritourism

Agritourism-related stakeholders were drawn from the private sector, given the nature of the agriculture industry. Throughout Northwest Michigan, there are countless agriculture-related tourism experiences, including corn mazes and vineyard tours. This respondent pool comprised 24 stakeholders from organizations such as family farms, sugar bushes, and vineyards of varying size. The breakdown of the total 24 respondents that participated in the study was a fair split between geographic areas, with 12 from Grand Traverse Bay and 12 from Little Traverse Bay. The agritourism respondents interviewed can be categorized into two groups: winery and vineyards, and family farms. Winery and vineyards respondents were focused on viticulture (grapes). Their organizations ranged in size from those producing small wine vintages with 14 acres to mass producers farming 150 acres. The majority of respondents are categorized under winery and vineyards, making up twenty-one of the twenty-four respondents. Those categorized as family farms incorporate diverse agriculture businesses, including orchards, organic farms and sugar bushes, and were of variable sizes ranging up to over 100 acres.

2.2.3.2: Water Recreation

As for water recreation, stakeholders were drawn from both the private and public sector from Grand Traverse Bay and Little Traverse bay areas, as well as the surrounding areas to a lesser degree, resulting in a respondent pool of 23. The respondents were stakeholders drawn from the private sector representing sub-sectors such as conservation, fishing charters, and watercraft rental. In contrast, recreation area managers at the local, state, and federal scale represented those drawn from the public

sector. Of the water recreation respondents, 10 were drawn from Grand Traverse Bay and 13 were from Little Traverse Bay. Those interviewed can be broken down into three categories by organizational focus: Waterfront and Marina Managers (18); Visitor Accommodation (2), mainly Charters and Rentals; Conservation and Preservation (3).

2.2.3.3: Winter Recreation

Finally, winter recreation stakeholders had the smallest sub-sample size of 15, and only nine respondents were interviewed. Among those interviewed, four were drawn from Grand Traverse Bay and five were from Little Traverse Bay. The respondents were broken into two categories, public winter recreation managers (4) and private winter recreation managers (5). The five representatives from the private sector were mainly from large winter resorts, whereas the four stakeholders from the public sector were associated with public goods, such as snowmobile paths and recreation areas.

In summary, the number of respondents selected for each of the three sub-sectors was sufficient to draw some generalizations about adaptation measures and climatic change impacts on the tourism industry sub-sectors. The interview process was done until we obtained saturation of new information added by additional respondents, and depending on availability of respondents and on unavoidable logistical challenges. These various respondents provided crucial information to facilitate the analysis that occurred following the interview process.

2.2.4: Interview Process

Once respondents were identified, interviews were done to collect the data, during the period of July 2022 to February 2023. The interview involved 32 open-ended

questions that were asked to all respondents. The interview process ranged in length from 30 minutes to one hour, and varied depending on the speed and depth of responses given.

2.2.4.1: Instruments

The study instruments used were approved by the Michigan State University Institutional Review Board, and include provisions for secure and confidential data collection and storage, as well as interview facilitation. The survey instrument sought various information including respondent background information, and questions on diverse aspects of perceived climate change risk, impacts, and adaptation efforts. Together these instruments helped to paint a holistic picture of the current situation being experienced.

Social Survey

A qualitative social survey was the primary research method to collect field data from main tourism stakeholders, including operators in the targeted sub-sectors, and tourism community planners. The survey questionnaire is structured in format and contains both open ended and closed questions that help to address three core research questions:

- 1.) What are the main climate risks to your tourism business and the tourism sector in your area?
- 2.) How are you or the local tourism industry adapting to observed and projected changes in climate?
- 3.) How effective have the measures taken been or are likely to be?

The survey questionnaire had 32 questions that were asked to all respondents, allowing standardization across respondents and recreation type. The survey's questions were mostly drawn from relevant city-oriented assessments indicators of adaptation to climate change selected from the literature to gauge the various stakeholders' adaptation activities (see details in Appendix 3 for the survey instrument).

Informed Consent

Before beginning each interview session, informed consent was received both verbally and written through an IRB approved consent form. A copy of this form is found in Appendix 2. This form ensured a consistent understanding amongst participants with regard to their rights and the conditions of the study. This form also outlined the basis of the study and reinforced what aspects were of interest to this research.

2.2.4.2: Data Collection

While each interview was underway, responses were recorded through an audio collection device. This device was positioned in an optimal location to record responses, alleviating issues such as volume change and signal interference. This device allowed future transcription for analysis. The recorded responses were kept on a password protected hard drive to ensure confidentiality and security.

To facilitate open discussion and response collection, characteristics of the site for conducting interviews was important. To minimize respondent discomfort and bias, respondents were given the choice of interview location, both when in-person and over the telephone. The optimal location was on facility premises or at the office of the respondent. This helped the respondents illustrate their answers through showing interventions on the ground, and allowed the interviewee the chance to observe some of

the interventions that provided contextualization. However, this setting was not always possible, which resulted in alternate interview locations. To help choose a location, respondents were informed that a quiet environment with minimal disruptions was most important. When executing over-the-phone interviews, quiet surroundings were crucial for both interviewer and interviewee.

During each interview, a common practice was employed if there were any interruptions. This practice took two forms, either a brief pause or rescheduling the interview. The active interview process was designed to be flexible, in an effort to best suit respondent needs and conditions.

2.3: Data Analysis

Interview data was analyzed to identify trends in climatic change impacts and adaptation efforts of the respondents. This was done to adequately convey the current situation faced by local tourism industries. The main form of analysis was qualitative, as this best allowed identification of current themes and trends from interview results.

2.3.1: Climate Projections

After climate projections were acquired from GLISA, secondary data analysis was done through identification, description and summarization of projections relevant for Northwest Michigan. The projections were used to describe expected changes in climate for Northwest Michigan. The climate variables used were growing season length, heavy precipitation events of more than one-inch, total precipitation by season, and average temperature by season. The scale of change for the projections was different for each variable, but does allow comparison across projections of similar variables. Following the secondary data analysis of climate projections, potential

impacts were based on previously identified impacts outlined in previous works. This secondary analysis of both projections and potential impacts allowed comparison to the currently observed climate changes experienced by respondents that were identified in the interview process.

2.3.2: Qualitative Data Analysis

After respondents were interviewed, their responses were transcribed. Transcription was done through a combination of both software and hand transcription. The software utilized was Otter.Ai, as that facilitated large-scale transcription. After software transcription, hand transcription was used to correct errors. These transcripts were then transferred to a Microsoft workbook where responses from all respondents within a tourism sub-sector were stored together and easily accessed and facilitated qualitative analysis through thematic coding.

After transcription, trends were established across industries and location. This was done through qualitative analysis, and drew on the thematic questions included in the questionnaire to facilitate thematic coding. The approach used was outlined by Gibbs (2007), and allowed trends to be identified for the sub-sector based on prevalence of like responses. For this research, trend identification was done through identification of themes that appeared through commonalities in responses, this ultimately allowed comparison within and across tourism industry sub-sectors. Analysis revealed the differences in risk perceptions, adaptation responses, and planning routines of management for each sub-sector. Additionally, the analysis identified different changes in climate, with variable impacts on the tourism industry sub-sectors. The research also identified the relative winners and losers in terms of climate impacts,

and the urgency with which respondents approached taking adaptive measures based on their perceptions of risk and their ability to manage it.

Chapter 3: Climate Projections for Michigan and the Greater Midwest, 2040 - 2059

In this chapter, a summarization and description of published quantitative projections of climate change contextualizes the issue of climate change in the study region in terms of the nature, extent, and spatial patterns of possible future change from already published projections. The focus is on projections of changes in temperature, precipitation, and growing season length, which are crucial but not the only climate parameters for understanding potential future changes in climate for the region with relevance to the tourism industry. The qualitative portion of this research allows comparison of respondents' perceptions of climate change to climate projections from the Great Lakes Integrated Sciences and Assessments (GLISA) for 2040-2059. Following the review of climate projections, expected trends of change are compared with potential impacts on the nature-based tourism industry identified through the literature review.

3.1: Average Temperature

3.1.1: Average Summer Temperature

Average summer temperatures and changes thereof are an important consideration for tourism. As shown in Figure 2, substantial increases in average summer temperature are projected by 2040 - 2059 throughout the Midwest, including Michigan. In Northwest Michigan, the projected increases in temperature range from 5.0 - 5.5 degrees Fahrenheit during summer.

Projected Change in Average Summer Temperature by Mid-Century
 Period: 2040-2059 | Higher Emissions: RCP 8.5

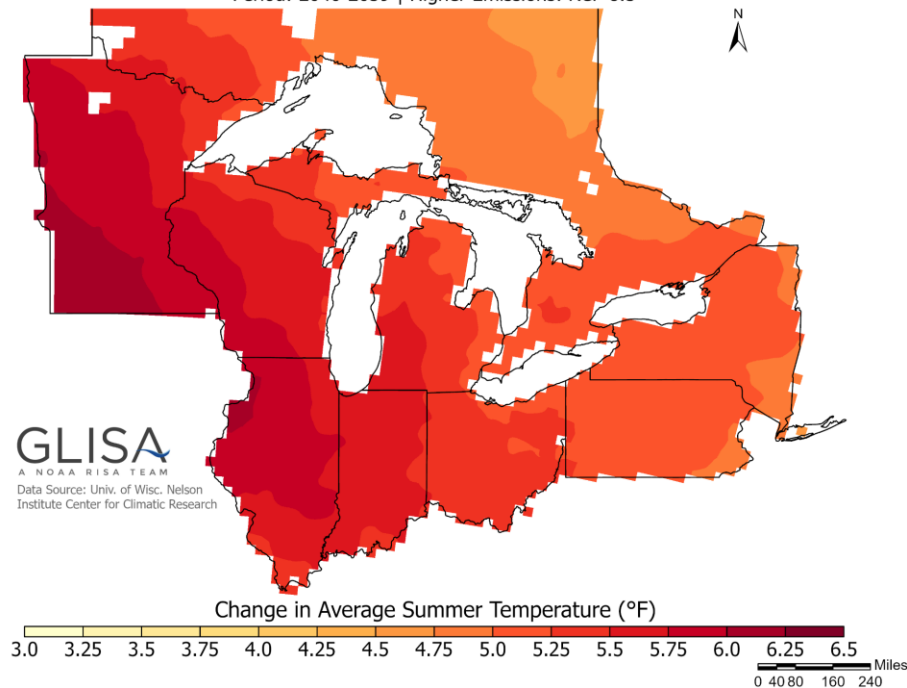


Figure 2: This figure shows average summer temperature for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.1.2: Average Autumn Temperatures

Changes in average autumn temperature for the region are presented in Figure

3. The rate of temperature increase projected is very high and similar throughout the Midwest and Michigan. For Northwest Michigan, average autumn temperature is expected to increase by 3.75 - 4.5 degrees by the 2040 - 2059 period. The projected mean temperature increases for the Northwest are nearly uniform to those across Michigan.

Projected Change in Average Autumn Temperature by Mid-Century
Period: 2040-2059 | Higher Emissions: RCP 8.5

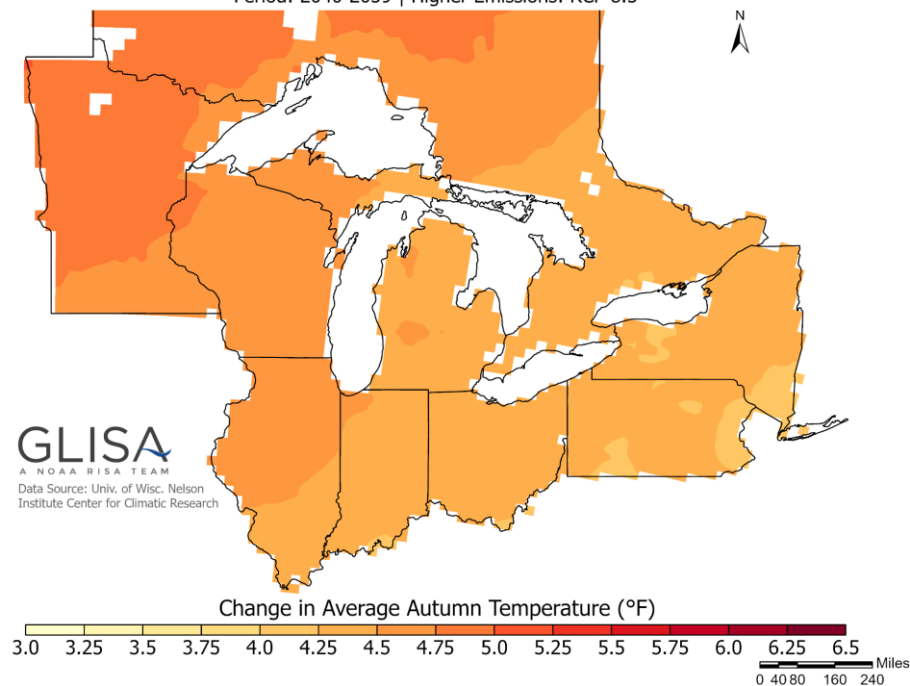


Figure 3: This figure shows average autumn temperature for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.1.3: Average Winter Temperature

The winter recreation sub-sector is dependent on having below freezing temperatures to sustain snow as well as manufacture their own. The projected changes of average winter temperature are presented in Figure 4. Northwest Michigan is projected to experience a very high but slightly lower increase in temperature than in autumn, ranging from 3.0 - 3.75 degrees. While this is the smaller projected temperature increase compared to the projected increases in summer and fall, there could be impacts for activities reliant on below freezing temperatures.

Projected Change in Average Winter Temperature by Mid-Century
 Period: 2040-2059 | Higher Emissions: RCP 8.5

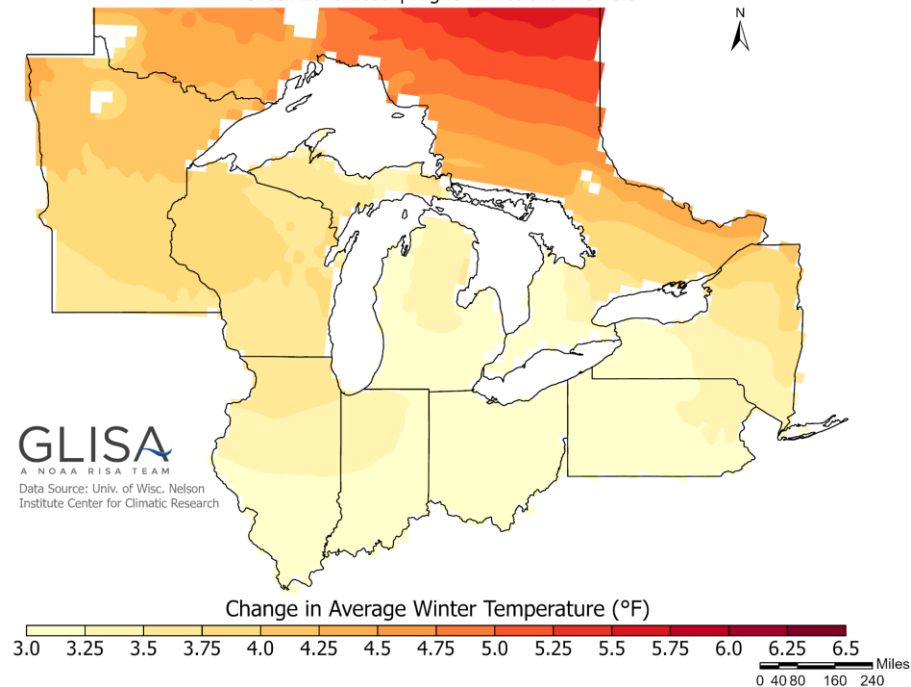


Figure 4: This figure shows average winter temperature for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.2: Total Precipitation Change

3.2.1: Total Summer Precipitation

Precipitation tends to be more variable and harder to project reliably into the future compared to temperature, and projected changes are mixed across spatial and temporal scales. In considering potential climate change impacts on water, agro-based and winter recreation sectors of tourism, all forms of precipitation are included in considering the published climate projection for the region – hail, rain, sleet, and snow). However, Northwest Michigan is projected to experience a decrease in total summer precipitation of 1 inch by the 2040 - 2059 period (see Figure 5). Some areas in the

Northwest region are projected to see an increase in precipitation, following the trends projected for Michigan. This change will result in variable impacts, and is to be discussed in subsequent sections in relation to what the impacts of the projected changes might be.

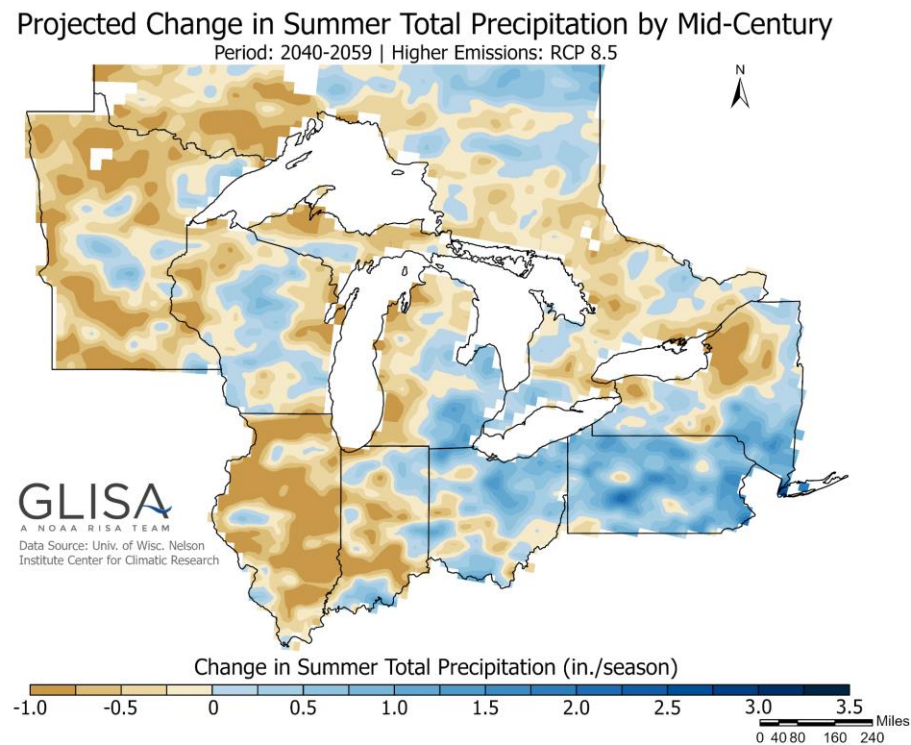


Figure 5: This figure shows total summer precipitation change for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.2.2: Total Autumn Precipitation

Slight increases in autumn precipitation are projected in isolated locations throughout Northwest Michigan, mainly being in Leelanau County. These increases may be up to 1 inch by 2040 - 2059. However, the projected general trend for the region's autumn precipitation is a decrease of up to 1 inch by the mid-century period. While the

projected change might appear small, the impacts could be significant, as discussed below. Trends in projected total autumn precipitation are presented in Figure 6.

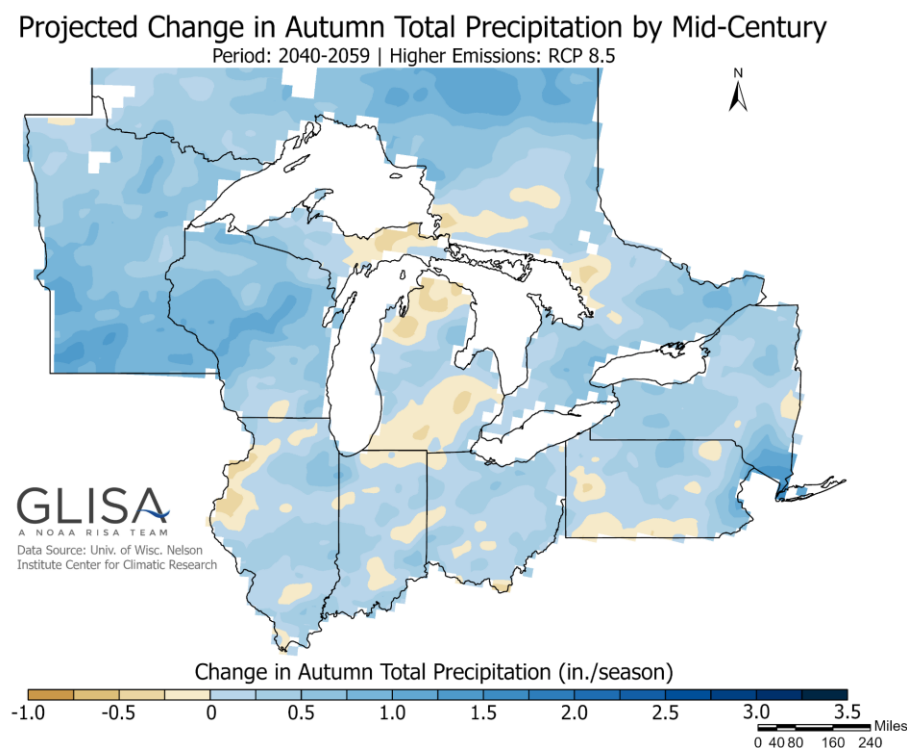


Figure 6: This figure shows total autumn precipitation change for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.2.3: Total Winter Precipitation

All of Michigan is projected to experience increases in winter precipitation; however, the northwest region is projected to experience a greater increase than the northwest, which may be attributed to lake effect precipitation. Projected trends for total winter precipitation are presented in Figure 7, and Northwest Michigan can expect an increase ranging from 0.05 to 1.5 inches by the mid-century period. While precipitation amounts are important, precipitation form is most important during the winter season and are discussed along with other potential impacts in later sections.

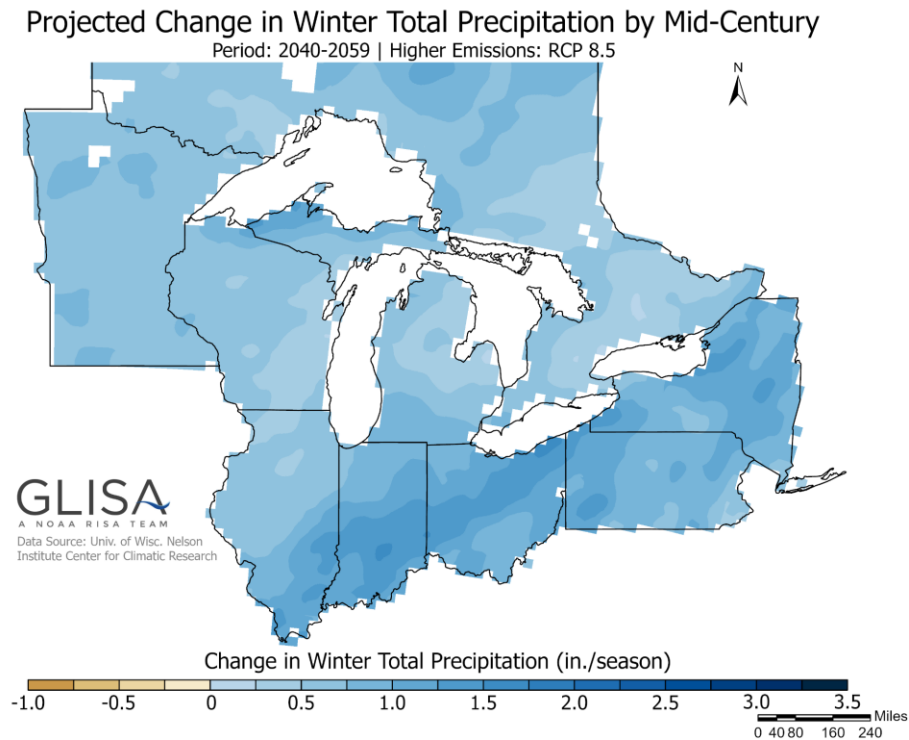


Figure 7: This figure shows total winter precipitation change for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.2.4: Heavy Precipitation Days

Northwest Michigan is projected to experience slight increases in the number of days with more than 1 inch of precipitation if any, by 2040 - 2059. The increases will range from 0.5 to 1 more day per year. Some areas within Michigan are projected to see slight decreases; however, these areas are small, only projected to experience a decrease of only 0.5 days per year.

Projected Change in Days with over 1" Precipitation by Mid-Century
Period: 2040-2059 | Higher Emissions: RCP 8.5

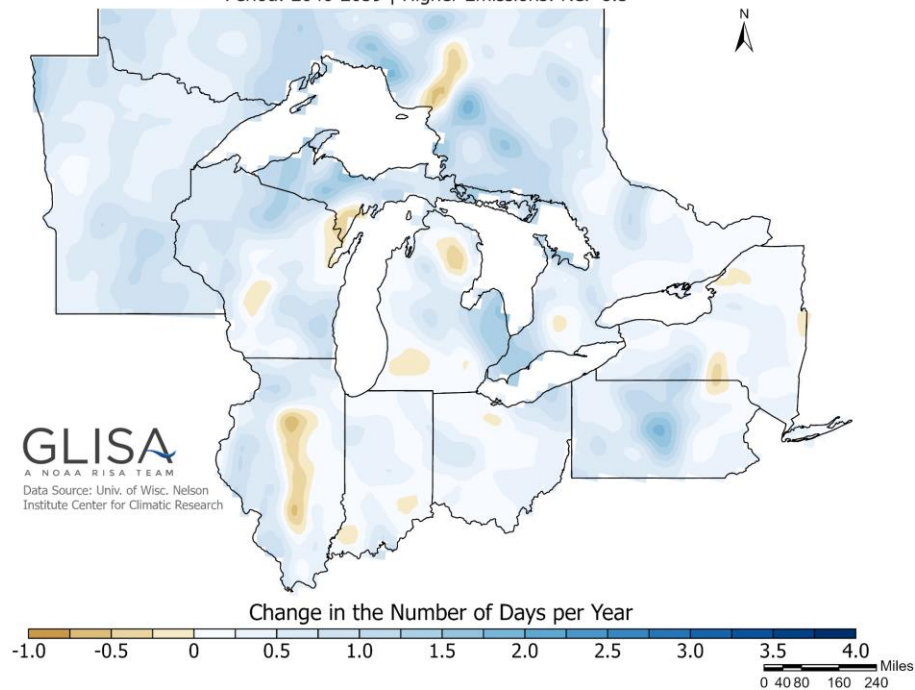


Figure 8: This figure shows change in days receiving more than 1 inch of precipitation for the Midwest region of the USA, 2040-2059. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

3.3: Growing Season Change

Growing season patterns are projected to have greater variability than temperature and precipitation changes within Northwest Michigan. The projected changes are presented in Figure 9. Generally, Northwest Michigan is projected to experience a large increase in the length of the frost-free season, ranging from 35 to 45 days. This climate change will have the greatest impact on the agricultural sector.

Projected Change in Days of the Frost-Free Season by End of Century

Period: 2080-2099 | Higher Emissions: RCP 8.5

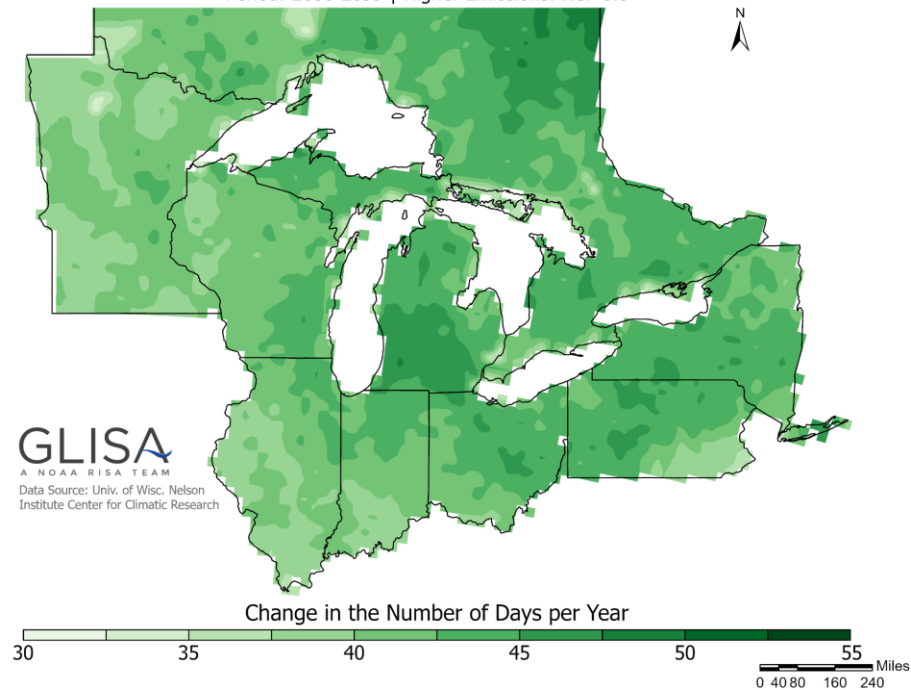


Figure 9: This figure shows change in days during frost-free season for the Midwest region of the USA, 2050-2099. Regional maps were produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research

Chapter 4: Projected Impacts of Climate Change on Tourism

The projected changes in climate previously described are expected to result in various impacts and have significant implications on the tourism industry. This section explains the potential impacts that could be expected from the projected changes in climate based upon previously identified impacts of climate change in the literature.

4.1: Potential Impacts of Temperature Changes

Changes in temperature may have large impacts for each season and associated tourism industry. The increase in average summer temperature could contribute to more frequent algal blooms, droughts, infestations of pests or invasive species, and tree losses (Winkler, et al., 2014; Kovacs & Barrett, 2020). Kovacs & Barrett (2020) identified serious potential impacts from projected temperature changes such as habitat loss for native species which is expected to cause large species die offs, and massive economic impacts to local communities. For example, the projected increases in fall temperature could contribute to increased tourism during autumn, and an expansion of the growing season in the study region (Kovacs & Barrett, 2020). At the same time, increased average winter temperatures will present obstacles to industries reliant on freezing temperatures for production processes (Shih, et al, 2009), such as maple syrup production, snowmaking, and snow retention. Shih, et al. (2009) identified historical cases in which up to 40% of normal revenue streams were lost due to insufficient snow making, and snow retention. A warmer winter is also impactful on maple syrup production, as it relies on temperature fluctuations above and below freezing to allow sap formation and collection (Dyer and Mote 2006).

4.2: Potential Impacts of Precipitation Changes

Changes in precipitation totals will have diverse impacts on the region, as some areas will be better suited for these impacts than others, mainly due to location characteristics and level of change. The projected decrease in summer precipitation is likely to increase the potential for crop damage and drought (Kovacs & Barrett, 2020). Kovacs & Barrett (2020) described how climate change impacts on agricultural production could negatively affect Michigan's economy as a whole. The projected decrease in total autumn precipitation could limit the risk of coastal erosion from decreased storm pressure, crop damage as a result of limited impacts from precipitation, and maintenance costs in regard to repairs. It can also potentially increase crop quality and yield for some crops, while limiting it for others (Andresen, et al., 2001; Wanyama, et al., 2020; Winkler, et al., 2014). Wanyama, et al., (2020) linked potential increases in agricultural output with increased suitability, which could lead to an expansion of planted acres. The winter season is projected to have increases in precipitation; however, the determinants of this impact will be more from the form of precipitation than amounts. While snow would be beneficial, rain could create problems with snow cover and quality consistency (Shih, et al, 2009). Shih, et al. (2009) found that rain events during busy tourism periods caused declines in visitor numbers and annual revenue for winter recreation operations.

4.2.1: Potential Impacts of Mass Precipitation Changes

The projected small increase in the number of days with more than one inch of precipitation will result in inequitable impacts, as some areas may be unaffected, while others are likely to face increased flooding and erosion. This increase could contribute

to a greater risk of coastal erosion, crop damage as a result of impacts from precipitation, and water contamination from increased wetland flush events (Abdel-Fattah, et al. 2014; De Loë, Kreutzwiser, & Moraru, 2001; Winkler, et al. 2014). De Loë, et al., (2001) identified highly variable impacts as a result of differing levels of erosion, including critical failures to certain operations such as water filtration failure or levee breaks. Given that the projected increase is one more day or less, many of the currently experienced impacts from heavy precipitation may still be experienced by the mid-century period.

4.3: Potential Impacts of Growing Season Changes

The length of the growing season is projected to undergo a large increase in Northwest Michigan. The expected main impacts of this change will be the projected increased suitability for agriculture and related recreation, which is expected to have impacts on all tourism sectors. This increased suitability may also lengthen the tourism season, as higher temperatures are more welcomed by and attractive to tourists (Kovacs & Barrett, 2020). These benefits will be felt by all tourism industries, as a longer growing season will likely increase tourism use during the autumn and spring seasons. The increased tourism visits and lengthening of the tourism season are likely to increase pressure on natural resources and complicate management issues in regard to conserving or preserving the conditions of recreation areas for the sustainability of tourism. The occurrence and timing of frost may pose a challenge for agricultural production, with variable impacts on the associated agritourism sector (Wanyama, et al., 2020). Wanyama, et al. (2020) attributed increased suitability for agriculture to the warming temperature.

Chapter 5: Interview Findings

Qualitative analysis of data collected through in-depth interviews allowed a deeper look into local perceptions and experiences of diverse tourism practitioners on what risks climate change poses, and what actions they are undertaking or plan to undertake to adapt to current and expected future climate changes. This analysis gives a realistic picture of possibilities in terms of industry preparedness under climate change, as tourism actors will base response actions on their perception of climate risk. Hence, an informed examination of perceptions of both climate risk and impacts provides a basis for assessing the potential underlying motivations that help to explain current adaptation efforts. This qualitative analysis provides insights on current and potential future preparedness of this important industry against climate change impacts. The analysis also teases out obstacles encountered or anticipated in the future and the relative importance and extent of adaptation actions, as well as highlighting promising or innovative, cost-effective strategies worth disseminating to other operators and locations.

Findings from the tourism practitioner interviews presented in this section address objectives 2 and 3 of the study: 2) Describing observed impacts for the tourism industries from changes in climate; and 3) Analyzing local agritourism, water recreation, and winter recreation industries' adaptation efforts throughout the Northwest region of Michigan. Operators and managers in the nature-based tourism industry in the region have displayed a high degree of awareness of climate risks and identified many current and expected negative impacts to their specific industry that were diverse in extent. However, the practitioners were also aware of observed and potential future benefits to

their industry arising from some climate changes. To adequately address objectives 2 and 3, and the differences across sub-sectors, our presentation of findings starts with the agritourism sector, then follows with discussion of the water and winter recreation industries.

5.1: Tourism Industry Perceptions of Climate Risks and Observed Impacts on the Tourism Industry

5.1.1: Agritourism: “More Risk, More Reward”

As shown through our description of projected (2040 – 2059) changes in the length of the growing season, the agricultural sector stands to experience variable impacts from climate change dependent on the type of agricultural enterprise. The sentiments and reported experiences of the agritourism respondents on climate risks, impacts, and successes and their concerns over adaptive responses, reflect awareness of these differential impacts. Most of the 24 respondents perceive the impacts of future climate change as being one of benefit. One respondent likened the potential beneficial situation to an “Agricultural Bubble.”

5.1.1.1: Perceptions and Concerns about Climate Change

While the operations and size of businesses varied for each respondent, their perceptions about climate change were similar. Nearly all respondents were not concerned about a change in climate and its potential impact on their industry. Respondents unanimously answered no when asked, “Do you think the impacts of climate change are a threat to your tourism business or sub-sector?” This perception was supported by various examples of current climate impacts and observed changes. Those involved with the wineries and vineyards (21) often supported their stance with

the increasing suitability for viticulture, as well as observed growing and tourism season expansion. Those involved with family farms (3) often referred to increasing yields and lengthened frost-free season as their cause for excitement. Thus, in general, there was low concern toward adverse impacts of changes as many considered the impacts to actually be positive. This perception also limited the level of adaptation efforts among the agritourism respondents.

Temperature

Agritourism respondents focused their positive sentiments on average summer temperature increases, but there was still variability in perceived impact. For example, organizations with older, more established plantings identified being well suited for the climatic changes they've experienced. Among respondents from the organizations with mature crop plantings (18), there was little concern about temperature changes. One respondent described increasing average summer temperatures as "a great benefit to the business," due to increased production and tourist visitation. Respondents from newer organizations, or those beginning operation within the last five years (6), reported more concern over currently observed summer temperature increases due to their implications on water use, as their crops do not have adequate root systems to pull groundwater. Such temperature increases can lead to crop and economic loss for such farming businesses, as one respondent stated, "We don't have the funds to purchase grapes, so a loss in (agriculture) production would affect our entire operations." This quote shows that there is some concern over potential impacts of summer temperature increases at least on the viticulture and winery industry.

The greatest concern propagates from winter temperature changes. Such concerns were crop dependent and mainly associated with freeze episodes, as a result of their intensity, timing, and duration, as well as the impact of increasing winter temperature. Nearly all respondents stated some form of potential vulnerability associated with increases in winter temperature when they were asked, “What do you see as your biggest vulnerabilities in terms of heat extremes and variability?” Many respondents (11 of 24) regardless of agricultural production type, associated their concern with their experience with the 2014 polar vortex, as that had caused immense production problems including freeze damage and minimal yields for all agriculture throughout the region. In contrast, potential fall temperature changes have caused much less concern, with no respondents mentioning it as a cause of vulnerability. Some concerns over winter temperatures were also linked to winter precipitation changes, and will be further discussed in the subsequent section.

Precipitation

Observed and projected changes in precipitation have caused far greater concern than changes in temperature. The degree of concern has varied from the differences in farms or vineyards, as those with newer plantings find themselves in a far different situation than organizations with well-established plantings. These can include fruit trees and grape vines. The observed and projected decrease in summer precipitation are welcomed as a benefit to the more established farms and vineyards. These respondents unanimously identified a special resilience among plantings due to far reaching root systems that enable them to withstand precipitation variance. This sentiment was not shared by respondents with younger plantings, as they see the

decreases in summer precipitation as a cause for great concern. Nearly all respondents (4 of 6) from organizations with newer plantings identified this decrease as potentially having a “crippling effect” on the business, as agricultural yields can be damaged from dry conditions that could prevent adequate growth. Despite such concerns, the respondents have also remained optimistic that there would be avenues available if a drastic change occurred. These avenues may include fruit purchasing and irrigation systems.

As for autumn precipitation changes, all agritourism respondents identified similar concerns. A majority of respondents (15 of 24) associated the concern to natural processes at play, with one stating, “You can’t stop the rain.” However, the main concern respondents unanimously identified is the potential risks of crop damage as a result of fruit damage or fungus and disease resulting from increased precipitation. All respondents identified current occurrences of damage, but said these occurrences aren’t a massive vulnerability to operations. One respondent described operational changes, such as pruning and watering routine changes as a result of increased autumn precipitation, as “causing more of a frustration than actual concern for an impact to the business.” This confirms there is modest concern over potential precipitation changes. However, respondents generally see these potential changes as manageable, mainly presenting operational challenges to which they can easily adapt.

Respondents focused on agritourism shared concerns related to winter precipitation change. The principal concern was the association of increased potential winter temperatures with variable winter precipitation, as presented in the previous section. The concern precipitates from potential crop damage that could occur when

there is not sufficient snow cover to insulate and protect the root systems. A majority of respondents (15 of 24) identified some form of concern about times when there is no snow cover during winter periods. This concern is paired with respondents reporting little they could do to counter such changes. The statement “We’re at the whim of mother nature” was reported by several respondents (8 of 24) when describing their situation. This helps to explain how such changes can leave respondents feeling “helpless” to counter changes in climate.

Changes resulting in heavier precipitation have caused minimal concern among respondents, with only five respondents identifying a concern over potential increases. However, of those who expressed concern, a majority (4 of 5) were from newer organizations. One respondent identified these concerns as being associated with “newness to the property, and not knowing its individual quirks,” associating such issues to the “growing pains of a business.” However, these respondents identified these concerns as temporary, often stating, “We will solve that problem eventually,” with many respondents indicating that it is low on their priority list.

Changes in the Growing Season

Perceptions toward projected changes in the growing season have been unanimously positive. Numerous respondents (5) identified the expected changes in the growing season as their main motivation to locate within the northwest region of Michigan. One respondent described their choice in location this way: “We were looking for the best place that will have long term suitability, because we want to set up a farm that will last and have a return on investment.” Similarly, a respondent categorized as a family farm representative identified steadily increasing yields over the past ten years,

stating, “Our business has really benefited from warming temperatures, where agriculture is almost getting easier.” Respondents from organizations with longer histories (18), highlighted positive impacts of perceived changes, particularly with the increasing suitability of local climate for less cold hardy crops. These crops include chardonnay grapes and peach trees. One respondent involved with viticulture further explained their positive expectations as the opportunity to broaden the range of new crops, “The potential ones (crops) we could grow now will completely change the identity of the region and propel us into the mainstream.” These quotes and examples help to explain the positive sentiments and anticipated benefits of respondents toward the projected lengthening of the growing season regardless of agricultural production focus.

5.1.1.2: Observed Impacts from Climate Change

Through the interview process, we utilized the potential climate impacts and the observed climatic changes to identify respondents' perceptions of climate change. We used open-ended questions for this purpose. Identification of adaptation efforts was done in a similar manner.

Temperature

Increases in temperature have been well received by nearly all respondents (22 of 24); however, the industry's main concern lies in the increasing variability of temperature. When respondents were asked “What do you see as your biggest vulnerabilities in terms of heat extremes and variability?” a majority (18 of 24) identified their cause of concern being low temperatures. All respondents explained that their concerns are about the potential increased variability between frost and non-frost days.

Aside from temperature variability, the general increase in average temperature has resulted in an increased length of growing season. Generally, the agritourism industry reported seeing increases in growing season and temperature as a benefit; however, respondents from newly established organizations reported experiencing more challenges than older organizations. Newer organizations (6) cited increased dryness and evaporation rates from rising temperatures as the main challenge, along with many of the concerns identified by the older organizations. Respondents from longer established organizations such as orchards and vineyards identified slight concern from increasing temperatures, mainly associated with increased pest and disease risk. Increased pest pressure was identified by all respondents as occurring during the summer period. “Previously, we didn’t have too many bugs to worry about, but it seems more pests are migrating that are normally contained to warmer climates,” explained one respondent. This quote helps to illustrate the changing situation faced by the agricultural community, while also explaining the concern about increased pest pressure.

Along with the impacts on crop production, temperature increases will also influence the tourist visitation experienced throughout the year. This has been experienced to the greatest effect during the autumn period. Many respondents perceived this change to be beneficial and provided various examples of benefits that may occur. Respondents unanimously identified the expansion of operations longer into the autumn season as autumn temperatures increased and lengthened the tourism season, as a major change. One respondent described the change this way: “Ten years ago we would really stop getting guests around Labor Day, and now we’re seeing

visitors well into the middle of October.” This response is illustrative of the perceived change and resulting benefits from increasing autumn temperatures for the tourism industry as a whole. However, among smaller organizations, increased tourism during the autumn season does create operational challenges. A majority of smaller organizations (5 of 6) identified a nearly double increase in visitors during autumn when compared to five years ago. This is of particular importance when trying to make sure there is adequate staffing for both guest services and harvesting tasks. In addition, respondents identified increased exposure to greater pest and disease levels during the autumn season, but they perceived these changes as slight. However, concerns from increased pest and disease incidence were largely seen as offset by prospective benefits from the lengthened tourism season.

Unlike temperature changes mentioned for other seasons, temperature changes during winter have caused the most concern. The change that was unanimously identified was decreasing snow cover as a result of more intense and elongated melt periods. This can make plantings more susceptible to freeze damage, which can limit production and life expectancy of the crop. A majority of respondents (11 of 18) from older organizations indicated that the necessary conditions for freeze damage were increasingly present. A small number of respondents (4 of 24) also identified a possible link between warmer winter temperatures and increased pest pressures throughout the year. “When we don’t get consistent cold, then the die-offs of invasive species don’t occur, taking away a natural defense mechanism of our ecosystem,” explained one respondent involved with viticulture, highlighting impacts of increases in winter climate and on his agritourism industry.

In contrast, potential increase in intraseasonal variability has been well received by organizations focused on maple syrup production, as they rely on changes in temperature between below freezing and above for maximum sap production. Respondents involved in maple syrup production identified a significant yield increase in recent seasons. This helps show that the impacts of these climatic changes on various forms of agricultural production differ, and in doing so, it will also bring varying benefits to some and challenges to others.

In summary, the main concern from projected increases in temperature has resulted from impacts such as an exacerbation of dry periods, freeze damage to crops, higher yields, increased crop pest and disease pressure, and an extended tourism season. These impacts have been addressed through various adaptation efforts that will be discussed in the subsequent section.

Precipitation

While both the observed and projected future precipitation changes for the region may be variable, seasonality determines their impacts. During the summer period, decreases in precipitation have had variable impacts on the agritourism providers, with the greatest being drought-like conditions. For all agriculture types, the scale of this impact's effect varies based upon farm location and the age of plantings. The location factor is more variable, and is mainly a result of groundwater differences that leave some organizations' crop root systems better off than others, especially crops that are perennial in nature. The age of plantings is the greatest determining factor to the impacts of summer precipitation changes. This is a result of deeper roots that can make the plants more resilient to drought or dry conditions, requiring less water for irrigation

than plantings with shallow roots as a result of a younger age or other reasons. This factor has mainly been experienced by those involved with vineyards and wineries (21), but is also experienced by organizations focused on orchards and perennial crops. Other impacts of these drought-like conditions identified by respondents include crop growth, summer temperature changes can affect quality and yield; crop loss, both in vines and cash crops; and increased expenses, stemming from increased maintenance and irrigation costs.

Increases in precipitation have also caused concern among respondents. This is due to such an increase causing variable impacts to respondents involved in viticulture (21), specifically for those managing vineyards. All respondents from vineyards and wineries identified a potential vulnerability from increased precipitation that occurs during autumn. Respondents identified this concern as resulting from decreased crop quality due to changing sugar levels. This occurs from changing water content within the grape, which impacts its natural fructose synthesis process and taste. These changes can have drastic impacts on wine manufacturing and final taste. This vulnerability can be further exacerbated by proximity of precipitation events to harvest times, giving the fruit little time to bounce back.

Similarly, an increase of precipitation during winter will bring variable impacts depending on the form of occurrence of the precipitation. Given that, the main change respondents have identified associated with winter precipitation has been decreasing snow cover while rainfall increased. Respondents attributed this change to increasing winter temperatures and increasing occurrence of precipitation as rain relative to snow. This contributes to and possibly exacerbates the potential for freeze damage to crops. A

number of respondents (11 of 24) indicated that conditions for a deep winter freeze and subsequent damage were occurring more frequently. Among respondents from longer established organizations, several (7 of 18) provided the example of the polar vortex of 2014 as an example of the economic vulnerability freeze damage could cause. Those seven respondents explained that this event resulted in up to a 90% loss in yield. This event was often cited as an illustration of the perception of adverse impacts of winter precipitation changes as being the greatest concern in regard to all precipitation changes.

Precipitation was also unanimously identified to be occurring in smaller but greater storms that can be seen as heavy precipitation. These heavy precipitation events have been of some concern among respondents, although these have been variable between locations. This variability could be a result of geophysical conditions such as soil makeup and slope, which can determine the scale of soil erosion and flooding events. However, there were few respondents (5 of 24) who identified flooding and erosion as a vulnerability to operations currently. Similarly, if heavy precipitation events occurred in autumn, there is the risk of fruit damage from rainfall. This was of particular concern to organizations focused on producing thin-skinned fruit varieties (3). Currently this vulnerability has had minimal impact, with respondents reporting estimates of only 1% to 5% losses in yield.

In summary, the general concerns among the agritourism industry related to precipitation changes focused on agricultural production. The associated impacts include reduced crop yield due to drought, crop quality complications from variable sugar levels, erosion, freeze damage due to reduced snow cover, fruit damage from

precipitation impact, and localized flooding. These impacts and their diverse adaptation strategies will be discussed in the subsequent section.

Changes in the Growing Season

The climate variable that received the most attention from agritourism respondents was that of the growing season. The increased length of growing season was mentioned by all respondents regardless of category, with the extent of reported changes varying by organizational history. Among organizations with long farming histories, several respondents (6 of 18) reported experiencing at least a 14-day increase in growing season, with one respondent describing it as “shocking.” Respondents have also identified a longer tourism season associated with the increase in growing season, contributing to significant growth in operations, both in production and tourism visitation numbers, regardless of agricultural focus.

In contrast, respondents from organizations that began operations within the last 5 years referenced the growing season changes and increasing suitability for agriculture in the region as a motivation in their choice of location. This sentiment was echoed by all respondents with a history of 5 years or less (6 of 24), with one respondent describing their rationale as follows: “We looked all over the country to find somewhere with long term suitability for the crops we want to grow.” The increased suitability for agriculture due to the lengthened growing season was unanimously identified to have contributed to many new establishments locating in the area, increasing competition among agritourism-focused establishments.

For respondents focused on viticulture (21), nearly all (19) identified increasing suitability for different varieties of vines. This increasing suitability was the main positive

perception of impacts of observed and projected climate change identified by respondents, and has resulted in many organizations planning how to best adapt and take advantage of such changes. In conclusion, the greatest impact from growing season changes has been the increasing suitability for a variety of crops and the expansion of the tourism season.

5.1.2: Water Recreation: “We’re trying our best”

While respondents involved in agritourism generally stand to benefit from the projected changes in climate variables such as a lengthening growing season, those involved in water recreation will encounter diverse benefits and newfound complications from said changes. Water recreation respondents identified their principal concern as winter temperature changes. However, there have also been various impacts of climatic change throughout the year.

5.1.2.1: Perceptions and Concerns about Climate Change

Before discussing climate vulnerabilities, it is important to discuss respondents' perceptions concerning a changing climate. Generally, their perceptions toward continued operations in the face of a changing climate were unanimously positive. All the respondents expressed optimism that their organization would adapt to any climate change faced, although nearly all respondents also expressed some uncertainty mainly due to the variable situations and support networks available to them. Much like the vulnerabilities to climate change that will be discussed below; the perceptions toward these changes vary between tourism operators.

Temperature

The principal concern among respondents was changes in winter temperature, but changes in other seasons were also raised as causing varying degrees of concern. In regard to summer changes, events such as species die-offs were identified as causing frustrations rather than operational complications, mainly due to the increase of resources needed to address them. For respondents involved in visitor accommodation, their frustration was from increased expenses of offering experiences. One example is those seeking to fish may have difficulty in finding optimal location, resulting in higher fuel charges. One respondent described their current situation as, “With how far we’re having to go out for every trip, the prices have gotten exorbitant, and it really isn’t economically sustainable to keep this up (operations).”

Increases in temperature have been well received, mostly around the benefit of a longer tourism season; however, there were also adverse impacts. A majority (17 of 23) of respondents identified concern over staffing requirements to keep up with increased visitation levels due to the extended tourism season. One respondent described their situation as “We love a warm fall, but so do our tourists, and after Labor Day we really struggle to keep up maintenance.” This quote shows how a potential change can be seen as a benefit while also causing complications for operations. Of those respondents who identified concerns over a longer tourism season due to increased autumn temperatures, many also expressed a feeling of uncertainty in the quality of tourism offerings they can provide. This is a result of declining resources to maintain adequate tourism-support conditions, as well as decreased suitability for certain recreation activities, such as fishing. The sentiment of one respondent focused on waterfront

management illustrates how climate changes could contribute to uncertainty for operations: “After Labor Day, our summer help (labor staff) leaves, and this really creates an upkeep problem...those being changing the trash, mowing, and stuff like that.”

In regard to winter temperature changes, a majority (15 of 23) identified significant uncertainty in future operations from increased erosion due to ice break up. One respondent’s statement encapsulates the general concern toward increased erosion by describing their situation: “Right now there is a lot of uncertainty on if our traditional trails will still be usable and safe 10 years from now.” There was also great concern over tree biodiversity and health given the projected increases in winter temperature. Respondents from all recreation types echoed this concern. A respondent involved in water recreation described their concern as “Right now, I’m really worried that our forests aren’t gonna look the same 15 years from now.” Similarly, a respondent focused on conservation and preservation had this to say about their concern: “We’re really worried about implications on natural food supplies for fauna; we could see massive die offs in the next fifty years if all of their food-supplying trees disappear.” The fauna at risk involves all local animals that rely on natural sources of food; these include deer and rabbits. In summary, these findings and illustrative quotes help show the perception of the local tourism industry toward climate change, and to explain the levels of concern present.

Precipitation

Observed and projected changes in precipitation have been met with a wide range of perceptions. Many respondents (11 of 23) perceived the potential changes as

no concern at all, with one respondent's characterization of observed and projected changes in precipitation as being "Pretty standard to what we've experienced" and this captures the common sentiment well. While others considered the changes beneficial, some considered them a significant threat to their businesses. Among respondents focused on waterfront and marina management, decreased precipitation has been welcomed as a potential mitigating factor of wetland flush contamination. "When we have these drier periods of summer it can actually help alleviate pressure on our rangers, as there isn't the need to be testing all the time," explained one respondent in reference to positive impacts of lower precipitation in the form of reduced need for water testing for contaminants that is generally done during wetland flushes. This quote helps illustrate why many respondents see this form of climate change as a benefit.

As for respondents focused on conservation and preservation, concerns were over adverse biodiversity impacts were associated with decreased rainfall. Biodiversity is an important ecosystem service that the ecotourism industry depends on, and threats to it can undermine businesses. One respondent described the concern as follows: "When we have dry summers, it really makes it tough on our ecosystems, as they're not used to these conditions... it's been a worry for us because it could seriously change our protected areas, and our whole biodiversity could change in this area." This illustrates the potential differential impacts of one form of climate change on different tourism sectors, in this case decreased precipitation. Thus, one change, such as reduced precipitation, is welcome to those focused on the human or hospitality side because of its positive impacts, but is unwelcome to organizations focused on other sectors, such as preserving our natural resources.

Respondents focused on visitor accommodation identified a concern over increased precipitation events occurring during summer, as that forms the peak season for their business. One respondent described their situation thus: “When we get big rain events, no one comes out, so if that happens more often it might really impact our bottom line.” This view shows how changes in climate might impact hospitality business operations throughout the region.

Winter precipitation changes are perceived based on the form during occurrence. The respondents saw increases in winter precipitation as snowfall as a welcome change. However, respondents involved in waterfront and marina management identified concerns over cascade effects from storm pressure if there were also an increase in precipitation in the form of rainfall. One respondent identified a fear of coastal erosion when paired with increased winter temperatures, as follows: “If we had solid ice cover in the bay, and it broke up and started smashing into our coast, it could remove some of our unprotected shores”. This suggests that concern might grow among respondents focused on waterfront and marina management as climatic changes have slowly become more pronounced. These examples show the variable impacts of change and explains the variable concern thereof.

Changes in heavy precipitation did not cause major concern. Respondents unanimously saw current patterns of precipitation as standard. A statement by a respondent focused on winter recreation is representative of this sentiment: “We’ve been getting generally the same number of big storms now as I did when I was growing up.” A waterfront manager cited coastal erosion and impacts on wastewater systems—and ultimately on water quality levels—as attributing the greatest concern. One

respondent expressed fear of a “critical failure” of the wastewater system that could cause serious complications for all tourism industries. In summary, the perceptions toward precipitation changes are highly variable by recreation focus, with some respondents highly worried and others paying little mind to climate changes.

Changes in Growing Season

As would be expected, there was little concern among water-recreation respondents over growing season changes. Most had limited focus on agriculture, although many maintain green space for cosmetic appeal rather than for productive or extractive purposes. Instead, the only concern relating to growing season changes was the increased use of recreation areas later into autumn. The cost and staffing challenges arising from the increased labor demand to sustain maintenance routines might result in less than ideal conditions for recreation, but no respondent considered it as a serious concern. “While yes, we may have some brown or tall grass, that’s just how it will be,” stated one respondent. Still, the arising challenges get attention from management organizations.

5.1.2.2: Observed Impacts from Climate Change

The following sections contain identification of observed climatic changes and impacts identified by respondents during the interviews. We use thematic analysis of the responses to qualitative research questions combined with climate projections described earlier, to compare and assess levels of understanding of climate change risks as a basis to explain adaptation efforts.

Temperature

All respondents mentioned temperature increases; however, the impact of the change was variable among respondents. The experience and vulnerabilities from climate change vary by subcategory. Respondents focused on waterfront and marina management identified two principal concerns: water contaminants and increased invasive species pressure. A majority (14 of 18) of these respondents linked water contaminations to increased summer temperatures. “Those (increased temperatures) have created more suitable conditions for contaminants such as E. coli to flourish,” explained a respondent. A vast majority of respondents (16 of 18) also identified an increased concern over invasive species outbreaks from the warming and variable temperature. “These lakes get more and more suitable for invasive species outbreaks every year; just a few years ago you wouldn’t see them (alewives) this far north,” explained one respondent. In contrast, respondents focused on conservation and preservation had their concern focused on terrestrial invasive species. For instance, while a respondent focused on conservation contended “We’re doing a lot of battle conservation work, it’s a never-ending problem”, they also admitted that that the issues were normal, and “a large focus of their organization.”

Another impact identified by respondents across water recreation was increased species die-offs. This was attributed to increasingly variable summer temperatures. Species die-offs are a natural occurrence. However, respondents indicated that the observed pace and extent was to a high degree not experienced before. All respondents involved in waterfront management identified a massive alewife die-off, leaving beaches covered in dead organic matter, and leaving managers with large

cleanup costs. However, the alewife die-off was not all negative, as the alewife is an invasive species to the Great Lakes. Therefore, its die-offs could have the potential of allowing populations of natural species to rebound from unrestricted food supplies. This situation has opened many organizations' eyes to increased suitability of the area for invasive species and the potential for their spread.

Similarly, the principal concern identified by visitor-accommodation (2) respondents was condition degradation of water resources. Respondents linked this to variable summer temperatures and their impacts on water temperature. One respondent focused on charter fishing identified greater challenges in fish stock and in locating the fish, stating, "The areas we customarily fished are not as plentiful as before." Such small changes in climate can undermine business profitability. One respondent's description of their situation is illustrative of this adverse economic impact: "With increased travel time, every minute we spend traveling decreases fishing time and increases fuel costs, which eats into my profits." This issue has persisted into the fall season. One respondent who was focused on charter fishing experiences identified increasing difficulty in figuring out fish locations during the autumn season. "The fish really don't like warm fall, so if it is warm, good luck finding any in the bay," opined another respondent in explaining this challenge.

The increasing temperature also contributes to a longer tourism season, which has been well received by most respondents (18 of 23). Therefore, all water-recreation respondents identified increased use of recreation areas during the autumn season as the main climate impact. Warmer temperatures are more welcoming for outdoor activities, and for increased site suitability for recreation. This has resulted in concerns

over the adequacy of maintenance routines, as organizations do not have the staff to maintain areas when the busy season has ended. “We’re seeing heavy tourism use ‘til the end of September, and higher than average use ‘til November. It’s great they’re getting outside, but we’re not keeping up on areas like we would in July,” explained one respondent. Increasing temperatures were identified to change annual visitor use make-up, creating quality issues for many recreation areas. In contrast, respondents focused on watercraft rental identified benefits from increased temperatures and an increased length of tourism season, as they have expanded the tourist population and increased visitation to their business, and therefore improved revenues. One respondent described the beneficial situation this way: “Normally we would put our boats away the week after Labor Day, and now we’re not putting them away until the beginning of October.” The differing situations of respondents provide a good example of both the benefits and complications climate change can bring.

As discussed earlier, changes in winter temperature have caused the greatest impacts, as perceived by respondents across diverse tourism operations. Nearly all respondents (22 of 23) focused-on water recreation identified increasingly variable winter temperatures as contributing to coastal erosion. This erosion can occur when temperatures change from below freezing to above, week over week, creating massive icebergs that slam into the coast. “We’re seeing more ice buildup and subsequent breakup than years before,” explained a marina operator. Increasing incidence of freeze/thaw transitions has weakened coastal formations and structures, creating new management challenges. All respondents from organizations located along large lakes (16) identified increased ice-based erosion from variable winter temperatures as a major

concern. Ice damage is further exacerbated by variable temperatures, as one respondent focused on conservation and preservation explained: “A cold spell allows ice to form, then a week later, a warm spell facilitates its breakup, and then once its broken, a storm system can cause this ice to smash into the coast.” The respondents also identified at least three occurrences that destroyed formations. All respondents have identified ice damage as increasingly prevalent in the last five years. Furthermore, coastal erosion can cause amplified concern when it is paired with increasing winter precipitation, as discussed further below.

Respondents focused on conservation and preservation unanimously identified difficulty in maintaining healthy biodiversity, such as trees and undergrowth. The importance of biodiversity for the functioning of ecosystems contributed to winter temperature and its changes, being labeled “most crucial” by a respondent. Another respondent identified a link between warmer winters and disruption to hibernation processes of various tree species throughout their region. This change was also identified to impact die-offs of pests and plants, including invasive species.

Respondents focused on conservation and preservation unanimously reported increased prevalence of invasive species and pests, and largely attributed this to winter temperature increases, which have made climatic conditions more suitable to non-native plants.

In summary, the concerns among respondents from water recreation result from impacts including biodiversity challenges, degraded conditions for recreation, heightened use of recreation areas, exacerbated invasive species pressure, increased ice-based erosion pressure, increased length of tourism, and more frequent water

contaminations. These concerns and their respective adaptation efforts will be discussed later.

Precipitation

Respondents perceived precipitation changes with more concern than changes in temperature, including cascade effects exacerbating certain adverse impacts of temperature changes. Similar to temperature changes, the principal concern for all respondents stemmed from precipitation changes during the winter season. However, various impacts have also been experienced throughout the year and are presented and discussed below.

Decreases in precipitation have been well received by respondents of water recreation, especially if such change occurs during summer. However, when precipitation does occur, most respondents (17 of 23) indicated that precipitation patterns changed to a more variable cycle including more intense rainfall events. One respondent characterized the change as “Seeing the precipitation coming in greater degrees when it does come, than years prior.” Given this greater intensity of precipitation, respondents from the waterfront and marina sub-sector identified increased water contamination as their principal concern. This change was attributed to wetland flushing. Although wetland flushing is a normal function of the ecosystem, numerous respondents (18) indicated that more intense precipitation events increased the quantities and frequency of contaminants in ecosystems. This was especially apparent during autumn, as one respondent explained: “Normally, we didn’t have too many visitors during the fall, but it seems now we’re seeing increased use and more

often we're having to tell people they can't use the water." This respondent's view illustrates operational impacts of wetland flush and subsequent water contamination.

Similarly, this increase in variability of precipitation was identified to impact the conditions necessary for recreation. This was of particular importance to respondents focused on visitor accommodation who associated increasingly variable precipitation patterns with greater influence and complications over visitors' recreation choice. A respondent associated with watercraft rental had the following observation:

"Precipitation events have led to far less consistency in busy days, week to week, but we have been seeing maximum use on dry days." This sentiment is representative of the views expressed by many such operators, and helps to illustrate the variable impacts of precipitation changes on tourism organizations.

The interviews revealed greater exposure of respondents to precipitation impacts combined with temperature-based extension of the tourism season, most notably into autumn, which would traditionally not be suitable for recreation. A majority of respondents (17 of 23) reported that the impacts of precipitation that would normally be contained to summer have stretched into the autumn season. The most notable impact has been water contamination from wetland flushes. This impact has become more apparent due to the increased volume of visitor traffic as a result of the increased length of the tourism season.

In addition to the compounding effect of precipitation and temperature during autumn, the combined effect of ice and temperature variability exacerbated impacts on coastal erosion during winter. All the water-recreation respondents identified this ice-based erosion exacerbation as a major climate-change impact, and nearly all (21 of 23)

identified increased erosion during and following rainfall events when ice buildup is present as the major risk. The sentiments of a conservation and preservation respondent is representative of the latter impact and overall concern over climate-accelerated coastal degradation: “Ice buildup alone presents us issues, but you pair that with a good rain storm, it’s a bad day for the dunes.” Because much of the observed coastal degradation was linked to heavy precipitation episodes, and there was a perceived increase in the intensity but not frequency of events, respondents unanimously perceived coastal erosion and associated flooding and water contamination to have escalated. A respondent’s statement supports this perception: “I’ve lived here all my life and I wouldn’t say I’ve seen any crazy increases in big storms, we still get about five a summer.”

Accelerated coastal erosion was of special importance to respondents focused on conservation and preservation, as many were responsible for managing historic sites that are located on bluffs or coastlines. Describing the level of damage from erosion during an extreme precipitation event, one respondent said, “We had a big storm last winter and we lost a quarter of the dune our welcome center is located on.” Such erosion has had the greatest impact on coastal structures because the coastlines are constantly changing. This problem has become so serious that two of the three respondents questioned the resilience and sustainability of coastal structures built on formations such as bluffs because erosion was identified to contribute to transporting massive amounts of sediment near sand dunes. Similarly, these heavy precipitation events were identified as worsening coastal and riverside erosion due to increased

water flow. One respondent identified this erosion as contributing to undermining of infrastructure, which has caused at least one critical failure in the last five years.

Another impact reported in areas near river ways was flooding as a result of heavy precipitation. This has been occurring due to the heavily channelized waterways that are insufficient to handle large influxes of water. More frequent occurrence of river way flooding was observed over the last five years by a majority of respondents from waterfront and marina management (12 of 18). These heavy precipitation events were also identified to contribute to water contamination frequency. A majority of respondents (12 of 23) saw a link between contaminations and heavy precipitation events, although they mostly perceived this increase in contamination as a natural process.

In summary, respondents focused on water recreation identified numerous impacts from precipitation changes, with the principal concern being a result of erosion exacerbation from storm pressure. Other impacts of concern include flooding, water contamination from wetland flush events, and water movement system failures. These concerns are met through many adaptation efforts that we discuss below.

Changes in the Growing Season

The growing season changes have had little impact on water recreation. However, all respondents regardless of management focus indicated that the same increases in autumn temperature that extend the growing season, also extended the tourism season. The resulting increase in visitation numbers associated with a lengthening growing season into times of the year that would normally be unsuitable to outdoor activities, and the pressures this brings on maintenance resources and routines such as grass mowing. This has mainly affected the overall look and appeal of natural

areas, but was identified as having minimal impact on operations and associated costs overall.

5.1.3: Winter Recreation: “We manage what’s in our control”

Winter recreation faces numerous challenges, with many a result of the short season the recreation is confined to. Given that, the changes of climate most important to respondents will center on their impacts during the winter season. This may account for the little discussion of climate change impacts presented by respondents for other seasons.

5.1.3.1: Perceptions and Concerns about Climate Change

Similar to respondents of water recreation there is great concern over winter temperature changes. However, perceptions of changing climate varied by sub-sector (e.g., between public and private organizations) and the specific type of tourism service provided. These perceptions are discussed below, organized by main climate variables.

Temperature

In contrast to respondents of water recreation, respondents involved in winter recreation have little concern over temperature changes during the summer and autumn seasons. However, those from private recreation, many of them offering summer recreation such as golf, expressed frustration from decreasing grass-cover conditions. This change was identified as causing minimal concerns, but was attributed to increased frustration in preserving the quality of recreation areas. One respondent described the cause of their frustration: “Every year it’s more and more prevalent (dry conditions), making my job more tedious.” These examples illustrate the common

sentiment that most temperature changes have caused more frustration than actual concern for winter tourism operations.

In contrast, respondents focused on winter recreation identified considerable uncertainty in their future operations from the observed and projected increases in winter temperature. Nearly all (8 of 9) respondents identified a fear of closures due to increased winter temperatures. “If we can’t make snow because it’s too warm, we can have serious revenue problems, especially if it is during our busy periods like Christmas,” explained one respondent. Aside from fears over snowmaking, increased winter temperatures have also caused fears over snow cover and retention. These complications can present limits to operations, as insufficient snow cover can result in the closing of recreation areas. One respondent described the situation in this way: “We’re seeing more green than white, and my fear is this will impact future return visits, because it’s really not what the guest was expecting.” This quote helps illustrate how respondents perceive winter temperature-change impacts, and why this climate change represents the principal concern amongst respondents.

Precipitation

The perception of respondents toward precipitation changes is dependent on the form of precipitation. When precipitation occurs as snowfall all respondents identified no concerns and welcomed any snowfall they can receive. However, if that precipitation occurs as rainfall, there are concerns over declining natural snowfall and snow quality. This is a result of the potential impact on guest experiences. “We really can’t keep our snow pristine, and that has big impacts on how guests perceive their experience, and hopefully it won’t keep them from coming back next year,” explained one respondent.

Respondents focused on winter recreation saw decreases in precipitation as little more than an inconvenience. The explanation of one respondent illustrates this position: “We really only need water for areas like golfing, and we’re already watering frequently, so it more just changes the frequency of when we do it.” This respondent was referring to summer precipitation decreases that occur as rain. There was slight concern from the occurrence of heavy precipitation events among respondents focused on winter recreation. Further, no respondents identified operational challenges from flooding. “We do see the occasional flooding, but that’s not a vulnerability to our operations. Yeah it might cause some difficulty, but we’re not really doing anything to immediately address it.” This sentiment from a winter recreation operator encapsulates the general perceptions of nearly all respondents regarding precipitation-based flooding.

Changes in the Growing Season

Similar to respondents of water recreation, little complications were presented from changes in the growing season for winter recreation operations. Given that, few were concerned with such changes. This lack of concern was attributed to there being other more relevant issues that have been of a higher priority for organizations.

5.1.3.2: Observed Impacts from Climate Change

Temperature

In regard to the temperature increases currently experienced, there were few impacts identified by respondents occurring during the summer and autumn season. Although respondents from private recreation areas reported increased watering routines as necessary for maintaining adequate grass quality. This was also unanimously considered as being of minimal impact to operations currently. As one

respondent described: “We’re already watering pretty consistently, so we really only shorten the time between, because we can’t have brown on our golf course.” This necessity of increased watering to maintain grass quality represents the main impact experienced by respondents involved in winter recreation.

Winter recreation respondents also identified expansion of the tourism season into the autumn months as another impact of increasing temperatures, but the extent of changes in tourist visitation levels and associated impacts varied. In the case of golf course management impacts, one respondent acknowledged a longer golf season while observing that this season extension did not have significant adverse impacts: “We have seen longer use on our golf course; the last few years we’ve been able to keep it open until at least mid-October, but that doesn’t really cause us any problems.” This represents the general sentiment among respondents toward increased autumn temperatures.

The impacts of increasing winter temperatures on snow cover and provider operations depend on the resource base of the respondents, and therefore their ability to adapt. In particular, if a provider has the resources to invest in snowmaking capabilities—usually the larger well established providers—they can mitigate climate-induced reductions in natural snowfall and cover. Smaller winter recreation areas (4) are mostly concerned with winter precipitation levels, while those with snowmaking equipment focus on the suitable conditions for snowmaking. One respondent from a large private recreation area described their concern as this: “The problem isn’t snowfall; we can make snow all day, but when it’s too warm to do that, we just have to

stay closed.” This quote illustrates the close relationship between climate and revenue streams.

Adverse impacts of a warming climate on snow cover have struck public recreation areas the hardest, as they often do not have adequate snowmaking equipment. The respondents focused on snowmobiling (2 of 9) underscored their business’s elevated risk from degraded snowmobiling conditions. Due to their inability to create snow, they are completely reliant upon natural snowfall and slow melt periods. “If we’re not getting proper winter conditions, we’re not opening,” one respondent from a smaller public recreation area described the stark reality of the climate related risks. All respondents repeated the perception of reduced snow cover from increasing winter temperatures. The nature of this problem was not only about reduced snowfalls, but also reduced longevity on the ground once the snowfalls or is manufactured. “After we make the snow, what really matters is how long it lasts,” explained a respondent from a large private recreation area. “We’ll get plenty of natural snow, but then a week later, the hills are bare and we can’t make snow,” chimed in another respondent from a public recreation area. These quotes help capture the common descriptions of this winter temperature-induced impact on snow cover in the study region.

In regard to the snow cover complications, increased winter temperature’s impacts also have a way of compounding each other. This occurs when increased temperatures contribute to increased and accelerated snow loss, furthering the reliance on manufactured snow. Furthermore, when temperatures are not low enough to preserve natural snowfall, they are often also not low enough to facilitate snowmaking, further exacerbating the issue. Most of the respondents (7 of 9) identified this heavy

reliance on manufactured snow as the standard within the industry. This reflects the unanimous identification of melt periods becoming more prevalent due to a warming climate, as well as its contribution to limits on operational days for winter recreation businesses. These limits to operations have undermined guest experiences. The decrease in operational levels because of winter-temperature increases in this sub-sector are currently so bad that one respondent claims that only 1 of 4 ski runs is in operation as this problem becomes “more and more prevalent” among winter recreation businesses.

These climate-induced disruptions on guest experience were echoed across nearly all respondents (8 of 9). This contributed to increasing uncertainty in maintaining the traditional guest experience. A respondent from a small private recreation area described a situation where annual visitors had left disappointed. This prompted customer comments such as the following: “The last three times I’ve made the drive up here; you guys only have one run open. What is going on?” This comment supports respondents' concern over increasingly variable operations as a result of warming winters. One respondent from a small private recreation area described their current situation as “pitiful compared to my childhood,” and that the ski slopes were “more green than white.” The ensuing decrease in suitability for winter recreation has undermined many recreation operations and businesses, including skiing, sledding, ice skating, and tubing. These impacts can reduce revenues for the operators, and have rippling effects on communities heavily dependent on winter recreation for their livelihood. While issues caused by changes in winter temperatures were perceived to

already be significant, they were also identified to be exacerbated by increasingly variable winter precipitation. This link will be further discussed later.

In summary, the principal concern among respondents from winter recreation linked to increasing winter temperatures was reduced snow cover and quality, and therefore degraded conditions for recreation. Impacts manifest in many ways, including conditions preventing snowmaking, increased frequency of melt periods, low grass quality, poor snow retention, and variable snow quality. The adaptation efforts employed to address these issues will be discussed later.

Precipitation

A decrease in precipitation was perceived to reduce grass quality. This is of particular concern to organizations with golf businesses that rely on high quality grass for operations, although the impact on operations was currently considered minimal. One respondent characterized it in this way: “We have our water routines set up in such a way, where we water as if there was no rain at all...this way we just need to adjust it when things are damp.” This quote illustrates that respondents had already internalized the adaptive response to precipitation decreases, and therefore perceived the problem as of limited concern for winter recreation. One respondent affirms this sentiment as well as the flexible use of irrigation systems and adds an element of cost effectiveness by noting: “After mid-September, we really don’t irrigate too often... it just isn’t always economically smart.”

Winter precipitation was of most importance to respondents from winter recreation. However, when discussing winter precipitation, the most notable aspect was the variable perceptions among respondents. This divide was partly the result of

whether the respondents had snowmaking capabilities or not, as those able to make snow are also able to augment snow cover when conditions are suitable. However, regardless of snowmaking capability, all respondents identified the variability in winter precipitation as a problem currently. Variable precipitation has the greatest impact on smaller recreation areas, as they often lack snowmaking technology. As a contrast, one respondent's description of their ideal winter conditions as: "If we could get a light dusting every night, it would go miles in keeping us open to the public."

This increasingly variable winter climate has been affecting operators unequally. A small majority (5 of 9) identified this inconsistent precipitation as currently adversely affecting operations. "We've been getting near normal precipitation amounts, but the timing between them has changed," explained one respondent. This illustrates how precipitation totals can distort the conditions observed by respondents. This increasingly variable precipitation has undermined snow retention. Respondents unanimously linked these problems to either reduced or inconsistent seasonal precipitation. This has created situations where even if there are more frequent large snowfall events, the resulting snow cover does not last long enough to be of sustained use for winter recreation activities. This reduced snow retention has been exacerbated by increases in winter temperature, creating a dire situation for many operators. One respondent speculated about a possible 50% reduction in season length if observed conditions continue into the future.

However, more often than not, respondents have experienced winter precipitation as rainfall. Most respondents (6 of 9) identified this change in precipitation form and pattern as having a "medium" impact on snow quality currently. This occurs

when precipitation changes form from snow to rain or sleet, thereby creating icy or slushy snow, which is seen as “less than desirable” by respondents. This climate impact on snow quality was characterized as a “critically important” factor affecting guest experience.

Another impact of precipitation when it occurs as a rainfall is the potential for localized flooding. Nearly all winter recreation respondents (7 of 9) linked such occurrences to heavy precipitation events already being experienced currently. These occurrences were perceived as a standard process of the natural drainage systems. In contrast, respondents considered heavy precipitation events that occur during winter as snowfall as a welcome benefit. However, respondents unanimously perceived such events to be increasingly “few and far between,” in the words of one respondent. A majority of respondents (6 of 9) also identified an indirect climate impact of heavier snowfalls – increased occurrences of power outages due to power-line damage, although many might be in other seasons, as a respondent noted, “We normally see a short power outage after a big storm, but these have largely been contained to our non-busy season.” Respondents also suggest this problem may worsen in the future given that the observed changes in precipitation patterns become more variable.

In summary, the principal concern over precipitation changes among respondents from winter recreation focused on variable precipitation form and its impacts on conditions for recreation. These impacts include complications surrounding guest experience, decreased snow quality, localized flooding, and power outages. Adaptation efforts for these impacts are discussed in subsequent sections.

Changes in the Growing Season

Similar to respondents of water recreation, the increased length of growing season has resulted in an extended tourism season as well. This was perceived as a manageable impact, with most even seeing it as a benefit. The impacts were of such low concern that no respondents mentioned growing-season changes when discussing their concerns over climate change. In summary, the principal climate impact relating to changes in the growing season has been an extended tourism season and rising visitation numbers.

5.2: Current and Planned Efforts to Adapt to Climate Change in the Tourism Industry

Before discussing the various adaptation efforts currently underway or planned, we first identify currently observed limitations over adaptation efforts underway. Nearly all respondents regardless of recreation focus (42 of 55) identified access to resources as the most crucial aspect in determining their adaptation capabilities. This access to resources comes in two forms, operational funding and personnel. Funding was identified as “most crucial” to adaptation efforts, as many adaptation projects can include expansive construction and planning which results in high costs. To illustrate, one water-recreation respondent described adapting to climate change as involving “a significant cost; we had a dredging project that's cost exceeded well over a million (dollars).”

At the same time, a plethora of resources are available to help operators adapt to a changing climate, such as expert knowledge and government support. Even though this often requires applying for funding or formal grant writing, sometimes seeking the services of a consultant can enhance chances of success. Consequently, smaller

organizations often find less support, as the bigger organizations can tap on more resources and draw more attention and focus. One respondent described a feeling of “playing second fiddle” to the larger businesses or operators. This has resulted in some small organizations yielding management of portions or all of their areas to larger municipalities. The requirements for accessing grants or outside funding also involve and affect staff and labor requirements. This was identified across the water recreation industry as a hindrance to an organization's ability to maintain current infrastructure and natural areas.

Similarly, numerous respondents (26 of 55) identified a conundrum in operations involving the limited capacity based on current staff levels for many organizations and the ability to maintain current operations, let alone start new adaptation focused projects. This conundrum was identified to be exacerbated among local governments, as they often manage winter and water recreation areas together. This can create a hierarchy of importance that was identified as being based upon customer-traffic levels and relative economic importance. This creates a situation where marinas and waterfront projects receive a higher priority because they often draw more and wealthier visitors. One respondent among winter recreation operators described the link between use traffic and funding as follows: “All adaptation efforts are connected to funding, and that stems directly from our size and use.”

While increased funding for employment could mitigate the problem of staffing, many smaller organizations (18 of 55) contended that they did not have the resources to spare, including on competing for new resources. “Right now, it’s almost like we’re robbing Peter to pay Paul,” stated a respondent, and elaborated further on the

predicament: “Every dollar is accounted for and increasing funding for employment draws away from funding for projects.” These few perspectives illustrate how funding limitations, including insufficient staffing, can be a crucial determinant of adaptation efforts, regardless of climate risk and impact.

5.2.1: Agritourism: “More Risk, More Reward”

5.2.1.1: Perceptions about Adaptation

While agritourism respondents may have a low concern about climatic changes that does not mean there have been no efforts to prepare for climate change. This generally low level of concern is also compounded by the nature of agriculture, described by one respondent as “There is little one can do against Mother Nature, so we just deal with what she gives us.” Despite that, many respondents have found innovative ways to prepare their operations for climate-change impacts. When respondents were asked, “Do current planning regimes include proactive resilience building to climate change, or are only reactive disaster responses being addressed?”, a stark majority (19 of 24) responded in a manner reflected in one farmer’s answer: “As proactive as we can be.” These respondents then continued to support their stance of cautious optimism through various initiatives that they have undertaken. This shows that there is willingness to adapt. We discuss the various adaptation efforts below.

5.2.1.2: Climatic Change Adaptation Efforts

Given the slight concern about climatic change among agritourism-focused respondents, all have met the currently observed climatic changes with diverse types and levels of effort for adaptation actions. The scales at which these efforts have been applied vary by organization, with some efforts focused on small areas of operations,

while others focus on completely overhauling farming and tourism operations such as guest services. These efforts have been met with various levels of support from local communities and tourists. The various adaptation efforts currently planned or underway are organized by the observed climate changes identified by respondents.

Temperature

In response to increased temperature impact on dryness, respondents from newer organizations with younger plantings (6 of 24) have focused adaptation efforts on planting location and optimal watering. Four of these six respondents characterized such efforts as the “growing pains” of the business, as they try to maximize their operations with their given capabilities. In contrast, respondents hailing from older organizations that contain well-established crop/vine/tree plantings (18 of 24) reported adopting small adaptation efforts, being focused on operational changes. Operators have adopted two forms of operational changes in response to increasing temperatures. The first was pruning methods. Pruning is a basic approach applied in all agriculture, it refers to trimming of the plant to control the growth and keep it manageable. A respondent involved with viticulture described pruning as “a winemaker’s best weapon against changes to the vine.” Pruning can and has been done in many ways, but in response to summer temperatures, it has been done to shade and protect the fruit from sun damage.

The second operational change in response to rising temperatures has been done to address increased disease and pest problems. This has been done through enhanced ecosystem services and the use of protective equipment. The ecosystem services relied on biological control, and have been applied to a lesser extent than

protective equipment, with only three respondents mentioning it as a response.

Examples of ecosystem-service approaches have included biological control of pests using bat and bird populations, and include habitat protection and creation. Biological control was done in the hope that the control species will reduce insect levels that threaten agricultural production through predation.

The application of protective equipment has been applied to a greater degree, but it is not widespread. Only five of the twenty-four respondents mentioned it. Those that used such equipment identified concerns over high cost once this adaptation measure was brought to large scale, limiting their application to key areas. Protective equipment has taken the form of nets, sound creation devices, and protective plantings. Nets were the most widespread protective measure, and were mainly used to protect against larger pests. Respondents indicated that these pests might turn to agricultural products for food given increasing challenges to tree biodiversity and ecosystems in relation to natural food supply. Similarly, sound creation devices are utilized to accomplish the same goal, and are rolled out through efforts such as alarm activation and firearm expenditure. Protective plantings were applied to a minimal degree and were very pest specific. They are often used in response to insect pressure, and often involve planting of aromatic plants that are proven to bother the pest of focus.

The expansion of recreation-use levels and visitation numbers during the autumn season as a result of increased temperatures was welcomed as a benefit. However, this has contributed to operational challenges, the most notable being labor requirements. These labor requirement challenges are the result of a decreased labor pool once the peak season concludes, as well as the limited funding available for wages. These

challenges can be further exacerbated by increased visitation during the autumn season but the resulting revenue gains can also help to mitigate the added costs. These challenges have been met by three main adaptation efforts: business operation changes, maintenance routine changes, and staggered harvest times. Business operations changes have been the most widely applied, with a majority of respondents identifying them in their response (13 of 24). Such operational changes can take various forms. One form involves changing service style, such as offering flights (larger volume, multiple varieties, and smaller sizes) as opposed to individual glasses for wine tasting, or switching to reservation requirements for food and beverage service. Similarly, increasing accessibility of products to guests has been especially prevalent with the goal of making it easier for guests to access the organization's products when not on site. This remote access has been done through distribution and online sales.

The adaptation efforts focused on changes in maintenance routine had modest application. Eight of the twenty-four respondents reported adopting them. These efforts address crop health, and include adjustments in the fertilizing, pruning, and watering routines. Fertilizing was done to protect fruit growth, and was a standard action for the industry. Providing airflow is done to counter the increased suitability for occurrence of fungal growth from increased temperatures. Similarly, pruning was done both to shade fruit and to prevent or reduce fungus and disease occurrence through providing spacing for airflow on the vine. Watering-routine changes were variable in practice, ranging from decreased watering for some organizations to a substantial increase for others, depending on the crop needs, as we explain further in relation to summer precipitation change.

Staggered harvest times was another adaptation action applied by a small portion of respondents (4), however it was mostly applied by smaller “mom & pop” organizations (3), citing “labor issues” as the main driver for application. The respondents involved adopted this practice to ensure harvest quantity and staff availability while limiting crop wastage. A respondent from a smaller organization linked their situation to a lack of resources, explaining, “Often we have to make difficult choices.” Another respondent further explained it in this way: “We lack the resources that would enable us to operate both the winery and harvest the fields.” These are illustrative of how smaller organizations must prioritize various aspects of their operations to stay afloat, and how climate change impacts add to the stress and compound these challenges.

In contrast to the climate-linked problems arising from increased visitation, the degree of concern over the risk of freeze damage on root systems has been significant. This risk is especially of note for respondents from agritourism. Respondents unanimously stated that there was little they could do to protect crops if there is no snow cover and a freeze event occurred, such as the Polar Vortex of 2014. That said, there was a small number of adaptation strategies identified by respondents at various degrees of development and implementation. The strategies that were identified are focused on root protection. One strategy involved burying the base of grape vines in a mound of soil, insulating the crucial portions of vines. The respondent who identified this strategy was skeptical of the practicality in terms of scaling up, “only being realistic to protect crucial vintages.”

A small portion of respondents (3) identified another strategy adopted in response to early and late freeze risks. This is done by heating the crops to keep them above freezing point. This strategy has taken various forms such as housing the crops in temporary shelter, or heating them directly via candles or fires. Much like root burying, the respondents that reported warming crops also questioned scale-up feasibility. However, while there may be little that can be done to protect whole fields, respondents reported some success in protecting crucial vintages.

In summary, various adaptation strategies have been applied to address temperature increases, the most widespread being the use of various pruning methods. Other adaptation efforts being applied include crop protection through heating or the use of protective equipment, ecosystem services through habitat creation and biological control, operational changes such as service styles, and changes in maintenance routine such as staggered harvest times and root protection applied at various scales. These adaptation efforts have been applied to varying degrees depending on the organization's needs.

Precipitation

In response to the exacerbated dryness that could occur from a decrease in precipitation, respondents from newer organizations with younger crop plantings undertook adaptation efforts focused on watering the crops. The most broadly applied method was hand watering. This action is not any different from normal operations, but the frequency has increased, resulting in greater labor requirements. In contrast, nearly half the respondents from organizations with long histories (8 of 18) identified the use of irrigation systems and water trucks as their adaptation actions to decreasing

precipitation. Regardless of the age of plantings, the largest divide amongst respondents was between those with (6) and those without (18) an irrigation system. Those without irrigation systems unanimously cited installation of irrigation as a top adaptive priority when asked, “What are the most important improvements that could be made to current infrastructure, in your opinion, to address known and anticipated vulnerabilities to climate change in the region?” In contrast, organizations with more established plantings (18) reported undertaking few adaptation efforts to address precipitation changes. This was attributed not only to having irrigation systems already in place, but also to the older plantings having deeper roots that are more resilient to water shortages. The result was flexible, variable use of irrigation to enhance crop resilience, as explained by one respondent: “During the dry periods, I only need to turn the water on once a month.”

In regard to precipitation increases, particularly if they occur during autumn, there have been numerous adaptation efforts focused on protecting harvests. The ideal harvest conditions are dryer and uniform, which a respondent described as “Increasingly unlikely.” This has caused many respondents (9 of 24) to rethink their operations, especially during fall. As mentioned in our discussion of temperature trends, staggered harvest times have been applied with some success. However, the application of this method has been done in response to crop-quality concerns from impacts of precipitation complications on sugar levels. This is done through keeping harvest times flexible, as this allows organizations to have a window of ideal times to harvest as opposed to a single date, enabling organizations to better manage crop-quality requirements.

Another adaptation strategy applied in response to increased precipitation is the use of drying agents to counter the chance of fungus and disease developing. While a modest share of respondents (8 of 24) described applying this method, those that did, identified great success in maintaining fruit quality.

In response to variable precipitation during winter and its association with freeze damage, respondents in the agritourism sector applied nearly identical strategies as those mentioned in our discussion of temperature changes, and were done in response to address both conditions. These efforts are focused on crop protection through efforts such as heating or insulating. Similarly, in response to winter precipitation that may occur as rain, or during snowmelt periods, the ground is frozen and cannot facilitate drainage and consequently, flooding occurs. This has been addressed through adaptation actions focused on water movement systems, involving infrastructure updates and will be discussed below.

Similarly, flooding as a result of heavy precipitation events contributes to most respondents having analyzed their drainage systems, management, and modes of operation. This might result in updates to water-movement systems from hardware to software among some respondents. While no respondent was currently engaged in water-system updates, there were three currently planning system updates. In contrast, a majority of respondents (14 of 24) identified naturalized approaches aimed at increasing drainage and environmental sustainability. These efforts have been done through planting cover crops on unused land and naturalizing areas. The respondents who engaged in these efforts found them preferable, as one respondent explained, they were “manageable and cost efficient,” even contributing to year-round drainage control.

In regard to system updates, one respondent identified an adaptation project focused on installing drain tiles to better manage melt and storm water, describing their reasoning as, “We more do it for the comfort of our livestock than the agricultural production.” Twelve respondents identified efforts that are focused on updates or completion of water-movement systems, and enforced by local governments.

Heavy precipitation may also present the risk of fruit damage, as a result of damage from precipitation and have been met through application of protective equipment. These include temporary shelters such as tents, or maintenance routine changes, such as pruning styles that allow for natural protection from leaves. These efforts have been widely applied by respondents and have found variable levels of success.

In summary, precipitation impacts have been met through variable adaptation strategies, most prevalent of which is the use of irrigation systems and pruning methods. Other adaptation strategies that have been applied include analysis of drainage systems (naturalization/water movement system updates), crop protection structures, drying agents, heating and insulation techniques, and staggered harvest times. In early stages of adaptation, respondents reported success, which has left them feeling optimistic in their application and preparation of adaptation efforts.

Changes in the Growing Season

The positive sentiment of respondents focused on agritourism due to an increase in growing-season length portends to the transformation potential that agriculture could have in the region. The expansion of growing season has led to a majority of respondents (14 of 24) identifying a diversification of varieties or plantings. Among

respondents focused on viticulture, the main diversification identified was a transition from white wine producing grapes to red, including Cabernet, Merlot, Pinot Noir, and many more. This diversification allows many winery organizations to expand into the more traditional varieties that have greater market appeal. The diversification of crop varieties also allows different harvest times, which could lessen maintenance burdens and staffing requirements throughout harvest periods.

The growth in tourism visitation traffic during the autumn season arising from the expanding growing season has been met through operational changes that include service styles, event offerings, and guest areas. Service-style changes include those mentioned previously, such as the type of wine tasting called flight tasting, and increasing accessibility through retail. Modest numbers of respondents (10 of 24) have adopted event offerings as an adaptation strategy. These include offering weddings and community events, done to both subsidize income and draw new guests. However, the most widespread adaptation effort applied by respondents has been expansion of guest areas. These include expansions of patios, rentals, and tasting rooms. In summary, the main adaptation efforts to an increased length of growing season has been an expansion of plantings and operational changes.

5.2.2: Water Recreation: “We’re trying our best”

5.2.2.1: Perceptions about Adaptation

Nearly all respondents (21 of 23) expressed optimism when discussing the various adaptation efforts being applied and planned. Respondents focused on waterfront and marina management unanimously indicated perceiving their adaptation efforts as being supported and useful. A respondent supported this position stating “We

had a project that needed to be done relatively quick, and we were able to get funding and approval from the city within a month.” In contrast, respondents focused on visitor accommodation unanimously identified a sense of helplessness in terms of effective options available to adapt to adverse impacts of climate change. While there are some adaptation efforts that can be taken, the scale to which they would need to be applied was often perceived as unmanageable. For instance, a charter experience operator explained their situation: “Yeah I can get more fuel, but that doesn't really solve the problem of the fish not being where they should, there's really nothing I can do to change the water conditions.” For respondents focused on conservation and preservation, although their perceptions of workable adaptation options were generally optimistic, many considered their adaptation projects as immense in size and scope, with one respondent using the word “daunting” to describe them.

5.2.2.2: Climatic Change Adaptation Efforts

Issues arising from changes in precipitation and temperature have given rise to many adaptation efforts, which vary between organizations. They can range from small efforts focused on water testing to massive efforts such as whole wastewater system updates. While some impacts may be present during multiple seasons, they can be met by vastly different efforts. Differences in recreation focus will also show different adaptation strategies, as well as provide an excellent exploratory look at how the same climatic change can have vastly different impacts. This discussion will follow the same format utilized in our discussion of observed climatic changes.

Temperature

Increased water contamination was identified as hardest to adapt to, especially for cases resulting from wetland flushes, as those are perceived as largely an uncontrollable natural phenomenon. A small majority of respondents (13 of 23) identified their adaptation efforts to such events as increased frequency of testing of water sources and communication with the public. These contaminants will be further discussed concerning precipitation changes.

Adaptation responses to the escalating problem of invasive species were identified by many (14 of 23) as focused on increased vigilance and policy action. Policy action has mainly focused on boat inspections and cleanings, which has been done in an effort to reduce man made species transfers. Respondents involved with marina management (2) identified expansion of boat washing stations as a possible entry point to effect meaningful adaptive change. In contrast, vigilance has been done through many informal initiatives focusing on increased observations of natural areas.

Two main forms of ecosystems-based interventions have been adopted in response to ecosystem-related climate risks. First, invasive-species control is done in an effort to give the natural species a better chance at dominating the introduced invasive species. The second type is tree migration, which has two goals – diversifying the tree stock to ensure forest preservation and ensuring natural food supply for fauna in the area.

Species die-offs that have created undesirable conditions for visitors desiring to recreate in nature, also have adverse social and economic impacts for the whole community. In responses to species die-offs, most respondents (17 of 23) identified

some form of effort to manage or prevent them from occurring. These efforts were reactive to visible manifestations—short-term in nature—and are mainly the low hanging fruit that are also public facing from a user perspective. These efforts focus on clean-ups of solid waste and deceased creatures. These can have serious operational complications as respondents identified these clean-up efforts as “costly and time consuming.”

Adaptation efforts in response to the observed increases in temperature and consequent extension of the tourism season were variable based on recreation focus. A majority of respondents (17 of 32) considered the temperature increases beneficial due to increasing customer visits. However, they also noted admittedly minor operational adjustments to address complications that arise from increased visitation. To address these complications, the main adaptation efforts have centered on increased communication with guests and on monitoring. Communication efforts have been focused on the form of notices to the public, through either written materials or social media. These are done to help manage guest numbers, expectations and experiences. One respondent rationalized these communication efforts as follows: “We hope that by telling them the grass might not be mowed or that there might be a full trash can, they won’t go and leave us a bad review on Google.” This perspective demonstrates that even when climate (temperature) change is expected to have positive impacts, adaptation efforts might still be needed to take advantage of those benefits.

Adaptation efforts focused on the impacts of warming winter temperatures varied among respondents, but focused on coastal erosion. In response to increased erosion pressure, respondents focused on waterfront and marina management have focused

their adaptation efforts on two main efforts, strengthening shorelines and updating infrastructure. Strengthening shorelines has been done through efforts such as boulder placements, updating coastal structures such as seawalls, and developing more resilient structures such as docks. A respondent's description of these efforts as "expansive and expensive" captures the common sentiment well. It also explains why only few adaptation efforts were currently underway, although it is notable that nearly all respondents (19 of 23) identified some adaptation effort as planned to begin within 1 - 5 years.

In summary, the adaptation efforts applied by respondents focused on water recreation in response to temperature changes have been diverse. These efforts include clean-ups following species die-offs, ecosystem protection through tree migration, infrastructure strengthening and updates, operational changes such as communication, and policy action.

Precipitation

In times when precipitation did occur, visitor accommodation focused their responses on approaches used to protect positive guest experiences. Increased communication with potential and current customers was the most widespread. Respondents applied this communication enhancement in all stages of the visitor experience. From the moment when a guest first books a reservation, they are made aware that it may not be a flawless experience. Similarly, for fishing charters, clients are informed that there is no guarantee of finding fish, allowing for a more authentic experience. A respondent focused on charter fishing explained that the visitors they accommodate are understanding of the difficulty, but are still disappointed when they

are unable to catch any fish. All such operators agreed this was not the ideal experience for guests, but did acknowledge that operations might be like that in the face of increased climate and condition variability in the future. Increased communication also forms the main adaptation strategy concerning increased prevalence of water contaminations, and has been met with success.

In response to decreased suitability for recreation, findings suggest that there might be hope in bettering the guest experience through equipment and organizational investments. A respondent focused on charter fishing experiences identified better engine efficiency, fish location technology, and fuel storage expansion as currently planned adaptation efforts. The goal of these investments is to better allow travel to many sites during an excursion in the case no fish can be found. Similar investments have also made up the focus of adaptation efforts for organizations associated with watercraft rental. Such investments have been focused on expanding capacities for visitor accommodation. A respondent focused on watercraft rentals identified current expansions to not only infrastructure such as docks or slips, but also watercraft stocks. Expansion of infrastructure will allow multiple uses of resources and space ranging from equipment storage to private rentals, thereby allowing more efficient use of the space available. A respondent currently undertaking these adaptation efforts identified the goal of these efforts as being able to maximize use on days when satisfactory conditions are met. However, through investment and engagement, the expressed hope was that guest experience would not be adversely impacted by precipitation increases.

Adaptation efforts in response to intensified ice-based erosion arising from winter temperature changes also formed the basis for efforts to address the compounding

effect winter precipitation can have. This has been done through efforts focused on strengthening shorelines and updating infrastructure. A small majority of respondents (13 of 23) also identified reported adaptation efforts focused on managing increased precipitation, but as one respondent noted aptly, these were “highly variable in scope and size.” These efforts have focused on increasing broader system resilience, and include increasing storm water movement systems, such as gutters and hardened drainage paths; reconstruction of coastal structures, such as bike paths or restrooms; and strengthening structures like seawalls and associated infrastructure. Given the highly variable form of adaptation, the majority of respondents (19 of 23) identified at least one project that was currently completed or underway.

In response to the localized flooding being experienced in the region, the main adaptation efforts have focused on infrastructure upgrades and ecosystem services. Similar to action taken in response to erosion, infrastructure upgrades make up the main adaptation effort to potential flooding increases. One respondent points to the challenge of old infrastructure that needs to be upgraded or repaired and the immense resources needed for the work: “Most of this was built and installed in the 70’s, so it’s at least 50 years old...it’s about time it was redone.” Another strategy identified by a number of respondents (13 of 32) to address flooding was naturalization of areas. These efforts have focused on expansion of deep-rooted plantings in coastal areas and wetlands. However, many respondents identified labor requirements as a current hindrance to such efforts. This strategy was identified by numerous organizations (16 of 32); however, few of them (7 of 16) identified current applications in the region under their jurisdiction.

To summarize, the main adaptation strategies in response to precipitation changes has focused on increasing the resiliency of systems. Efforts have included ecosystem services such as selective plantings, infrastructure upgrades to docks and marinas, and strengthening of structures through boulder placement and enhanced materials.

Changes in the Growing Season

Since extended growing seasons have been largely perceived as positive for business, adaptation efforts have been more about adjusting to increased labor demands and uncertainties of guest experiences than on addressing direct adverse impacts. To address increased labor demands, respondents have relied on organizational changes focused on increased communication. This is done to inform the public of conditions to expect when utilizing recreation areas. This is similar to approaches applied in earlier sections. These dynamics have been addressed under responses to lengthening of the growing season due to their relation to an increased size of tourism season.

5.2.3: Winter Recreation: “We manage what’s in our control”

5.2.2.1: Perceptions about Adaptation

The respondents involved with winter recreation emerged with the highest level of optimism among all respondents in terms of the potential and levels of action to adapt to observed and projected climate change. A respondent from a smaller public recreation area attributed the optimism to the support networks available from tourism officials and other winter recreation operators. “We really get a lot of support from the bigger resorts, and that comes through in funding, expert advice, and knowledge... it

really leaves us feeling like they have our backs,” observed the respondent. In sum, while perceptions across the different tourism operators were diverse, respondents were generally positive about their preparedness and adaptation efforts.

5.2.3.2: Climatic Change Adaptation Efforts

Temperature

Although impacts from increases in temperature were perceived as minimal on winter recreation, the most notable impact respondents identified outside of winter were associated with decreased grass quality. To address this, respondents unanimously indicated that irrigation systems were the main adaptation response. This allows them to both water plants, as well as provide them nutrients they may be lacking. While irrigation is often standard for operations, a small number of respondents (2 of 9) indicated specifically increasing the use of irrigation systems in recent years as a response to exacerbated dryness.

Similar to respondents of water recreation, the winter recreation respondents were also engaged in ecosystem protection to address ecosystem concerns. Although tree migration was known to protect the overall biodiversity of natural areas, little has been done. Some adaptive efforts such as tree migration were also reported to be in the planning stages.

The principal concern for these respondents was on impacts to guest experience, as this has been impacted by snowmaking constraints and snow retention problems that were linked to winter warming. In the face of snowmaking constraints, the main adaptation approach has focused on expansion and updates of snowmaking machines. For organizations lacking the equipment (3), their main adaptation efforts have been

installing such equipment, the goal being to at least obtain partial coverage of recreation areas. The size of investment in these technologies varies depending on organization size and available resources.

In response to complications to guest experience, respondents from larger private recreation areas focused their adaptation on efficiency improvements for their current snowmaking equipment. In some cases, temperature increases have kept large operators from utilizing their equipment to the full extent, as a respondent narrated: “We’ve got adequate snowmaking capabilities, but we lack opportunities to use them.”

Similarly, to address issues undermining guest experiences, some respondents focused their efforts strategically on diversifying revenue streams. This is a result of their fears that revenue streams could be undermined year over year. One respondent explained their precarious situation as, “Everything relies on snow; no one will make the trip if it’s not what they expect.” Given that, respondents have turned to alternative revenue streams that have included construction of new facilities, incentives for guest use, and land use changes. A majority of respondents (8 of 9) cited the creation of new recreation areas as the main approach to protect guest experience and revenue levels. The main way this has been done is through changing land use to better facilitate all-season use. Respondents unanimously expressed the hope that creating new recreation areas will help preserve a positive guest experience. This can be done by providing a more diverse experience with more opportunities for enjoyment. This has taken forms such as converting forested areas to mountain biking trails, establishing birding areas, and even creating a disc golf course. This effort was popular, as 7 of the 9 respondents identified changing land use in order to secure new revenue streams as

either planned or completed in at least one form. Many respondents considered creating new recreation areas useful to protect revenue streams. “Particularly useful if temperature conditions for snow are not met”, in the words of one respondent.

Another approach identified in response to threats to revenue levels has been to keep all expenditures by guests onsite. This can involve considerable construction, as the main projects identified to achieve this were restaurants, movie theaters and stores. One provider adopting this approach provides a rationale: “Having these facilities onsite gives guests a reason not to leave and really makes it a more centralized experience.”

In summary, given the increased summer and autumn temperature, respondents perceived them as minimal. Given that, principal adaptation efforts have focused on preserving suitability to both guests and the natural ecosystem. Similarly, the issues arising from winter temperature increases have mainly been met through diversified revenue streams, ecosystem protection, equipment expansion and updates, and operational changes. Such efforts are done primarily to preserve guest experience, and can lay the foundation for long-term success as we move into the mid-century period.

Precipitation

The exacerbation of dry periods as a result of increased temperature, and the increasingly variable precipitation patterns led a number of respondents (3) to identify changes in watering routines to maintain grass quality. This is done through adjustments to watering systems to deliver adequate water amounts where it is needed. However, these changes were perceived to have minimal impacts by respondents, and therefore only few respondents identified concern over such changes.

In response to precipitation increases, impacts and responses to increased precipitation depended on the form in which the precipitation occurred. If winter precipitation occurs as rainfall, numerous adaptation efforts were reported as applied. Application of snowmaking equipment or increased snowmaking formed the principal adaptation to decreasing or variable snowfall. It is worth noting that snowmaking can bring along its own set of problems, namely economic and other operational problems. One respondent explained economic complications that they encountered while manufacturing snow: "The issue isn't being able to produce snow, but the quality of said snow and how high the associated costs are to produce...this is a constant worry with snowmaking, and it makes the margins very tight." Still those who had adequate snowmaking equipment could focus on increasing the efficiency of their equipment, as one respondent explains: "We can cover all our runs, so the real focus now is making them better, and hopefully it might save us on our water bill." However, installing or upgrading snowmaking equipment has been slow to be applied, as all respondents identified high expenses involved in expanding snowmaking capabilities.

Another impact from winter precipitation falling as rainfall was compromised snow quality, mainly in the form of icy or slushy snow. The only potential adaptation strategy identified by respondents to solve this problem was to employ specific snow groomers designed to break up icy snow. For respondents from public recreation areas, potential application of these groomers was considered "a far off request, as there are far higher priorities," in one respondent's words, explaining why respondents unanimously said groomers were rarely used by local organizations.

In response to the risk of increasingly variable precipitation undermining guest experience, the diversification of recreation offerings was also identified as an adaptation. This adaptation was done through similar efforts as those discussed for winter temperature changes. One respondent referred to such shared responses as “killing two birds with one stone.”

In summary, expansion of recreation offerings, infrastructure upgrades, increased watering, and snowmaking system expansion were the main adaptation efforts applied in response to precipitation changes. The adaptation efforts are likely to provide a basis for success for respondents of winter recreation as we progress to the 2040- 2059 period. In addition, it is worth noting that the interviews of tourism providers have brought to light the perceptions, climate risks and vulnerabilities, and adaptation strategies of respondents about and in response to climatic changes. These have varied across recreation types and organizational focus. However, the key takeaways from the interviews will be further discussed together in the subsequent section, and conclusions.

Changes in the Growing Season

The greater tourism season and subsequent increased recreation use from an increased length of growing season has been met with identical approaches as those identified by other recreation managers in sections above. Respondents of winter recreation have focused their adaptation efforts on organizational changes such as communication levels and watering routines. All respondents reported these efforts as successful currently in their limited application. In summary, respondents from winter recreation have focused efforts on organizational changes to address the increased length of growing season and subsequent larger tourism season.

Chapter 6: Discussions and Conclusion

This thesis research sought to examine the perceptions of observed and projected risks and impacts of climate change among the agritourism, water and winter recreation providers in Northwest Michigan, and current and planned measures to adapt to these changes in order to assess the nature and extent of preparedness of this sub-sector to address adverse impacts of climate change. We addressed this and organized the discussions around the three research objectives: 1) to identify the projected changes in climate for the Northwest region in Michigan; 2) to describe observed impacts for the tourism industries from changes in climate; 3) and to analyze local agritourism, water recreation, and winter recreation industries' adaptation efforts throughout the Northwest region of Michigan. The discussion is organized by research objective.

6.1: Projected Changes in Climate

Secondary data show that the northwest Michigan region is already experiencing significant changes in climate that could significantly affect the tourism industry and economic mainstay in the region. The future projections to the year 2059 show that these changes in climate will escalate, with significant but variable impacts across space and time on the three sub-sectors of the tourism industry under study.

6.1.1: Climate Projections

6.1.1.1: Temperature

Temperature is projected to increase in all seasons, the scale of the increase varies by location. In regard to average summer temperature, it is projected to increase by 5.0 - 5.5 degrees Fahrenheit by midcentury (2040-2059 period). Similarly, average

autumn temperatures are expected to see a similar increase as those experienced during summer, projected to rise by 3.75 - 4.5 degrees Fahrenheit. The projected increases in average winter temperature of 3.0 - 3.75 degrees Fahrenheit by mid-century. Within the study region, the greatest increase will be experienced in Grand Traverse Bay.

6.1.1.2: Precipitation

Projected changes in precipitation are more variable and location specific, making them harder to predict than temperature changes. The total summer precipitation is projected to experience a decline of 0.25 - 1.0 inches across Northwestern Michigan. Similarly, the change in autumn precipitation totals are projected to have the greatest degree of variation throughout the region, ranging from a decrease of up to 1 inch, to a possible increase of 1 inch. There may also be increases during winter, which will vary from 0.05 to 1.5 inches. Similarly, projections of heavy precipitation mostly show modest increases in the number of days receiving more than one inch of precipitation. The increase varied from 0.5 to 1.0 days with over 1 inch of precipitation by midcentury.

6.1.1.3: Changes in the Growing Season

The projected increase in the length of the growing season is due to increases in frost-free days. Although this varies by location, the projected increases are across the entire Midwest region and across the Great Lakes. The projected increases were also significant, varying from 35 to 45 days, and exhibiting a north to south distribution, with the greatest increases experienced in the south of the region and south Michigan. This change will have the greatest impact on the biosphere, and have the potential for both

positive and negative impacts on nature-based tourism in the region, particularly agritourism. More importantly, discussions about the impacts of climate change have traditionally been focused on adverse impacts of climate change. The findings of this exploratory study show that while the practitioners recognize and have observed such negative impacts, for this sub-sector the observed and potential future potential positive impacts appear more prominent and can help to advance the message on the need for action to address climate change with a more positive message. In this case, it is to get the agritourism industry and planners ready to take advantage of the opportunities that climate change offers, particularly through a lengthening growing season, while also implementing strategies to mitigate the adverse impacts.

In summary, the climate projections utilized in this research supported the previously identified climate projections. The temperature projections did support the findings of Kovacs & Barrett, (2020) in their assessment of temperature changes during the late-century. While Cutter & Finch (2008) perceived that changes in climate would be moderate, and for some variables this might be the case, the projections and findings suggest that the temperature changes (3.00 - 4.5 degree increases in aggregate in winter and summer temperatures) and the degree of lengthening of the growing season (35-45 days) are considerably high for the region. Findings from Skaggs & Baker (1985) and Wanyama, et al., (2020) also align with the projections that the extent of growing season lengthening is already highly significant, and the lengthening will continue. Given the impacts of such lengthening already observed, both positive and negative, growing season changes will remain a major dimension of climate change in the region. In summary, the climate projects have provided a

fundamental basis to understand the current situation faced by respondents from climate change, and have supported numerous previous works, all affirming that climate change will be an even more important factor in Northwest Michigan that the tourism industry should pay more attention to because of its potential disruptive nature.

6.2: Observed Climatic Change Impacts

The following section is organized by sub-sector or recreation type, and starts with a brief identification of impacts identified by respondents before discussing the implications of such impacts, including comparison to previous work.

6.2.1: Agritourism

The impacts identified by respondents from agritourism as a result of precipitation changes include crop growth hindrance due to drought, crop quality complications from variable sugar levels, erosion, freeze damage due to lacking snow-cover, fruit damage from precipitation impact, and localized flooding. Impacts of temperature changes have similarly been diverse, and include exacerbation of dry periods, freeze damage to crops, higher yields, increased pest and disease pressure on crops, increased yields and diversity of crop varieties, and an increased tourism season. The findings demonstrate that the perceived and observed impacts of climate change from the practitioners' perspectives have already been numerous and significant, suggesting that they are likely to increase in the future, affirming the need to hasten responses for the industry.

The increasing yields of agricultural production and increased tourism season length agree with the findings of Kovacs & Barret (2020), and offer opportunities for the agritourism sub-sector. Similarly, this increased suitability for viticulture is one of those

climate-change induced opportunities also confirmed by the findings of Wanyama et al. (2020). There is evidence that some operators are already taking advantage of the new opportunities evidenced by accounts of new people moving into the region specifically because conditions for agriculture (including viticulture) have improved. Wanyama et al. (2020) also note this increase in interest and actual growth in agriculture. In regard to some of the negatives that may be experienced, the increased exposure to invasive species and pests, also noted in findings by Kovacs & Barrett (2020) in their synthesis report of climate change in the Midwest, highlight the need to also prepare to deal with these pest and invasive species challenges. Our findings of the increased potential for fruit damage from changes in precipitation intensity, form and amounts, as well as temperature variability, support findings from Kovacs & Barrett (2020). The special contribution of this research is that the confirmation comes from the voices of the tourism practitioners, and grounded in their specific realities within different parts of Michigan. Studies that examine the tradeoffs between impacts of the longer growing season and the adverse impacts including pests and diseases and invasive species to have a holistic sense of the net impacts of climate change in agritourism, as well as in other tourism sub-sectors.

6.2.2: Water Recreation

Overall, findings suggest that the water-recreation tourism sector in the region was the least affected compared to the other two sub-sectors studied in terms of short-term impacts, except to operators in erosion-vulnerable coastal areas and poorly drained locations. The impacts tended to be longer term in effect and the more significant ones operated through the combined effects of temperature and precipitation,

suggesting the need for longer-term solutions and investments. This however, might also have the disadvantage of discouraging short-term interventions or an early start to addressing the long-term issues. To be sure, respondents identified numerous impacts of climate changes that are already being experienced currently. In relation to precipitation changes, the impacts include erosion exacerbation from storm pressure, flooding, water contamination from wetland flush events, and water movement system failures. The temperature changes were mixed and diverse in terms of impacts. Impacts include biodiversity challenges, degraded conditions for recreation, heightened use of recreation areas, exacerbated invasive species pressure, increased ice-based erosion pressure, increased length of tourism, and more frequent water contamination. These impacts cause variable complications to operations and will present challenges in the future. The issues of invasive species need longer term ecosystems-based solutions to protect that natural heritage of the region that is the key attraction and is central to the tourism branding *Pure Michigan* while coastal areas need infrastructural solutions against erosion.

Our core finding from water-recreation practitioners that the main impact of increasing temperatures was expansion of the tourism season accompanied by increased water-recreation use, is confirmed by findings in the synthesis report for the Midwest by Kovacs & Barrett (2020). This is another example of climate change expanding opportunities to certain types of nature-based tourism, and the water-recreation sector, as other sectors where a longer season is a benefit, have the opportunity to prepare for the expanded traffic and visitor numbers in cost-effective ways. Our findings show that these adjustments were in process, currently still on a

trial-and-error basis, but there are many creative ideas being tried out including diversification of services. The finding of erosion exacerbation as a result of increased ice-based impacts and storm pressure supports the findings of Abdel-Fattah, et al., (2014), and their projections that erosion pressure would increase – a major and growing challenge for tourism activities located in or based on coastal areas. In addition, increased invasive species pressure agrees with findings in the synthesis by Kovacs & Barrett (2020) that it will only increase. These positions further develop the connection of climate impacts on recreation, regardless of its geographic location.

6.2.3: Winter Recreation

Findings from practitioner perceptions suggest that winter recreation was the most vulnerable sub-sector in terms of exposure to adverse impacts of climate change, in this case, warming winters. The principal concern among respondents from winter recreation focused on degraded conditions for recreation, particularly erratic and reduced ice cover and quality. The observed temperature change impacts including conditions preventing snowmaking, increased frequency of melt periods, insufficient grass quality, snow retention issues, and variable snow quality, illustrate the dimensions of this unique vulnerability. Similarly, the impacts of changes in precipitation have focused on the guest-experience complications identified above, as well as impacting snow quality, localized flooding frequency, and power outage frequency. All winter recreation respondents have encountered these impacts; however, the scale of this impact varies by location. The fact that snowmaking has now become almost a regular operation in the ski/skating subsector illustrates both the impacts and levels of awareness of the related climate impacts to this tourism sector. It can also explain why

the sector might be the most advanced in taking response actions, especially for the larger providers with sufficient resources.

As would be expected, the impacts of temperature and precipitation change have had the greatest impact when such changes occur during the winter season. The observed and perceived importance of winter precipitation on snow cover and quality, and on the revenue streams of many of providers affirm findings of Winkler et al. (2014) who had contended that winter precipitation would become particularly important going into the future. De Loë, et al. (2001) also observed increasingly variable snow cover, as our respondents did, as a major climate impact that would get worse with time. These findings illustrate that the winter recreation sector is acutely aware and concerned of climate change risks and impacts for their sector. For small inadequately resourced operators, this climate risk represents an existential threat to their business. This research will better support the knowledge of climate change impacts for the winter recreation sector.

6.3: Adaptation Effort Analysis

Given that research on climate change adaptation efforts is still in the early stages in Northwest Michigan, our exploratory study contributes to filling this gap, with a limited number of studies to provide points of reference. This makes a brief recap of the various adaptation efforts (see APPENDIX 4), in particular, a potentially significant contribution to the literature. Their potential for wider application of such adaptation efforts is also discussed for each of the tourism sub-sectors.

6.3.1: Agritourism

Findings show agritourism practitioners have applied various adaptation strategies, illustrating a reasonable level of preparedness to respond to climate change impacts. To address temperature increases, the most widespread approach used is different pruning methods. Other adaptation efforts being applied include crop protection efforts through heating or the use of protective equipment, ecosystem services through habitat creation, expansion of plantings and operational changes such as service styles, and maintenance routine changes such as staggered harvest times. Similarly, in response to precipitation changes, adaptation strategies focused on use of irrigation systems and pruning methods, as well as including analysis of drainage systems (naturalization/water movement system updates), crop protection structures, drying agents, heating and insulation techniques, and staggered harvest times. These adaptation efforts have found success in application when applied, and may be useful to any agritourism operator facing climate changes. The diversity of these response actions illustrates the level of preparedness of this sector against adverse impacts of climate change but evidence that the sector practitioners are also actively adapting to take advantage of the opportunities that climate change has opened out are only now emerging and will require more work to bring. The latter is important in spreading the message of the need for preparatory action because it brings a positive dimension.

6.3.2: Water Recreation

Adaptation efforts vary between water recreation respondents, and range in size and scope. Responses to temperature changes include clean-ups following species die-offs, ecosystem protection through tree migration, infrastructure strengthening and

updates, operational changes such as communication, and policy action illustrate the need for a broad-based industry-led approach. In contrast, precipitation change responses have focused on increasing the resiliency of systems, done through focusing on ecosystem services such as selective plantings, infrastructure upgrades to docks and marinas, and strengthening of structures through boulder placement and enhanced materials. These are critical for the long run. Responses to a lengthened tourism season appeared to be more reactive, focusing on addressing increased labor demands, adjusting organizational practices such as increased communication, than they were proactive to take advantage of the opportunity this offers, although some evidence of that was beginning to emerge. These efforts have been widely applied throughout the region, and may provide a view of the adaptation efforts applied by the industry as a whole, both mitigating the worst adverse impacts of climate change while being nimble to take advantage of new opportunities to remake the industry and enhance its sustainability.

6.3.3: Winter recreation

The enhanced awareness of climate risks and the taking of early action against them explains the level of optimism that respondents appeared to approach adaptation with, and the number and extent of adaptation efforts currently adopted. In response to increased temperatures and their threat to guest experience, adaptation efforts include diversified revenue streams, ecosystem protection, equipment expansion and updates, and operational changes. In contrast, expansion of recreation offerings, infrastructure upgrades, increased watering, and snowmaking system expansion were the main adaptation efforts applied in response to the precipitation changes. These adaptation

strategies were well received by respondents and local communities, which may provide a demonstration for winter recreation respondents nationwide. While this industry appeared well prepared to address climate change impacts, it remained precarious when cost-effectiveness issues come into play as projected change shows escalation of adverse impacts into the future.

6.4: Study Limitations

Several limitations may have affected this qualitative research. The main limitations surround the sample size and data collection. The small sample size, particularly for winter tour operators, can limit the representativeness of the views sampled from respondents in the sample size in relation to the entire population of tourism operators for each of the three sub-sectors of the industry within Northwest Michigan – agritourism, water-based recreation and winter recreation. Still, the other two sub-sectors were well represented in terms of sample size for such qualitative studies. The convergence of responses by questions in each of these subsectors confirms our contentions, as it suggests saturation in the diversity of viewpoints, and therefore indicate reliable levels of representativeness. The winter recreation sector in the region only has a small number of operators even though we captured a good share of them. In addition, there potentially are limitations to the reliability of the findings from future climate projections chosen, as well as elements of the interview instruments.

6.4.1: Climate Projections Limitation

Lack of climate projections that are specific to particular recreation types is one way that chosen climate projections could pose limitations to this research. While agritourism was relatively well addressed through the climate projections utilized giving

a broad landscape level picture, projections on frost-free season were addressed inadequately even though they were respondents' principal concern. Similarly, for water recreation, useful projection metrics would include storm frequency and cloud cover, as those can have major implications on customer use patterns, which the projections do not address adequately. In contrast, climate projections focused on intra-season variability would have provided a more complete view of climate change's impact. Further, the climate projections are based on relatively coarse spatial scales that do not adequately address climate dynamics experienced by the respondents at localized scales. The projections had not been downscaled. However, these limitations have been at least partially mitigated through the design of the study. Interview questions allowed respondents to identify whatever implications they observed or saw fit, and were not limited in their discussions to specific climate variables addressed in the projections.

6.4.2: Survey Instrument Limitations

The content of the survey questionnaire might also limit the qualitative research findings. The questionnaire was designed as a generalized instrument to allow structure and systematic analysis across respondents and recreation types, while also allowing all respondents to identify the various situations being experienced. This meant that some questions had little applicability to some recreation type or other. This might have the impact of diluting attention from principal concerns of respondents, as they were asked about and had to sift through aspects that may have little relevance on their specific operations. For instance, questions on climate changes were not broken up by season, but instead sought information on any and all impacts related to specific

changes in climate. This was done to be considerate of respondent's time, as well as minimize redundancy while still allowing the identification of any climate impact that the respondent deemed relevant. This further allows the systematic identification and linking of perceived and observed climate change risks, their impacts, and adaptation responses or efforts.

6.4.3: Sampling Limitations

The selection, numbers and relative diversity of the sample makeup might influence the representativeness of perceptions and other study findings relative to the study population. Although the sampling design was stratified to ensure representation from each of the three tourism sub-industries, they were also chosen for the study based on their importance in the region. The overall sample size of 55 is good for such a qualitative study but the distribution across the three sub-sectors was uneven. The actual numbers and composition of the sample depended largely on the necessity of voluntary participation by respondents and the number of organizations within each sub-sector type in the study region. This made for variable numbers and representation across tourism sub-sector types and sizes in the makeup of the respondent pool. We took multiple efforts to enhance participation across tourism types, including using multiple modes of communication and reminders (phone, e-mail, and personal visits) and flexibility in the mode, timing and venue of the interview (allowing both in-person and remote interviews by phone). Similarly, variable levels of responsiveness of potential respondents combined with actual variable numbers of businesses by sub-sector in the region determined both the number and composition of study participants. For the agritourism category, for instance, the 50% response rate resulted in relatively

poor representation of organizations focused more on agricultural production than agritourism. In addition, the lower response rates among water recreation providers resulted in a small number of respondents focused on visitor accommodation as well as conservation & preservation. Conversely, the small number of winter recreation operators in the sample was because there is only a small number of such operators in the region, and proportionally, the representation was reasonable.

In the end, although the sample size for winter recreation was relatively small and hard to improve on, and some aspects of recreation tourism may not have been included, the views expressed by the respondents tended to be convergent, suggesting potential saturation of representation of views. Despite the numbers, this gives us a window into a first exploratory examination of local perceptions and preparedness against adverse climate impacts in the form of adaptation efforts. Further, it is normal for in-depth qualitative studies that focus on depth rather than numbers and breadth to have small numbers of study participants, which makes our total of 55 respondents relatively large. In that regard and based on the nature of the sample population, the number and composition of our study was such as to not inordinately undermine the reliability of study findings.

6.5: Conclusion

The goal of this research was to identify the projected changes in climate for Northwest Michigan, and the perceptions, observed impacts, and adaptation strategies of practitioners focusing on the agritourism, water recreation and winter recreation sub-sectors. Overall, the study sought to investigate the level or awareness of climate change risks and impacts, and the preparedness of this crucial tourism region and

economic mainstay for Michigan, to address the impacts of climate change. This was done through in-depth interviews with 55 respondents hailing from agritourism, water recreation, and winter recreation. The most important climatic variable for agritourism organizations surrounds the growing season, while water and winter recreation had their attention on winter temperature changes. In response to these climatic variables, various adaptation strategies have been applied.

This research contributes to knowledge of both climate change impacts on the tourism industry, as well as the adaptation efforts that could be employed to address such efforts. It is also notable that the analysis is based on the views of the tourism practitioners, allowing a realistic assessment of the level of climate change knowledge, risk perception, adaptation responses and the potential for future action. Identification of adaptation efforts will provide knowledge to an increasingly crucial portion of climate science. In addition, this research may have broader implications such as identifying potential research areas, supporting tourism operators, and informing policy makers. Potential areas for future research may include industry specific analysis within the study region, or application of the study to a different tourism community. Support for tourism operators will come from informing respondents on the various adaptation strategies available, as well as their success. Insights from the perceptions and experiences of tourism practitioners, options for climate adaptation and their implementation firsthand can help to inform policy makers and practice, as well as planners at regional and state levels.

In summary, projected changes in temperature increase and extension of the growing season will be considerable while other changes are expected to be more

moderate for the Northwest region of Michigan by the 2040-2059 period relative to state, national and global projections. The industry practitioners are well aware of climate risks to their industry based on observation and experiences as well as acquired knowledge, but the impacts are variable across sub-sectors and geographically and include both positive and negative effects. While all have some level of vulnerability, the winter recreation sub-sector appeared particularly vulnerable. The practitioners have taken different forms of adaptive actions to adapt to climate change based on the perceived degree of risk and the availability of resources. More action and creative strategies are still needed both in the short and long term to enhance the preparedness of the sector with the goal of protecting a crucial portion of Michigan's economy and tourism sector. Additional research on the effectiveness of particular adaptive strategies can enhance this effort, and this study contributes to the initial list of such options.

BIBLIOGRAPHY

1. Abdel-Fattah, S., & Krantzberg, G. (2014). A review: Building the resilience of Great Lakes beneficial uses to climate change. *Sustainability of Water Quality and Ecology*, 3, 3-13. <https://doi.org/10.1016/j.swaqe.2014.11.006>.
2. Allan, J. D., Smith, S. D., McIntyre, P. B., Joseph, C. A., Dickinson, C. E., Marino, L., ... & Adeyemo, A. O. (2015). Using cultural ecosystem services to inform restoration priorities in the Laurentian Great Lakes. *Frontiers in Ecology and the Environment*, 13(8), 418-424.
3. Andresen, J. A. (2012). Historical climate trends in Michigan and the Great Lakes region. *Climate change in the Great Lakes region*. Michigan State University Press, East Lansing, Michigan, USA, 17-34.
4. Andresen, J. A., Alagarswamy, G., Ritchie, J. T., Rotz, C. A., & LeBaron, A. W. (2001). Assessment of the impact of weather on maize, soybean, and alfalfa production in the Upper Great Lakes Region of the United States, 1895–1996. *Agron. J*, 93, 1059-1070.
5. Arup. (n.d.) City Resilience Index. London, UK: Author. Retrieved from <https://www.arup.com/publications/research/section/city-resilience-index>.
6. Aurer M.T., L.M. Tomlinson, S.N. Higgins, S.Y. Malkin, E.T. Howell, H.A. Bootsma (2010). Great Lakes Cladophora in the 21st century: same algae – different ecosystem *Journal of Great Lakes Research.*, 36 , pp. 248-255, 10.1016/j.jglr.2010.03.001.
7. Feltman, B. C., Norris, P. E., & Batanian, J. L. (2017). Gauging concerns about climate change in Great Lakes coastal communities. *Journal of Great Lakes Research*, 43(4), 670-677.
8. Brohan, P., Kennedy, J. J., Harris, I., Tett, S. F., & Jones, P. D. (2006). Uncertainty estimates in regional and global observed temperature changes: A new data set from 1850. *Journal of Geophysical Research: Atmospheres*, 111(D12).
9. Bush, K. F., Fossani, C. L., Li, S., Mukherjee, B., Gronlund, C. J., & O'Neill, M. S. (2014). Extreme precipitation and beach closures in the great lakes region: Evaluating risk among the elderly. *International Journal of Environmental Research and Public Health*, 11(2).
10. Changnon, D., Sandstrom, M., & Bentley, M. (2006). Midwestern high dew point events 1960-2000. *Physical Geography*, 27(6), 494-504.

11. Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social vulnerability to natural hazards. *Proceedings of the national academy of sciences*, 105(7), 2301-2306.
12. Dai, A. (2006). Recent climatology, variability, and trends in global surface humidity. *Journal of Climate*, 19(15), 3589-3606.
13. De Loë, R., Kreutzwiser, R., & Moraru, L. (2001). Adaptation options for the near term: climate change and the Canadian water sector. *Global Environmental Change*, 11(3), 231-245.
14. Dyer, J. L., & Mote, T. L. (2006). Spatial variability and trends in observed snow depth over North America. *Geophysical Research letters*, 33(16).
15. Easterling, D. R., Horton, B., Jones, P. D., Peterson, T. C., Karl, T. R., Parker, D. E., ... & Folland, C. K. (1997). Maximum and minimum temperature trends for the globe. *Science*, 277(5324), 364-367.
16. Gibbs, G. R. (2007). Thematic coding and categorizing. *Analyzing qualitative data*, 703, 38-56.
17. IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541-562, doi:10.1017/9781009157940.008.
18. Knowles, N. (2019). Can the North American ski industry attain climate resiliency? A modified Delphi survey on transformations towards sustainable tourism. *Journal of Sustainable Tourism*, 27(3), 380-397.
19. Kovacs, T., & Barrett, K. (2020). *Michigan Climate Assessment 2019: Considering Michigan's Future in A Changing Climate*.
20. Kunkel, K. E., Easterling, D. R., Redmond, K., & Hubbard, K. (2003). Temporal variations of extreme precipitation events in the United States: 1895–2000. *Geophysical Research Letters*, 30(17).
21. Lee, Y., Penskar, M. R., Badra, P. J., Klatt, B. J., & Schools, E. H. (2012). Climate change vulnerability assessment and adaptation strategies for natural communities in Michigan, focusing on the coastal zone. *Michigan Natural*

Features Inventory, 194.

22. Lofgren, B. M., Quinn, F. H., Clites, A. H., Assel, R. A., Eberhardt, A. J., & Luukkonen, C. L. (2002). Evaluation of potential impacts on Great Lakes water resources based on climate scenarios of two GCMs. *Journal of Great Lakes Research*, 28(4), 537-554. [https://doi.org/10.1016/S03801330\(02\)70604-7](https://doi.org/10.1016/S03801330(02)70604-7).
23. Longwoods International. (2020). Travel USA Visitor Profile Region 2: Northwest Region Overnight Visitation. MEDC. <https://medc.app.box.com/s/s0fysmcetgnrks1fwhe7tji08quysod2..>
24. Notre Dame Global Adaptation Initiative. (2018). Urban Adaptation. Retrieved from <http://gain.nd.edu/our-work/urban-adaptation/>.
25. Nugent, J., Piromsopa, K., Rothwell, N., Zavalloni, C., Clark, J., Min, H. K., ... & Prawiranata, H. (2013). 8. Michigan's Tart Cherry Industry: Vulnerability to Climate Variability and Change. *Climate change in the Midwest: Impacts, risks, vulnerability, and adaptation*, 104.
26. Owen, G. 2020. What makes climate change adaptation effective? A systematic review of the literature. *Global Environmental Change* 62 (2020) 102071.
27. Pan, Z., Arritt, R. W., Takle, E. S., Gutowski Jr, W. J., Anderson, C. J., & Segal, M. (2004). Altered hydrologic feedback in a warming climate introduces a "warming hole". *Geophysical Research Letters*, 31(17).
28. Perkins, W. T. (2020, September 22). Report: shoreline repairs could cost millions. In Petoskey News Review.
29. Pryor, S. C., Howe, J. A., & Kunkel, K. E. (2009). How spatially coherent and statistically robust are temporal changes in extreme precipitation in the contiguous USA?. *International Journal of Climatology: A Journal of the Royal Meteorological Society*, 29(1), 31-45.
30. Quinn, F. H. (2002). Secular changes in Great Lakes water level seasonal cycles. *Journal of Great Lakes Research*, 28(3), 451-465.
31. Runsten, K. (2018). Climate ready Boston?: identifying indicators to evaluate the City of Boston's efforts to implement its climate change adaptation initiatives (Doctoral dissertation, Massachusetts Institute of Technology).
32. Scott, D., Hall, C. M., & Gössling, S. (2019). Global tourism vulnerability to climate change. *Annals of Tourism Research*, 77, 49-61.
33. Scott, D., Steiger, R., Rutty, M., Pons, M., & Johnson, P. (2019). The differential

- futures of ski tourism in Ontario (Canada) under climate change: the limits of snowmaking adaptation. *Current Issues in Tourism*, 22(11), 1327-1342.
34. Shih, C., Nicholls, S., & Holecek, D. F. (2009). Impact of weather on downhill ski lift ticket sales. *Journal of Travel Research*, 47(3), 359-372.
doi:10.1177/0047287508321207.
 35. Skaggs, R. H., & Baker, D. G. (1985). Fluctuations in the length of the growing season in Minnesota. *Climatic Change*, 7(4), 403-414.
 36. Sottini, V. A., Barbierato, E, Bernetti, I., & Capecchi, I. (2021). Impact of Climate Change on Wine Tourism: An Approach through Social Media Data. *Sustainability*, 13(13), 7489.
 37. (U.S. Department of Agriculture, National Agricultural Statistics Service. Michigan Fruit Rotational Survey 2014–2015.
https://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/Michigan_Rotational_Surveys/mi_fruit15/fruit.html, accessed April 22, 2017).
 38. U.S. Environmental Protection Agency. (2017). Evaluating Urban Resilience to Change: A Multi-Sector Approach. Washington, DC: Author. Retrieved From <https://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=322482>.
 39. Wanyama, D., Bunting, E. L., Goodwin, R., Weil, N., Sabbatini, P., & Andresen, J. A. (2020). Modeling land suitability for vitis vinifera in michigan using advanced geospatial data and methods. *Atmosphere*, 11(4)
doi:10.3390/atmos11040339.
 40. Winkler, J. A., Andresen, J. A., Hatfield, J. L., Bidwell, D., & Brown, D. (2014). Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment. Washington, DC: Island Press.. Manufactured in the United States of America, 10(9), 8.
 41. World Travel and Tourism Council. (2021). Travel and Tourism Economic Impact 2021 Global Economic Impacts & Trends.
 42. Zhang, X., Vincent, L. A., Hogg, W. D., & Niitsoo, A. (2000). Temperature and precipitation trends in Canada during the 20th century. *Atmosphere-ocean*, 38(3), 395-429.
 43. Zhang, Y., Wu, S., Dai, E., Liu, D., & Yin, Y. (2008). Identification and categorization of climate change risks. *Chinese Geographical Science*, 18(3), 268-275.

APPENDIX 1: STANDARD OPERATING PROCEDURE

Standard Operating Procedure

Respondent Identification:

- Analyze organizations presented on local tourism websites to identify potential respondents.
- Snowball sampling may be applied, where a respondent provides the contact information for others that may be suitable participants.
- Perform a Google search based on desired recreation type to identify other potential respondents that may have been missed.

Participation Solicitation:

1. Once identified, contact information will be collected to facilitate contact and participation.
2. Utilizing contact information, a dual approach of reaching out through email and over the phone will be applied.
3. Once contacted, first introduce yourself and the study, providing a breakdown of focus, participation, and desired outcomes.
4. If participation is selected, set a meeting time and method to conduct the study.

APPENDIX 2: CONSENT FORM

Climate Change Adaptation and Preparedness: Impacts of Climate Change on the Tourism Industries of the Northwestern Region of Michigan USA

Michigan State University Department of Geography, Environment, and Spatial
Sciences

Oral Consent for Public and Private Sector Key Informants

Greetings. My name is Clayton Sigmann. I am a part of a research project at Michigan State University that focuses on gauging local tourism providers' adaptation abilities in the face of a changing climate. The goal of the research is to conduct key informant interviews with various individuals from the tourism sub-sector. This will facilitate analysis of current adaptation efforts as well as inform future tourism focused efforts to adapt to climate change.

We are asking members of various tourism sub-sector services and relevant related industries about their knowledge of current adaptation efforts and plans for the future. We seek to learn from you information on the major climate change threats in the area, what and who is vulnerable, relevant adaptation policies, major climate adaptation projects and programs, and the performance of such programs. We also seek

information on relevant indicators for measuring impacts of adaptation efforts, data available for impacts assessment, and on adaptation scenarios that can enhance adaptation planning and impact monitoring in the area.

Beyond gathering information for research, the Research Team hopes that improved understanding of adaptation risks and interventions, the level of preparedness of local tourism providers, and developing an approach on how to measure their impacts, might help governments and private industries to improve adaptation planning and monitoring.

Your participation is voluntary. If you choose to participate, I will ask you a number of questions on the topics mentioned earlier. You can choose not to answer any particular questions. Your answers will be confidential and only the research staff will see them. In any report or publication that we produce, we will group your answers with other individuals' to provide an overall picture of climate change adaptation efforts and impacts in Northern Michigan.

There is no cost or compensation offered to participate.

If you have any questions about the study, you may contact:

Clayton Sigmann or Dr. Leo Zulu at Michigan State University at emails:
sigmannc@msu.edu and zulu@msu.edu, respectively.

Documentation of Informed consent.

Your signature below means that you voluntarily agree to participate in this research
study.

Signature Date

APPENDIX (3): INTERVIEW QUESTIONNAIRE

Climate Change Adaptation and Preparedness: Impacts of Climate Change on the Tourism Industries of the Northwestern Region of Michigan USA

Michigan State University Department of Geography, Environment, and Spatial Sciences

Guide Questions for Focus Group and Key Informants Interviews

Guide questions for local or regional tourism/economic planning agencies

What is the title of your organization?

What is your mandate or function? How intertwined with the tourism industry is your organization?

How large is the area you are responsible for geographically?

What are the major climate change risks that the region of their jurisdiction faces?

What policies and strategies have been implemented to address these issues? Please, explain?

Could you explain any success or challenges currently or recently faced?

Could you explain any future adaptation plans? If so, what is its focus?

Guide questions for local or regional tourism/economic planning agencies

Adaptive Capacity:

Do you think the impacts of climate change are a threat to your tourism business or sub-sector? Explain your answer.

Do you have your own risk evaluation framework? Could you explain the general structure and function of it?

Do you know whether a vulnerability assessment for your organization has been conducted in the past? If so, explain its focus.

Do you know of ways that vulnerabilities of your tourism sub-sector to climate change can be measured? Do you know of existing data streams that could be used?
Do you know how much funding has been available for adaptation of these vulnerabilities in the past? If so, could you explain its focus?
Do you know if funding is available for adaptation to address climate related vulnerabilities currently or in the past? If so, what are the sources, eligibility requirements, and how much money is available?
Do current planning regimes include proactive resilience building to climate change, or are only reactive disaster responses being addressed? Explain your answer
Do you know if resilience building/adaptation efforts has been incorporated into existing programs that you are engaged in regularly? If so, please explain?

Guide questions for local or regional tourism/economic planning agencies

Condition Degradation:

Do you experience precipitation extremes in your business or sub-sector? How much of a problem do precipitation extremes pose as a vulnerability?

Have precipitation extremes and variability been assessed as vulnerability to your industry? If so, explain what the assessment(s) focused on, and what the general finding(s) was or were?

Do you know what methods are used to counter precipitation extremes? Please, explain them.

What do you see as your biggest vulnerabilities in terms of water quality? Is it connected to climate change? If yes, how?

Do you know what methods are used to counter climate-induced challenges in water quality? Explain.

What do you see as your biggest vulnerabilities in terms of heat extremes and variability? Has there been any assessment of vulnerabilities? If so, what was the focus?

Do you know what methods are used to counter these extremes? Could you provide any examples?

Do you know if current planning policies and land zoning plans have been developed with reference to a relevant hazard-risk assessment? Please explain your answer, providing any examples you might have?

Guide questions for local or regional tourism/economic planning agencies

Economic Disruptions:

Have you assessed the total economic losses from climate-related events per year over the past five years? Explain. Has this encouraged adaptive improvements? Explain your responses.

Do you know of other businesses that have insurance cover for high risks relevant to the industry? If yes, how many? Please, explain the nature or focus of any such insurance?

Do you know if risk reduction management elements are incorporated into physical planning and infrastructure development? Could you provide any examples?

How resistant to potential impacts of climate change are critical areas/ facilities? Could you provide any examples?

Have you made business continuity arrangements in the case of disruptions for the tourism sector or subsectors? Could you provide any examples?

Do you know how many years since the last area-wide review of the adequacy of the city's protective infrastructure assets? Could you explain its focus and main conclusion?

What are the most important improvements that could be made to current infrastructure, in your opinion, to address known and anticipated vulnerabilities to climate change in the region?

How adequate is current infrastructure in resisting adverse climate change impacts?

Has there been any degradation of natural formations, could you explain any examples?

APPENDIX 4: ADAPTATION STRATEGIES

Adaptation Strategies for the Agritourism Sub-Sector		
Adaptation Strategy	Use	Currently Applied Y/N
Pruning	Protect/Control Growth of crops	Y
Heating	Crop Protection	Y
Protective Equipment (Shelters)	Crop Protection	N
Habitat creation for Bats/Birds	Ecosystem Service	N
Expansion of Plantings	Increased Production	N
Service Style Change	Labor Management	N
Staggered Harvest Times	Labor Management/Crop Protection	Y
Irrigation System Use	Crop Protection	Y
Drainage System Updates	Crop Protection	N
Drying Agent Use	Crop Protection	Y
Crop Insulation Mounds	Crop Protection	Y
Naturalization of Areas	Biodiversity Protection	Y
Adaptation Strategies for the Water Recreation Sub-Sector		
Adaptation Strategy	Use	Currently Applied Y/N
Beach Clean Ups	Guest Experience Protection	Y
Tree Migration	Biodiversity Protection	N
Infrastructure Updates	Coastal Protection/ Water Management	N
Increased Communication	Guest Experience Protection	Y
Increased Monitoring	Guest Experience Protection	Y
Boat Inspection Policies	Biodiversity Protection	Y
Selective Plantings	Water Management	Y
Dock Upgrades	Coastal Protection/ Water Management	Y
Hardening of Structures (Boulders)	Coastal Protection/ Water Management	Y

Figure 10: Identified Adaptation Strategies

Figure 10 (cont'd)

Adaptation Strategies for the Water Recreation Sub-Sector		
Adaptation Strategy	Use	Currently Applied Y/N
Tree Migration	Biodiversity Protection	N
Recreation Offering Diversification	Guest Experience Protection/Revenue Protection	Y
Snowmaking Equipment Expansion	Guest Experience Protection	Y
Snow Grooming Equipment Expansion	Guest Experience Protection	N
Increased Communication	Guest Experience Protection	Y
Irrigation System Use	Guest Experience Protection	N
Efficiency upgrades	Revenue Protection	N
Special Event Sales	Revenue Protection	Y

APPENDIX 5: DEFINITIONS

Adaptation: *In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (IPCC 2018).*

Climate Change: *Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC 2018).*

Climate Variability: *Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC 2018).*

Ecosystem Services: *Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food or fibre, (3) regulating services such as climate regulation or*

carbon sequestration, and (4) cultural services such as tourism or spiritual and aesthetic appreciation (IPCC 2018).

Impacts (consequences, outcomes): *The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial (IPCC 2018).*

Resilience: *The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation (IPCC 2018).*

Sustainability: *A dynamic process that guarantees the persistence of natural and human systems in an equitable manner (IPCC 2018).*

Vulnerability: *The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2018).*