Center for Rural Communities
NORTHLAND COLLEGE
SPRING 2019

AUTHORS

Robin Kemkes
Faculty Research Associate
Center for Rural Communities

Robin Kemkes is an ecological economist whose work focuses on livelihoods and well-being in rural places. For this report, she collected community input across the Chequamegon Bay Area on quality of life impacts, household preparedness, and planning priorities, and she incorporated existing information on populations of concern. She also helped identified the Priority Areas for Coordinated Action and put forward implementation goals and supporting resources.

Meghan Salmon-Tumas
Faculty Research Associate
Center for Rural Communities

Meghan Salmon-Tumas is a geographer specializing in large-scale observation of human-environment interactions. For this report, she evaluated climate change impacts in the Chequamegon Bay Area, determined the current scientific confidence in these impacts, and intersected these impacts with the topics and goals of the area's comprehensive planning documents. She also contributed ideas and editing to the Priority Areas for Coordinated Action.

ACKNOWLEDGMENTS

This report was developed by the Center for Rural Communities (CRC) at Northland College. Funding was provided by Wisconsin Sea Grant. We would like to thank our colleagues at the Mary Griggs Burke Center for Freshwater Innovation at Northland College, the Lake Superior National Estuarine Research Reserve, and the Great Lakes Indian Fish & Wildlife Commission for valuable input and feedback. Thank you to the community members and stakeholders who participated in the mail survey and interviews for the Chequamegon Bay Area community study. We also acknowledge the work of the student research assistants at the Northland College Center for Rural Communities who entered survey data and transcribed interviews.

PREPARED BY

Center for Rural Communities
NORTHLAND COLLEGE

Report design and layout by Jill O'Neill, Director of Digital Marketing at Northland College

FUNDED BY

Sea Grant
University of Wisconsin

TABLE OF CONTENTS

An Adaptive Planning Guide for:

- City/county/tribal staff, planning commissions, and councils
- Developers and businesses
- Property owners and residents
- Natural resource managers

It's estimated that over 70 percent of adults in Bayfield and Ashland counties believe that global warming is happening.*

* Howe, Peter D., Matto Mildenberger, Jennifer R. Marlon, and Anthony Leiserowitz (2015). "Geographic variation in opinions on climate change at state and local scales in the USA." Nature Climate Change, doi:10.1038/nclimate2583

Executive Summary

KEY FINDINGS

The effects of climate change can already be observed and experienced in the Chequamegon Bay Area (CBA), and further changes are expected to impact across all municipal, county, and tribal planning and development topics. Adaptation work is underway in many regards, ranging from addressing undersized infrastructure to assessing the vulnerability of north woods species. The purpose of this guide is to focus attention on priority areas for adaptation, which span multiple planning topics and will therefore require collaboration and cooperation amongst planners and across communities. It also serves as a resource for current climate change science and potential impacts to valued community assets and vulnerable populations specific to the Chequamegon Bay Area. The findings and recommendations offered herein are meant to be starting points for discussion toward coordinated implementation of climate change adaptation. Adaptation can be incorporated into individual plans, and collaboration will help align resources and efforts across planning topics, organizations, and jurisdictions.

The guide is broken down into the following four sections.

Ⓐ CLIMATE CHANGE

Climate Change in the Chequamegon Bay Area describes climate change trends and projections, CBA community values and priorities, vulnerable populations, and household preparedness. The high confidence projected climate change effects in the Chequamegon Bay Area are:

- Rising annual average air temperatures
- More heavy rain events
- Warmer water in Lake Superior
- Less ice cover
- More microbial activity

Ⓑ PRIORITY AREAS

Priority Areas for Coordinated Action highlights three potential climate change adaptation arenas of particular concern to the CBA:

- Protect Drinking Water Quality
- Prevent Washouts and Mitigate Flood Hazards
- Prepare for Variable Recreation and Tourism Conditions

These priority areas were selected based on the following criteria:

	CRITERIA	SYMBOL
✔	High confidence of climate change effects	
✔	Highly valued CBA community asset may be affected	
✔	One or more vulnerable populations may be affected	
✔	Community priority planning topics are involved	
✔	Non-climate stressors could exacerbate impacts	
	Vulnerability of assets **to be determined** by communities	

Ⓒ PLANNING TOPICS

Planning Topics provides a description of projected climate change effects relevant to common objectives for planning topics.

Ⓓ IMPLEMENTATION

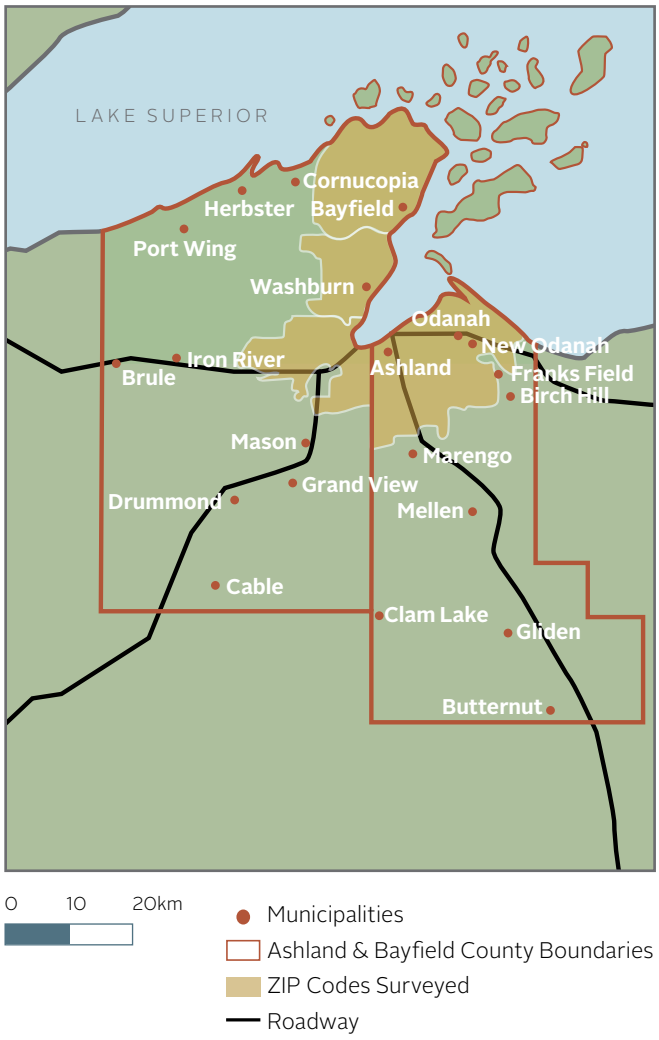
Implementation of Adaptation offers recommendations for how to move forward under uncertainty.

Introduction

The Center for Rural Communities at Northland College has prepared this guide to help municipal, tribal, and county planning and development bodies in the Chequamegon Bay Area (CBA) toward incorporating climate change adaptation into decision-making. The effects of climate change can already be observed and experienced in the CBA as demonstrated by more frequent storm events and warmer winters, among other effects. Further changes are expected. It is time to be proactive about planning for climate change given that preventive measures are more cost-effective than reactive disaster response, vulnerable populations will be disproportionately affected, and valued community assets may be at risk. Although climate change is often considered to be a polarizing topic, it is estimated that 72 percent of adults in Bayfield County and 71 percent in Ashland County believe that global warming is happening.[1] Interviews with community members and stakeholders revealed a desire for more proactive discussion and collaboration on climate change.[2] Considering climate change adaptation across planning topics offers an opportunity to build broad support, to think through how adaptation might align with other community objectives, and to build an overall resilient community.[3] Some small cities and rural areas are looking to mainstream adaptation, that is, to integrate it into routine plans and procedures as a way to move forward when resources, staffing, and time are scarce.[4]

This guide brings together findings from global climate change assessments, national human health reports, regional–and state–level climate change impacts, and primary social science data collected across Chequamegon Bay communities to share information and make recommendations that are as specific and tailored to the Chequamegon Bay Area as currently possible. Throughout this report, the Chequamegon Bay Area (CBA) refers to ZIP codes 54806, 54814, 54891, across which household survey data were collected for community input (see Figure 1). Some secondary data is reported at the Ashland and Bayfield county levels and is indicated as such. The information and recommendations provided in this guide are particularly relevant to communities in the CBA but will also be informative for communities across both counties.

Figure 1. Map of Chequamegon Bay Area and Ashland and Bayfield Counties



[1] Howe, Peter D., Matto Mildenberger, Jennifer R. Marlon, and Anthony Leiserowitz (2015). "Geographic variation in opinions on climate change at state and local scales in the USA." Nature Climate Change, doi:10.1038/nclimate2583

[2] In July 2018, the Center for Rural Communities at Northland College released the results of the Chequamegon Bay Area Community Climate Change Study which reports results from a representative household survey, community member interviews, and stakeholder interviews. https://www.northland.edu/wp-content/uploads/2018/08/CBA-Climate-Change-Study-2018.pdf

[3] Moser, S.C., Coffee, J., Seville, A. (2017) Rising to the Challenge, Together: A Review and Critical Assessment of the State of the US Climate Adaptation Field. A report prepared for The Kresge Foundation.

[4] Ibid.

Who should use this guide

City, county, tribal staff; planning commissions; and councils can use this plan to:

- Anticipate climate change effects that might impact infrastructure, natural landscapes, human health, and cultural resources
- Prioritize climate change adaptation actions
- Mainstream climate change adaptation into planning documents and efforts
- Identify opportunities for collaborating across departments and jurisdictions
- Develop a communication strategy
- Stay current on climate change science and funding resources

Developers and businesses can use this plan to:

- Anticipate impacts to the regional economy, particular industries, and enterprises
- Envision a green economy and build on ongoing sustainability initiatives
- Identify and create funding mechanisms to promote all aspects of a green economy
- Develop skills retraining programs

Property owners and residents can use this plan to:

- Anticipate impacts to property from climate change effects such as flooding or erosion
- Determine best use of public and private properties
- Understand infrastructure needs and improvements
- Start a community conversation about climate change adaptation

Natural resource managers can use this plan to:

- Identify opportunities for collaborating across jurisdictions and departments
- Further develop best management practices and community education to better achieve climate adaptation goals

How to navigate this guide

This guide is organized into three main sections and concludes with a section on implementation of adaptation:

?

Where can I find information about **climate change trends** in the CBA?

What do **residents value** about living in the CBA?

Who is **most vulnerable** to climate change effects?

GO TO Ⓐ CLIMATE CHANGE pg 6

This section describes climate change trends and projections, CBA community values and priorities, vulnerable populations, and household preparedness.

?

What are the **highest priority climate change issues** for the CBA?

GO TO Ⓑ PRIORITY AREAS pg 24

This section highlights three potential climate change impacts of particular concern to the CBA that span multiple planning topics and jurisdictions.

- Protect drinking water quality.
- Prevent washouts and mitigate flood hazards.
- Prepare for variable recreation and tourism conditions.

?

Where can I find **climate change impacts** specific to land use? Housing? Transportation?

GO TO Ⓒ PLANNING TOPICS pg 46

This section provides a summary of common objectives for planning topics included in municipal, county, and tribal planning documents, along with a description of projected climate change effects and how they might impact those objectives. Tribal Integrated Resource Management Plan areas correspond to planning topics as shown in Table 1.

?

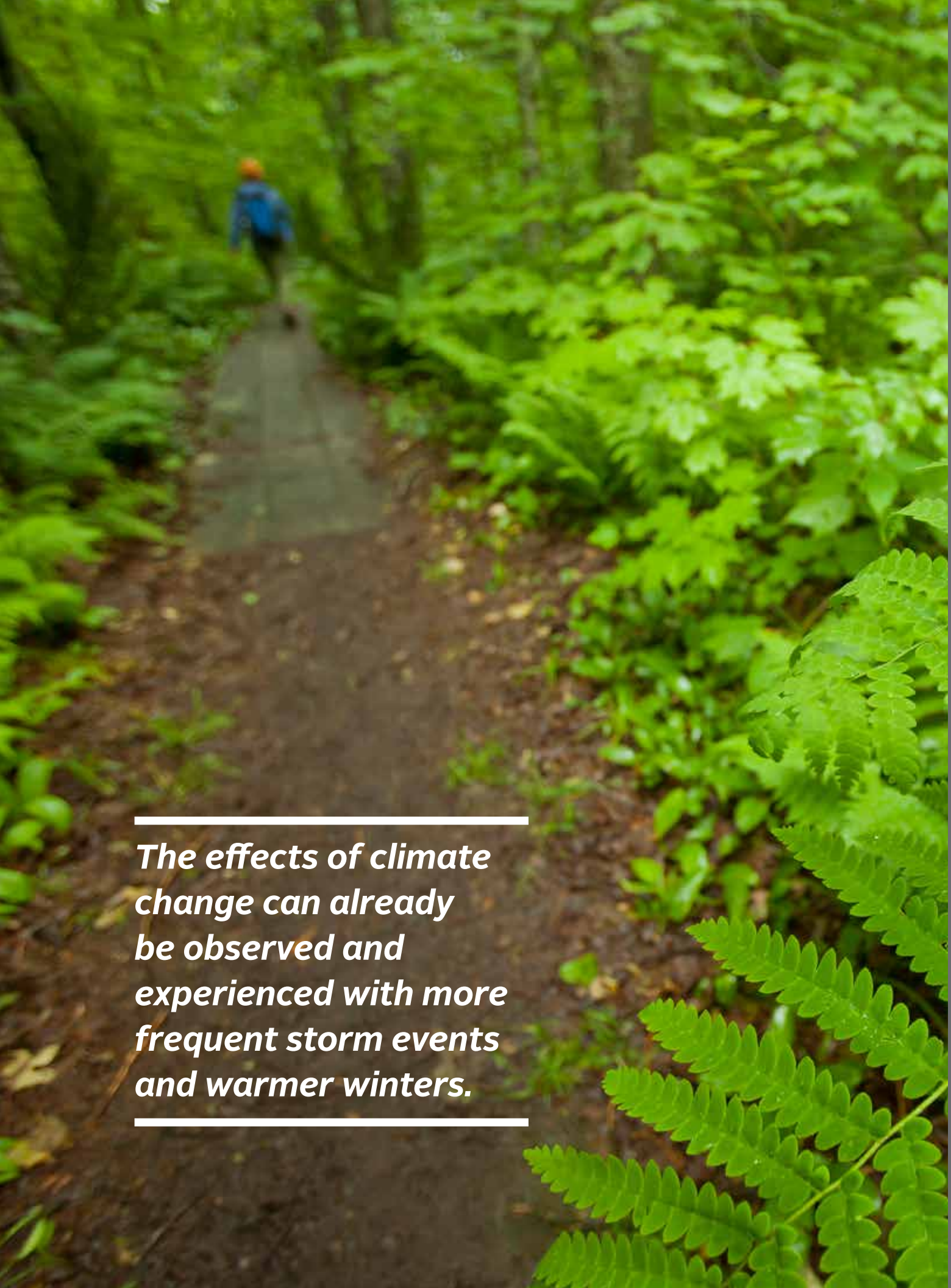
What's next? What can we do about climate change?

GO TO Ⓓ IMPLEMENTATION Page 78

This section offers recommendations for how to move forward under uncertainty.

Table 1. How to map tribal Integrated Resource Management Plan topics onto the planning topics in this report

IRMP TOPICS	PLANNING TOPICS IN THIS REPORT
Cultural/Traditional Resources	Agricultural, Natural, & Cultural Resources
Forest Resources	Agricultural, Natural, & Cultural Resources Land Use
Land Resources	Land Use
Wildlife & Habitat Resources	Agricultural, Natural, & Cultural Resources Land Use
Fish Resources	Agricultural, Natural, & Cultural Resources
Water Resources	Utilities & Community Facilities Agricultural, Natural, & Cultural Resources Waterfront & Coastal Resources
Soil Resources	Agricultural, Natural, & Cultural Resources Waterfront & Coastal Resources
Air Resources	Transportation
Agricultural Resources	Agricultural, Natural, & Cultural Resources
Housing Resources	Housing
Recreational Resources	Utilities & Community Facilities Waterfront & Coastal Resources
Energy Resources	Utilities & Community Facilities
Waste Management	Utilities & Community Facilities
Resource Emergency Response	Utilities & Community Facilities



The effects of climate change can already be observed and experienced with more frequent storm events and warmer winters.

Climate Change in the Chequamegon Bay Area

Climate Change Projections

To identify the climate change impacts with greatest relevance to the Chequamegon Bay Area, we surveyed the climate change science literature. Since uncertainty is an unavoidable aspect of climate change projections (see sidebar on opposite page: Climate Change Projections and Uncertainty), we categorized the predicted climate change impacts by the degree of confidence associated with the current science and knowledge. Sources for this factor include peer-reviewed literature as well as summary reports such as: the Wisconsin Initiative on Climate Change Impacts (WICCI),[5] the Lake Superior Climate Change Impacts and Adaptation report,[6] the USFS Ecosystem Vulnerability Assessment and Synthesis report,[7] the U.S. Climate Resilience Toolkit Climate Explorer,[8] and the 2015 report State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrologic, and Ecological Effects.[9]

For each climate change theme, we identified any discernible trends in the historic record and future projections for the Chequamegon Bay Area. We then assessed the most well-supported trend for the quantity and consistency of evidence in the published literature. We utilized a point system based upon four questions to assign one of three confidence levels (low, medium, or high) to the prominent trend (see Table 2). The identified climate change effects are listed in Table 3, with prominent trends and confidence levels.

More information on these effects can be found in Appendix A.

Table 2. Method for Determining Confidence on Climate Change Effects

Step 1 **Assess evidence of climate change effect in published literature and assign point values.**

Is there a significant trend in the historical data record?	**2 points**
Is there agreement among multiple model projections under varying emission scenarios (see page 7)?	**3 points**
Are the predictions free of assumption and guess-work?	**1 points**
Are we sure the science relates to the CBA?	**2 points**

Step 2 **Tally point values for each climate change effect and assign a confidence level.**

CONFIDENCE LEVEL		POINT TOTAL
○	None	0
◔	Low	1
		2
		3
◑	Medium	4
		5
●	High	6
		7
		8

[5] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

[6] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

[7] Swanston, Chris, Maria Janowiak, Louis Iverson, Linda Parker, David Mladenoff, Leslie Brandt, Patricia Butler et al. "Ecosystem vulnerability assessment and synthesis: a report from the climate change response framework project in northern Wisconsin." (2011).

[8] U.S. Federal Government, 2018: U.S. Climate Resilience Toolkit Climate Explorer. https://climate-explorer2.nemac.org Accessed September 2018.

[9] McDermid, J. L., S. K. Dickin, C. L. Winsborough, H. Switzman, S. Barr, J. A. Gleeson, G. Krantzberg, and P. A. Gray. "State of climate change science in the Great Lakes Basin: a focus on climatological, hydrological, and ecological effects." Toronto and Region Conservation Authority (2015).

Climate Change Projections and Uncertainty

Uncertainty about future climate arises from the complexity of the climate system and the ability of models to represent it, as well as the inability to predict the decisions that societies will make.[10]

Climate models and projections are useful for helping practitioners engage in discussions about potential future climate conditions and adaptive responses.[11]

Uncertainty is unavoidable; transformative change will require embracing uncertainty about the future.[12]

Climate projections are not predictions.[13]

- Each projection is based on a storyline about future human emissions of greenhouse gases and other policy choices.
- Typical story lines represent low, middle, or high emissions options, and are intended to represent the range of possibilities in population change, fossil fuel availability, economic growth, technological change, and mitigation actions.
- Considering a range of projections may help form a more complete picture of potential future risks.
- Climate projections do not attempt to predict the timing of meteorological events such as storms, droughts, or El Niños. The location and timing of future extreme weather events cannot be deduced from climate model projections.

[10] U.S. Climate Resilience Toolkit definition of uncertainty: https://toolkit.climate.gov/content/glossary

[11] Moss, R. H. J .A., K. A. Edmonds, M. R. Hibbard, S. K. Manning, D. P. Rose, T. R. van Vuuren, S. Carter, M. Emori, T. Kainuma, G. A. Kram, J. F. B. Meehl, N. Mitchell, K. Nakicenovic, S. J. Riahi, R. J. Smith, A. M. Stouffer, J. P. Thomson, J. P., Weyant, T. J. Wilbanks. 2010. The next generation of scenarios for climate change research and assessment. Nature, 463: 747-756.

[12] Moser, S.C., Coffee, J., Seville, A. (2017) Rising to the Challenge, Together: A Review and Critical Assessment of the State of the U.S. Climate Adaptation Field. A report prepared for The Kresge Foundation. https://kresge.org/sites/default/files/library/rising_to_the_challenge_together_linked_0.pdf

[13] U.S. Climate Resilience Toolkit https://toolkit.climate.gov/tool/downscaled-cmip3-and-cmip5-climate-and-hydrology-projections

Physical Effects

Table 3. Effects of climate change in the Chequamegon Bay Area[14]

CONDITION	PROJECTIONS	CONFIDENCE & TREND
Air Temperature	• In CBA, the annual average temperatures have risen 1-1.5°F in last half-century • Most model predictions estimate another 3-9°F increase by 2055 • Winter temperatures are expected to rise the most • Nighttime temperatures will increase more than daytime temperatures • Models predict fewer very cold nights and more very hot days • Models predict an increased frost-free period and a longer growing season	High Annual average rising
Precipitation	• In CBA, the annual precipitation has risen 1-7 inches in last half-century, with greatest rise in the southern portion of the region • There is virtual certainty that precipitation patterns will change more in coming decades • Most model predictions estimate that annual precipitation will change by -1 to 4 inches by 2055 • Evidence is strongest for an increase in winter precipitation • Still, snow is expected to decrease due to increases in the frost-free period	Medium Annual average rising
Temperature Fluctuations	• Some models predict more freeze/thaw cycles • Some models predict more freezing rain events	Low More freeze/thaw
Evaporation & Transpiration	• Higher temperatures increase evapotranspiration, but these increases will be modulated by increases in cloudiness • Models and experts predict more evapotranspiration, especially in spring and fall	Medium More evaporation & transpiration
Precipitation Fluctuations	• Since heavy rain events are infrequent by definition, a very long data record is needed to confirm changes in their frequency • However, existing records do indicate that heavy rain events have become more frequent in the CBA • Most models and experts agree that heavy rain events will continue to increase in frequency and strength	High More heavy rains

[14] following the format of McDermid, J. L., S. K. Dickin, C. L. Winsborough, H. Switzman, S. Barr, J. A. Gleeson, G. Krantzberg, and P. A. Gray. "State of climate change science in the Great Lakes Basin: a focus on climatological, hydrological, and ecological effects." Toronto and Region Conservation Authority (2015).

Physical Effects

CONDITION	PROJECTIONS	CONFIDENCE & TREND
Wind	• Winds will be stronger • Stronger winds will lead to larger waves • Stronger winds may damage trees and property	Low More winds
Floods	• Flooding will be more frequent and severe	Medium More floods
Droughts	• Droughts will be more frequent, especially in the later portion of the growing season • Drought frequency is implied by more dry days, higher summer temperatures, and more evapotranspiration	Low More drought
Soil Moisture and Groundwater	• Changes in groundwater recharge are possible, but not well understood • High-groundwater conditions could increase • Soil moistures could decrease	Low More high-groundwater
Erosion	• Increased heavy rain events will increase erosion • Shoreline erosion will increase due to reduced ice cover and increased wave action • Shoreline erosion will be exacerbated if lake levels lower • The Apostle Islands National Lakeshore shoreline is especially vulnerable, due to its geomorphology	Low More erosion
Lake Level	• Lake Superior water levels will remain highly variable, making prolonged periods of either high levels or low levels possible • Long-term Lake Superior water levels might decrease, increase, or remain similar	High Variable water levels in Lake Superior
Lake Temperature	• Surface water in Lake Superior is warming about twice as quickly as air temperatures • Water temperatures will continue to increase • The stratification season will lengthen	High Warmer water in Lake Superior
Lake Ice Cover	• Ice cover duration measured at Bayfield decreased by 3 days/decade during 1857-2007 • The maximum extent and duration of ice cover will both decrease • Ice cover duration is expected to decrease by 1-2 months by 2100	High Less ice on Lake Superior

Chemical Effects

Table 3. Effects of climate change in the Chequamegon Bay Area (continued)

CONDITION	PROJECTIONS	CONFIDENCE & TREND
Air Pollution	• Air pollution will increase due to higher temperatures	Low More air pollution
Elevated CO2	• Increases in atmospheric CO2 are expected to continue, though the rise could be modulated by human actions • Higher atmospheric CO2 concentrations will lead to increased growth for many (but not all) plants, affecting forests, crops, invasives, weeds, and others • Increased plant growth will lead to increased pollen	Scenario dependent
Lake Chemistry	• Lakes could contain increased dissolved organic carbon, phosphorous, nitrogen, and CO2 (leading to lower pH) • Increased mercury mobilization • Heavy rains, increasing runoff, could bring into lakes increased pollutants, sediments, nutrients and contaminants • Increased lake temperatures could reduce dissolved oxygen	Low Decreased water quality

Ecological Effects

CONDITION	PROJECTIONS	CONFIDENCE & TREND
Pests	• Many pests will experience less winter die-off, increasing their impacts on forests and crops	Low More pests
Invasives	• Non-native species will be increasingly established • Warmer temperatures could expand invasive species' ranges Northward	Low More invasive species
Diseases	• Increased temperatures will bring more outbreaks of vector-borne diseases, e.g.. West Nile Virus	Low More vector-borne disease
Phenology	• Recurring natural events, or phenology, will shift in response to changes in temperature and precipitation • Phenology shifts will differ by species, leading to disruption of ecological relationships, such as pollination	Medium Varied phenology shifts
Habitat	• Tree species' suitable ranges will shift northward with virtual certainty • In many cases, habitat ranges will shift more quickly than species' can migrate • In the CBA, cold water fish habitat will decrease while warm water habitat will increase • Northern Wisconsin will contain less habitat for white spruce, black spruce, quaking aspen, balsam fir and paper birch, as well as their associated lichens • Moisture stress could reduce habitat for conifer lowland species (tamaracks, black spruce and white cedar) • Brook trout could lose habitat, due to rising air and stream temperatures • Increased algal blooms could reduce dissolved oxygen, reducing fish habitat in lakes	Medium Species range shifts
Microbial Growth	• Wells and lakes will contain increased bacterial and algal growth due to increased temperatures and heavy rain events • This could lead to more "algal blooms", which can be composed of algae or cyanobacteria	High More microbial activity

Economic Effects

Table 3. Effects of climate change in the Chequamegon Bay Area (continued)

CONDITION	PROJECTIONS	CONFIDENCE & TREND
Energy	• Buildings will have reduced heating needs • Buildings will have increased cooling needs	Medium More cooling needs
Crop Stress	• Crops are extremely sensitive to climate, and will respond to many changing climate variables in intricate ways that are difficult to predict • Warmer summers and more droughts will stress crops, reducing yields • Yield reductions from warming could be modulated some by more summer precipitation • Growing season changes could justify new choices of crops and varieties • Higher atmospheric CO2 will increase plant growth and crop yields (for soybeans, but not for corn), but also weed vigor • Higher humidities could promote disease and fungus	Low More crop stress
Livestock	• Warmer summers and more frequent droughts will stress livestock and reduce their productivity[15]	Low More livestock stress
Tourism	• Variable winter conditions, more frequent beach closures, and changes to fisheries may impact the CBA tourism industry	See relevant climate effects above

[15] This assessment applies to Wisconsin livestock. At the northern extreme of Wisconsin, the livestock of the CBA may be buffered against this trend.

Community Input

As community planners and leaders work to implement climate change adaptation, it will be important not only to understand which climate change effects are most likely to impact the Chequamegon Bay Area, but also how those effects, in turn, might impact the quality of life of those who live in the region. To that end, in the early winter of 2018, the Center for Rural Communities at Northland College conducted a mail survey of 1,084 randomly selected households across the CBA. The results of the survey inform several aspects of this report.[16] Responses regarding which features of the CBA are valued by residents, how specific climate change effects might impact quality of life, and community planning priorities are described in this section. They are also referenced in the three Priority Areas for Coordinated Action in Section B and throughout the Planning Topics Section C. Survey results indicating how prepared households are to respond to the effects of climate change are incorporated into the discussion of vulnerable populations.

Knowing what aspects of place are valued by community members, to what extent quality of life might be impacted by specific climate change hazards and effects, and which planning and development topics are most important to residents will help decision-makers identify priorities for consideration & action.

[16] The full summary report can be found at: Chequamegon Bay Area Community Study (July 2018) Center for Rural Communities. https://www.northland.edu/wp-content/uploads/2018/08/CBA-Climate-Change-Study-2018.pdf

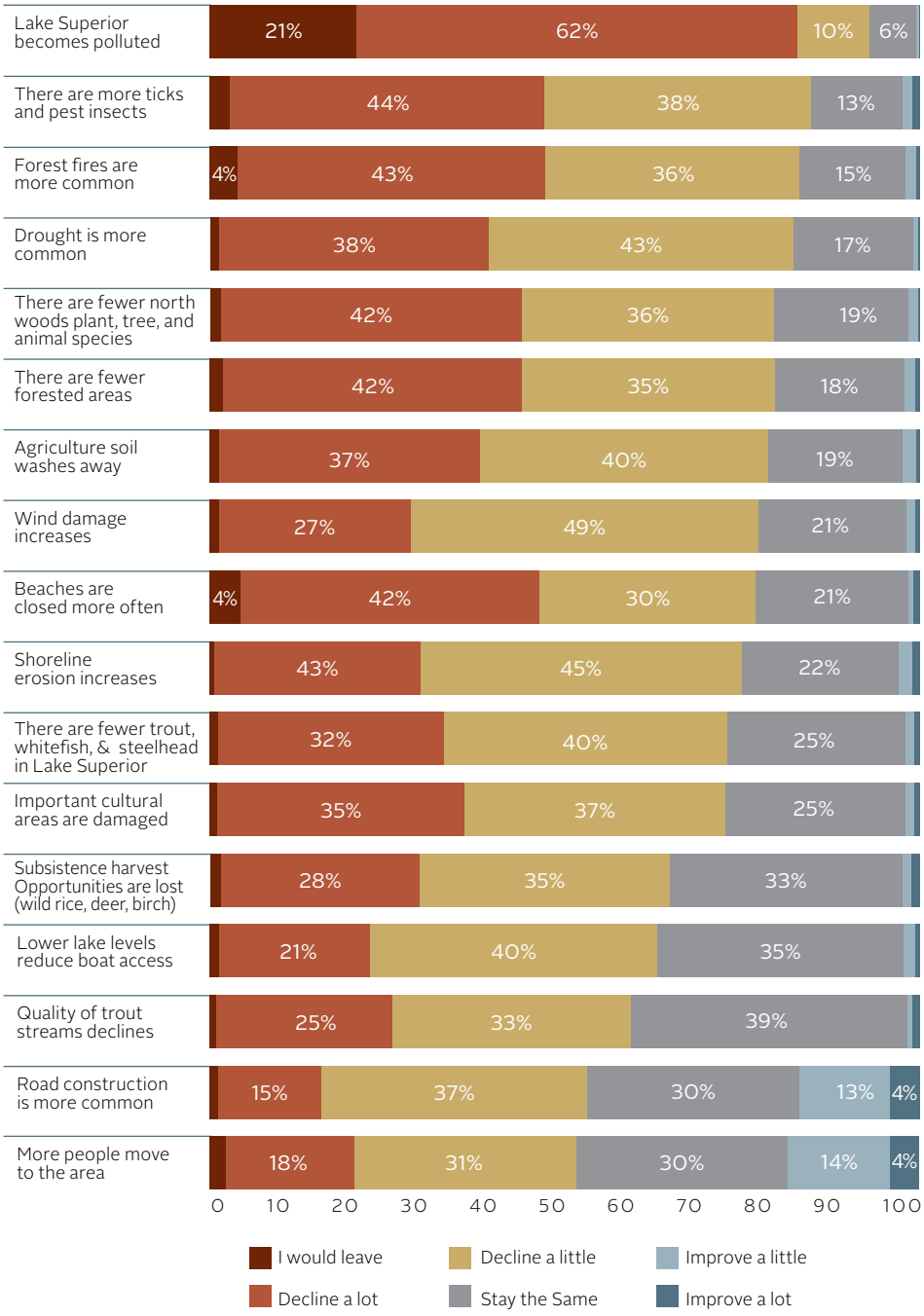
Quality of Life Impacts from Climate Change Hazards

Survey respondents were asked to indicate the extent to which potential changes to the natural environment would improve or decline their quality of life. They could also indicate if a change would impact their quality of life to such an extent that they would leave the area. Quality of life was defined as how one's needs are fulfilled in terms of his or her livelihood, health, relationships, education and knowledge, and spiritual and cultural fulfillment. Summary results of potential climate change effects and hazards that would negatively impact quality of life for a majority of residents are shown in Figure 2.

Highly Valued Features of Place

In addition to quality of life impacts, survey respondents also indicated which features of place contribute to why they live in the CBA. While a proportion of the population live in the area for community features such as schools, music and arts, medical facilities, employment opportunities, and downtown amenities, among others, the following were cited by a majority of the population. Changes to these features would also impact quality of life for many residents.

Figure 2. Potential climate change effects that would negatively impact quality of life in the CBA



Note: The survey results are weighted by demographic variables in each community using 2015 US Census ACS estimates; the final effective sample size is 1,055. The results reported here are representative of ZIP codes 54806, 54814, 54891 with a margin of error of +/-3 percentage points. All results are reported as valid percentages of the total, 'No Answer' responses are not included in percent of total calculations.

Highly Valued Features of Place

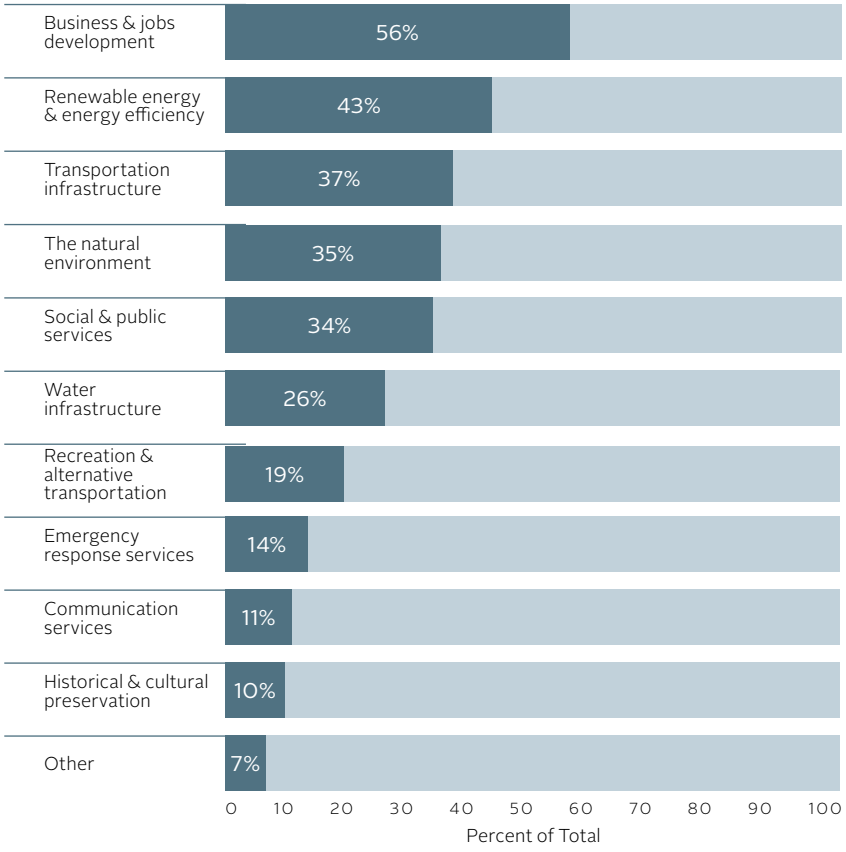
- **Lake Superior, beaches, and clean water** Ninety percent of community members agree that they live in the area because of the proximity to Lake Superior. Similarly, 86 percent live here because of access to clean water. In fact, if Lake Superior were to become polluted, quality of life would decline for 72 percent of the population and an addition 21 percent report that they would leave the area. Clean beaches are also an important feature of the lake. Quality of life would fall for 72 percent of community members if beaches were closed more often, and an additional 4 percent would leave the area in response to more beach closures.
- **Natural beauty, forests, and north woods species** 92 percent of community members value the natural beauty of the area, and 85 percent value the trees, plants, and animal species native to the north woods. Quality of life would be diminished for 77 percent of the population if there were fewer of these species, and 2 percent of the population would leave the area in response to these changes. Furthermore, quality of life would decline for 77 percent of the population if there were fewer forested areas and, again, 2 percent of the population would leave the area.
- **Rural landscape, agriculture, and local food** 85 percent of community members live here for the rural landscape, and 57 percent value living in an area with local food producers. Quality of life would decline for 77 percent of the population if agricultural soils washed away, and 1 percent would leave the area.
- **Seasonal recreation** Summer recreation is valued by 84 percent of community members, and winter recreation is valued by 66 percent of the population. Access to public land is important for both seasonal recreation and harvesting opportunities. 66 percent of the population values public access to land. Similarly, access to the lake is important for both recreation and subsistence. Quality of life would decline for 61 percent of the population if lower lake levels reduce boat access, and 1 percent would leave the area. 53 percent of the population values community parks.
- **Subsistence harvest and recreation** Fishing opportunities are valued by 57 percent of community members, and hunting opportunities are valued by 52 percent. Quality of life would decline for 72 percent of the population if there were fewer trout, whitefish, and steelhead in Lake Superior, and 1 percent would leave the area. Quality of life would decline for 63 percent of community members if opportunities for subsistence harvest of resources such as wild rice and venison were to decline, and 2 percent would leave the area. Northern wild rice is considered to be a cultural, economic, and subsistence resource that is highly to extremely vulnerable to climate change.[17] If the integrity of trout streams were to decline, quality of life would be affected for 58 percent of the population, and 1 percent would leave the area.
- **Cultural areas** Quality of life would decline for 72 percent of the population if important cultural areas are damaged or changed, and an additional 1 percent of community members would leave the area.
- **Small communities** The small size of communities is valued by 82 percent of the population, and quality of life would decline for 49 percent of the population, and an additional 2 percent would leave if more people move to the area.
- **Travel routes** Quality of life would decline for 53 percent of the population if road construction is more common.

[17] According to the GLIFWC Climate Change Vulnerability assessment, northern wild rice is vulnerable to climate change with a moderate degree of confidence. https://data.glifwc.org/archive.bio/GLIFWC_Climate_Change_Vulnerability_Assessment_Version1_April2018.pdf

Community Planning Priorities

Survey respondents were asked to choose from a list of ten planning topics which three they think their community should focus on. There was also an option for respondents to write in a planning topic that was not on the list. The priority topics in Figure 3 are meant to inform future local government planning efforts.[18]

Figure 3. Community planning priorities for the CBA



[18] Planning priorities by ZIP code are reported in the summary report found here: https://www.northland.edu/wp-content/uploads/2018/08/CBA-Climate-Change-Study-2018.pdf

Vulnerable Populations

Climate change produces a number of health concerns, which are time and place-specific, such as temperature-related death and illness, air quality impacts, extreme events and safety concerns, vector-borne diseases, water-related illness, food safety and distribution, and impacts on mental health and well-being.[19] As part of climate change adaptation efforts, it will be important to anticipate and plan for how climate change will affect populations of concern in the Chequamegon Bay Area.

Populations of Concern

Climate change impacts are likely to disproportionately affect vulnerable populations depending on their exposure, inherent sensitivity, and adaptive capacity to respond and cope (see Table 4). Some groups face several climate and non-climate related stressors simultaneously. People living in isolated rural areas are at risk of increased exposure, as are indigenous communities who experience higher numbers of existing health risks. Those who are dependent on the environment for sustenance are also likely to experience greater exposure. Furthermore, changes in the availability of culturally relevant plant and animals species threaten ceremonial and cultural practices for indigenous populations.[20] Each population of concern is vulnerable to climate change impacts in particular ways, and a proportion of people living in the CBA may be impacted (see Table 5).

Table 4. Components of vulnerability

EXPOSURE	• Occupation • Time spent in risk-prone areas • Ability to respond (i.e., evacuate) • Socioeconomic status • Infrastructure condition • Compromised mobility or cognition • Traditional foods diet
SENSITIVITY	• Overall health status • Children • Pregnant women • Older adults • Indigenous communities
ADAPTIVE CAPACITY	• Socioeconomic status • Condition and accessibility of infrastructure • Accessibility of health care • Human and social capital • Institutional resources

Source: USGCRP, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. http://dx.doi.org/10.7930/J0R49NQX

Climate change impacts are likely to disproportionately affect vulnerable populations depending on their exposure, inherent sensitivity, and adaptive capacity to respond and cope.

[19] USGCRP, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp. http://dx.doi.org/10.7930/J0R49NQX

[20] Ibid

Table 5. Potential climate change impacts to populations of concern in the Chequamegon Bay Area

POPULATION OF CONCERN	CLIMATE VULNERABILITIES	IMPACTS	CHEQUAMEGON BAY AREA DEMOGRAPHICS
Low income	• Heat waves • Extreme weather events • Poor air quality • Water-borne and vector-borne diseases • Food safety • Psychological stressors	• Death and disease from exposure to extreme heat • Increased illness, injury, death, displacement • Allergens and asthma • Gastrointestinal illness • Reduced nutrient content of food • Stress-related mental health impacts	• 27 percent of households have an annual income below $25,000. 15 percent of people are living below the poverty level.[21]
Indigenous peoples	• Food safety and security • Water security • Loss of cultural identity • Degraded infrastructure	• Declines in traditional and subsistence foods, loss of nutrient content • Contaminated drinking water, increased instances of diarrhea • Reduced access to evacuation routes and emergency services	• 24 percent of the population is American Indian or American Indian combined with another race. 41 percent of American Indian families living on a reservation have an annual household income below $25,000. 30 percent of households have an annual income below the poverty line.[22]
Children and pregnant women	• Extreme heat events • Other weather extremes • Air quality • Water-borne illness • Vector-borne and other infectious diseases • Food safety	• Heat stress from physical exertion • Asthma and allergies from long pollen seasons • Trauma from disaster • Gastrointestinal illness • Eye and ear infections from water-borne bacteria • Illness from algal bloom toxins • Lyme disease	• 16 percent of the population is under age 15. 5 percent of the population is under age 5.
Older adults (65+)	• Extreme heat events • Other weather extremes • Air quality • Vector-borne and water-borne diseases	• Heat exposure, cardiovascular and respiratory disorders • Difficult evacuation and sheltering • Asthma, COPD, risk of heart attack • Gastrointestinal illness	• In 2010, the population age 65 and over was 17 percent in 2016 it increased to 20 percent.

Source: USGCRP, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. http://dx.doi.org/10.7930/J0R49NQX

[21] Summary statistics are from the ACS 2016 estimates for ZIP codes 54806, 54814, and 54891 unless otherwise noted.
[22] Tribal Census, 2010-2016 estimates.

POPULATION OF CONCERN	CLIMATE VULNERABILITIES	IMPACTS	CHEQUAMEGON BAY AREA DEMOGRAPHICS
Occupational groups (outdoor workers: farmers, ag workers, fishermen, construction workers, paramedics, firefighters and other first responders, transportation workers; indoor physical laborers without AC)	• Extreme heat events • Other weather extremes	• Heat-related illness, heat stroke, heat exhaustion, fatigue, risk of injury • Respiratory illness • Exposure to physical and psychological hazards • Aeroallergen exposure • West Nile, Lyme disease	• 10 percent of the population is employed in natural resources, construction, or maintenance sectors; 3 percent are employed in protective services, such as fire fighting and prevention; and 10 percent are employed in production, transportation, or material moving.
Persons with disabilities (hearing/ speech/vision, cognition, mobility)	• Extreme weather	• Emergency response needs • Risk communication • Uninterrupted utilities/ electricity access	• 8 percent of the population has ambulatory difficulty
Persons with chronic medical conditions (cardiovascular disease, respiratory disease, diabetes, asthma, obesity, psychiatric illness, on medication, Alzheimer's disease, mental illness)	• Extreme heat	• Impaired body temperature • Fluid and electrolyte imbalances • Disease exacerbation • Impaired response in crisis • Treatment interruption	• 11 percent of the population in Ashland County has been diagnosed with diabetes; 9.5 percent in Bayfield County.[23] 27.3 percent of the population in Ashland County and 28.7 percent in Bayfield County suffer from obesity. Rates of Lyme's disease and heart attack in 2017 were higher in both Ashland and Bayfield counties than the state overall.[24] Rates of heat stress in Ashland County were higher than the state.

[23] Centers for Disease Control and Prevention, 2013 data.

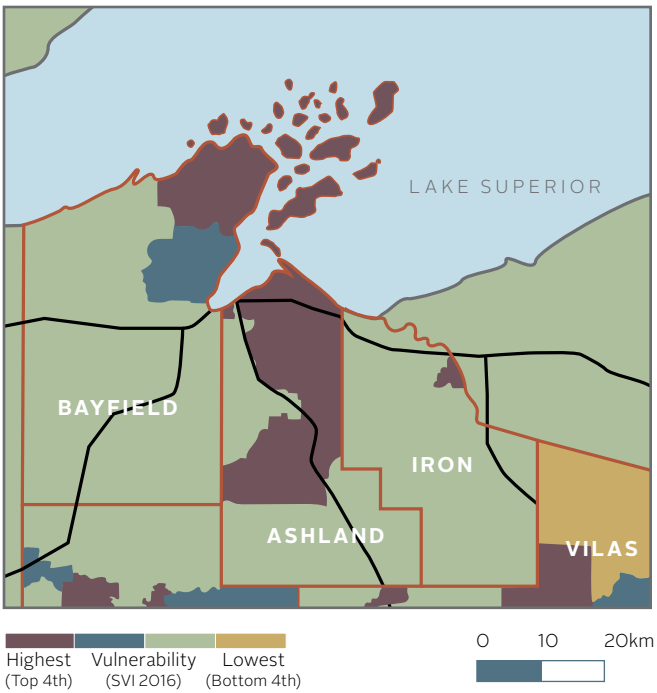
[24] 2017 Wisconsin Environmental Health Profile.

The Centers for Disease Control and Prevention (CDC) calculates a Social Vulnerability Index (SVI) at the county level using census tract data to summarize the extent to which an area is socially vulnerable to disaster. The purpose is to help local officials identify groups and areas that may need support in preparing for hazards.[25] Census-derived factors in the overall SVI include socioeconomic status, household composition/ disability, race/ethnicity/language, and housing/ transportation. Figure 4 shows the geographic range of vulnerable populations across Ashland and Bayfield counties.

Household Preparedness

Findings from the 2018 mail survey conducted by the Center for Rural Communities provide a baseline for the ways in which households in the Chequamegon Bay Area are prepared or unprepared to respond to climate change hazards and effects, making them vulnerable to future climate change impacts (Table 6).[26] For example, 29.5 percent of the total population disagrees or strongly disagrees with the statement, 'I am prepared to deal with a prolonged power outage,' and, notably, 31 percent of households with annual incomes under $25,000 are unprepared for a prolonged power outage.

Figure 4. Overall social vulnerability



[25] https://svi.cdc.gov/

[26] The results of the survey are representative of the Chequamegon Bay Area population with a margin of error of +/- 3 percentage points. The full summary report can be found at: Chequamegon Bay Area Community Study (July 2018) Center for Rural Communities. https://www.northland.edu/wp-content/uploads/2018/08/CBA-Climate-Change-Study-2018.pdf

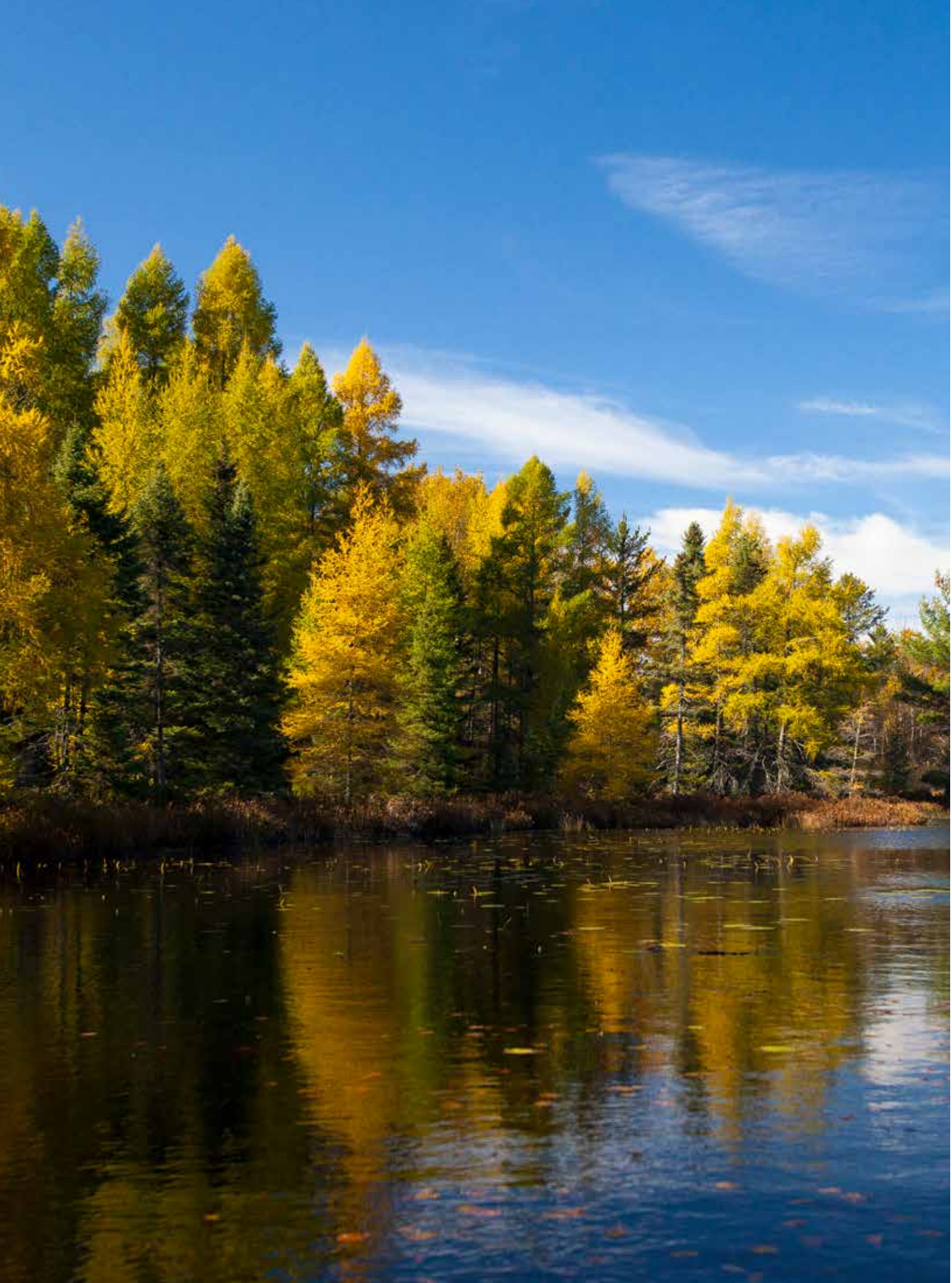
Table 6. Percentage of people in each population of concern who are unprepared (strongly disagree or disagree with each statement) under current conditions and may be vulnerable to climate change impacts

POPULATION OF CONCERN	TOTAL POP	<$25,000 HH INCOME	LIVE IN TOWN	LIVE IN COUNTRY	AMERICAN INDIAN	OVER AGE 65
Preparedness measure						
Exposure	*Percentage of households who are unprepared*					
I am able to avoid exposure to ticks and other harmful insect	14.7	12.5	13.2	21.9	16.4	10.7
I have shelter in case of severe weather	7.6	15.6	7.4	9.6	12.9	5.2
I can keep my home cool in the summer	9.1	19.9	14.3	6.4	4.7	2.8
I can keep my home warm in the winter	2.7	8.2	3.3	0.6	3.9	1.6
Information	*Percentage of households who are unprepared*					
I know how to find information about beach closures	10.1	7.8	13.0	10.6	10.2	7.9
I know how to find information about the quality of my drinking water	10.1	14.9	13.7	6.1	10.9	6.4
I know when a weather advisory is in effect	1.1	1.4	1.2	1.6	0.0	1.6
Transportation	*Percentage of households who are unprepared*					
My vehicle can withstand most road conditions	7.1	16.3	8.3	7.4	11.4	4.4
I have multiple routes to the places I need to go	6.1	5.3	5.8	7.4	3.9	5.1
Household resources	*Percentage of households who are unprepared*					
I am prepared to deal with a prolonged power outage	29.5	31.0	37.2	28.0	24.3	27.8
I have enough food in my home to last a week	4.3	10.7	4.6	3.5	8.2	1.2
I have adequate resources to deal with property damage9	16.8	29.8	20.1	14.5	18.8	9.1
I have adequate resources to respond to a family health problem	11.7	16.0	14.3	11.3	9.1	7.5
My utility rates are affordable	23.8	29.4	25.6	24.8	31.6	20.6
Community support	*Percentage of households who are unprepared*					
My neighbors watch out for me	10.1	24.2	11.0	10.0	12.9	5.2
I have people I can stay with if something happens to my home	7.4	8.9	8.3	7.4	4.7	8.7
I know who to call if I have an emergency	0.3	0.4	0.4	0.0	0.0	0.4

Source: Chequamegon Bay Area Community Study (July 2018) Center for Rural Communities. Full report available here: https://www.northland.edu/wp-content/uploads/2018/08/CBA-Climate-Change-Study-2018.pdf

Population of concern disproportionately unprepared

Community-wide lack of preparation



Priority Areas for Coordinated Action

Three Priority Areas for Coordinated Action are put forward here for consideration and discussion by local leaders and Chequamegon Bay Area communities at large. These priority areas span planning topics and will require cooperation and coordination across jurisdictional boundaries for effective preparation and adaptation (see Table 7 for planning topics affected). For each Priority Area for Coordinated Action, references and links to climate data and community input findings are offered. Also included are goals and sets of questions to help guide implementation of adaptation for each priority area. The recommendations and resources are not meant to be comprehensive; rather they are to serve as illustrative examples and starting points for discussion and exploration.

Three Priority Areas for Coordinated Action

Protect Drinking Water Quality

Prevent Washouts and Mitigate Flood Hazards

Prepare for Variable Recreation and Tourism Conditions

The three Priority Areas for Coordinated Action were selected based on meeting a combination of the criteria shown in Figure 5.

Following are descriptions, definitions, and sources for each of these criteria.

Climate change effect confidence level is the likelihood that a planning topic will be exposed to a climate change effect or hazard based on historical frequency of events and computer-based model projections.[27] Projections are based on sets of assumptions about future scenarios that may or may not be realized. Therefore, ongoing impacts and future risks are noted for which there is presently considerable agreement across sources (see Section A, Climate Change Projections for more information).

Community assets are the tangible and intangible things people or communities value. Highly valued assets in this report are identified using primary survey data collected from a representative sample of households across the Chequamegon Bay Area about what they value about living in the area and to what extent the effects of climate change will impact their quality of life (Section A, Community Input for a summary of these data).

Vulnerable populations are those who are adversely and disproportionately affected by climate change impacts. Vulnerability encompasses exposure, sensitivity, potential impacts, and adaptive capacity. Sources for this factor include the U.S. Global Change Research Program 2016 report which describes impacts of climate change on human health[28] and primary survey data collected from a representative sample of households across the Chequamegon Bay Area about household and community preparedness (see Section A, Vulnerable Populations for more information).

Figure 5. Criteria for Priority Areas for Coordinated Action in the Chequamegon Bay Area

	CRITERIA	SYMBOL
✔	High confidence of climate change effects	
✔	Highly valued CBA community asset may be affected	
✔	One or more vulnerable populations may be affected	
✔	Community priority planning topics are involved	
✔	Non-climate stressors could exacerbate impacts	
	Vulnerability of assets **to be determined** by communities	

Community priorities are drawn from primary survey data collected from a representative sample of households across the Chequamegon Bay Area (see Community Input for a summary of results).

Non-climate ecosystem stressors are changes or trends that increase the likelihood of a hazardous event occurring.[29] For example, altering drainage patterns and replacing open land with roads and buildings are non-climate stressors for flooding hazards. The IPCC has identified the following non-climate drivers:[30]

Land-use change

- Conversion of forest to agriculture–declines in habitat, biodiversity loss, increased soil erosion, nitrification
- Urbanization and transportation–ecosystem fragmentation, deterioration of air quality, increased runoff and water pollution
- Afforestation–restoration or establishment of tree cover

[27] See the U.S. Climate Resilience Toolkit for further definitions. https://toolkit.climate.gov/content/glossary

[28] USGCRP, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp. http://dx.doi.org/10.7930/J0R49NQX

[29] https://toolkit.climate.gov/content/glossary

[30] Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, P. Tryjanowski, 2007: Assessment of observed changes and responses in natural and managed systems. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 79-131.

non-climate drivers continued:

Land-cover modification

- Ecosystem degradation–reduction in ecosystem services, reduction in biomass, biodiversity loss, changes in microclimate

Pests and invasive species

- Sea lampreys, zebra and quagga mussels, gypsy moth, emerald ash borer, forest tent caterpillar, spruce budworm, common reed.[31]

Pollution

- Ozone, toxic waste, exhaust, pesticides, emissions–reduction in biodiversity, species mortality, health impairment, melting of snow and ice

Other non-climate stressors relevant to the Chequamegon Bay Area not listed by the IPCC:

- Aging sewerage and wastewater infrastructure
- Population growth along coastlines
- Impacts of recreational use

The final component for determining priorities for climate change adaptation is for each community or planning body to **assess the vulnerability** of built, natural, and cultural assets. Doing so will help determine the degree to which those assets might be exposed to harm and most in need of protection as a result of climate change. Vulnerability is comprised of sensitivity and adaptive capacity.[32] The sensitivity of a particular asset is the degree to which it is susceptible or resistant to impacts from weather or climate events. Adaptive capacity is the ability to cope with stress or to adjust to new situations. Communities should also assess the magnitude of the loss of a vulnerable asset; this could be assessed in terms of financial loss or in terms of quality of life for residents. The U.S. Climate Resilience Toolkit offers guidance for how to assess risk to assets: https://toolkit.climate.gov.

[31] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

[32] Definitions and tools for assessing vulnerability of assets can be found at the U.S. Climate Resilience Toolkit: https://toolkit.climate.gov/steps-to-resilience/assess-vulnerability-risks

Table 7. Planning topics involved in the Priority Areas for Coordinated Action

PLANNING TOPICS	PRIORITY AREAS FOR COORDINATED ACTION		
	Protect Drinking Water Quality	Prevent Washouts and Mitigate Flooding	Prepare for Variable Recreation and Tourism Conditions
Housing	Fouling of Wells	Flooding Damages	
Transportation		Damage to Roadways	Reduced Ice Cover
Utilities and Community Facilities	Drinking Water Stresses; Stresses to Human Health	Increased Runoff and Flooding Damages; Emergency Response Demands	Emergency Response Demands
Agricultural, Natural, and Cultural Resources	Natural Ecosystems	Food and Forage Crops and Livestock	Natural Ecosystems (Hunting, Harvesting, & Fishing); Recreation
Economic Development			Affected Industries
Land Use		Wetland Changes; Floodplain Changes	
Waterfront and Coastal Resources			Stress to Beaches

PRIORITY AREA #1

Protect Drinking Water Quality

	CRITERIA	SYMBOL
✔	High confidence of climate change effects	
✔	Highly valued CBA community asset may be affected	
✔	One or more vulnerable populations may be affected	
✔	Community priority planning topics are involved	
✔	Non-climate stressors could exacerbate impacts	
	Vulnerability of assets **to be determined** by communities	

- Hazards to drinking water sources, including both private wells and public water supplies, in the Chequamegon Bay Area are expected to increase with climate change.
- There is a high level of confidence that there will be an increase in microbial activity in drinking water sources due to higher temperatures and more frequent and more intense rain events.
- Wells are more exposed to contamination during heavy rain events when they are not protected from nutrient and sediment loading to surface waters or in cases where septic systems are sited too near to wells or surface waters.
- Since microbial activity increases as waters warm, contamination could feed bacterial growth in wells if they warm.
- Similarly, public water sources could be stressed by more algal blooms near water intakes resulting from heavy rains, warmer waters, reduced ice cover, and possible lower lake levels (see Appendix A, Combined Effects, Algal Blooms for more information).
- Algal blooms could strain drinking water treatment facilities, requiring additional monitoring, treatment, and reserves (see Section C, Utilities and Community Facilities/Drinking Water Stresses for more information).
- If communities rely on groundwater, they should be prepared for changes in discharge and recharge to affect that supply.

▶ See Section A and Appendix A for more on climate change effects

▶ See Section C for more on planning topics

PRIORITY AREA #1

Protect Drinking Water Quality

community asset

- Water quality is one of the most highly valued features of living in the Chequamegon Bay Area, with 86 percent of the population reporting that they live here because they value access to clean water.
- If Lake Superior were to become polluted, quality of life would decline for 72 percent of the population and an additional 21 percent report that they would leave the area.

vulnerable populations

- Several populations of concern in the Chequamegon Bay Area are vulnerable to water-borne diseases and illness, including lower-income households (27 percent of households have an annual income below $25,000), children and pregnant women (16 percent of the population is under age 15), and older adults (20 percent of the population is over 65 years of age) (see Section A, Vulnerable Populations for more information).
- Indigenous populations are vulnerable to water insecurity.
- Not only are these populations vulnerable to drinking water stresses, some are unable to access information pertaining to drinking water quality. 10 percent of the overall population in the Chequamegon Bay Area does not know how to find information about drinking water quality. Specifically, 15 percent of lower-income households do not know where to find this information, nor do 14 percent of households who live in town, 11 percent of American Indian households, and 6 percent of those who live in the countryside.

planning priorities

- Over one-quarter, or 26 percent of households, cited water infrastructure as a top three planning priority for their community.

non-climate stressors

- Wells will be more susceptible to climate impacts if they are improperly sited or incomplete.
- Historic deforestation and wetland loss increase the flow of nutrients into lakes during heavy rain events.
- High impact agricultural practices and intensive lawn care expose lakes to additional excess nutrients after heavy rains.
- Heavy rain events bring hazardous materials into lakes if the substances were not properly disposed of.
- Aging sanitary and stormwater infrastructure can allow wastewater to enter surface drinking water sources during heavy rains.

IMPLEMENTATION

Protect Drinking Water Quality

GOAL

Maintain access to safe drinking water as climate change hazards increase

Questions for guiding discussion and coordinated effort toward goal:

- How can we reduce the public health risks of water-borne illness and disease, particularly for vulnerable populations?

Subgoal 1

Prepare rural households for increased risk to wells

Questions for guiding discussion and coordinated effort toward goal:

- Are homeowners aware of the increased hazards to wells due to climate change and the factors that could make wells more susceptible to impacts?
- Are well testing services readily available to homeowners?
- How can we support homeowners to take actions to protect wells from climate change hazards?

RESOURCES

- The United States Environmental Protection Agency (EPA) What to Do With Your Private Well After a Flood: https://www.epa.gov/sites/production/files/2015-05/documents/epa816f05021.pdf
- The Wisconsin Department of Natural Resources provides a broad array of information for private well owners: https://dnr.wi.gov/topic/wells/
- The University of Wisconsin-Stevens Point Groundwater Center hosts private well water testing and provides data online through https://www.uwsp.edu/cnr-ap/watershed/Pages/WellWaterViewer.aspx

Subgoal 2

Prepare municipal water utilities for increased stresses to source waters

Questions for guiding discussion and coordinated effort toward goal:

- Are our drinking water treatment facilities sufficient to address potential increases in toxins?
- How can we prepare for changes to groundwater supply discharge and recharge?
- Do we have a wellhead protection plan or ordinance in place if our public water supply is groundwater?
- Do we have a source water protection plan if our public water supply is surface water?

RESOURCES

- The Wisconsin DNR provides resources for source water protection planning: https://dnr.wi.gov/topic/DrinkingWater/SourceWaterProtection.html
- The Bayfield County Water-Table Map and Water Well Database can be used to evaluate well susceptibility to contamination and vulnerability to depletion. The document and maps can be downloaded here: https://wgnhs.uwex.edu/pubs/wofr201702/

IMPLEMENTATION

Protect Drinking Water Quality

Subgoal 3

Ensure effective emergency response systems are in place for drinking water contamination scenarios

Questions for guiding discussion and coordinated effort toward goal:

- How can we reduce exposure if public drinking water becomes contaminated?
  - » What is our process for testing drinking water quality and assessing source water given the increased potential for contamination?
  - » Do we have an effective public notification system?
  - » Are households ready to treat or filter water?
  - » Do vulnerable populations have access to alternative clean drinking water sources?

RESOURCES

- The EPA provides guidance for designing communications systems for water quality: https://www.epa.gov/sites/production/files/2017-04/documents/srs_communications_guidance_081016.pdf

Subgoal 4

Increase resilience of surface waters to harmful effects of heavy rains (pollutants, nutrient and sediment loads in runoff)

Questions for guiding discussion and coordinated effort toward goal:

- Do our planning and development practices take into account non-climate stressors to drinking water?
- How can we work across jurisdictions, organizations, and departments to reduce nutrient and sediment loading to surface water?
- How can we reduce stormwater discharges (see Priority Area 2) and pollutant runoff?
- How can we reduce wastewater/sewage system overflows?
- How can we protect surface water from septic system overflow?
- How can we support the natural functionality of wetlands? (see Priority Area 2)
- How can we manage upstream resources to slow the flow of runoff? (see Priority Area 2)
- Can we utilize a Regional Sediment Management (RSM) plan to maintain beneficial uses of sediments?

RESOURCES

- The Source Water Collaborative has a guide for incorporating drinking water protection into land use planning: https://sourcewatercollaborative.org/wp-content/uploads/2017/05/SWC-PlannersGuide_v1c.pdf
- The EPA maintains a clearinghouse of resources for programs to prevent polluted stormwater runoff. The focus is on outreach and education: https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

IMPLEMENTATION

Protect Drinking Water Quality

GOAL

Maintain access to safe drinking water as climate change hazards increase

Questions for guiding discussion and coordinated effort toward goal:

- How can we reduce the public health risks of water-borne illness and disease, particularly for vulnerable populations?

Subgoal 5

Develop drinking water protection strategies based upon current scientific knowledge

Question for guiding discussion and coordinated effort toward goal:

- Are policies flexible to respond to changing conditions and subsequent knowledge regarding drinking water protection?

RESOURCES

- Agal Blooms–Researchers at the National Park Service, the University of Minnesota–Duluth Large Lakes Observatory, and University of Wisconsin–Milwaukee School of Freshwater Sciences are conducting ongoing research to understand the potential for harmful algal blooms in Lake Superior.
- Nutrient and sediment loading–The Northland College Burke Center for Freshwater Innovation is studying sediment and phosphorus loads to Chequamegon Bay. Follow their work here: https://www.northland.edu/sustainability/mgbc/our-work/
- Private well owner testing–The University of Wisconsin-Extension Fond du Lac County conducted a survey in 2015 exploring testing practices and behaviors among private well owners. Find more information here: https://www.wiscontext.org/what-motivates-rural-wisconsinites-test-their-drinking-water-source
- Groundwater pathogens–n an article published in 2017, a Florida State University professor investigated how climate change might make people in Wisconsin more vulnerable to groundwater-borne pathogens in the decades ahead. Find more information here: https://www.wiscontext.org/more-rain-means-more-bacteria-and-viruses-northern-wisconsins-groundwater

WHAT COMMUNITIES ARE DOING

The city of Ashland, WI is working on a Source Water Protection Plan and is participating in a stormwater education and outreach program through the ThinkWater School funded by the U.S. Department of Agriculture. The City's Unified Development Ordinance requires new developments to have Stormwater Management Plans and Permitting Requirements.

The city of Two Harbors, Minnesota, has formed a working group to address resilient stormwater planning. The working group created a plan to identify specific sites where stormwater infrastructure and flood control structures could be implemented to manage large surges of runoff from storm events. This analysis took into consideration the way in which water flowed, looking at past flood events for examples, as well as looking into soil type and topography, cost of implementation, and availability of land. The plan ultimately had to satisfy the goals of reduced runoff, reduced pollution possibility in runoff, and funding constraints. Three detention basins were built to reduce flood runoff. Erosion control was addressed in the Urban Forest Management Plan and a rain garden was created in front of the Courthouse. These projects were completed in partnership between Lake County and University of Minnesota Extension staff, and state and federal agencies (Minnesota Department of Transportation). More information can be found at http://greatlakesresilience.org/case-studies/infrastructure/resilient-stormwater-planning-takes-time-and-pays

IMPLEMENTATION

Protect Drinking Water Quality

The Flagler Wetland Restoration Project aims to restore full functionality to the Guana Marsh area by filling an extensive series of ditches that were dug many decades ago for mosquito control. https://www.sjrwmd.com/facts/flagler-wetland-restoration-project/

The Massachusetts Bays Program Comprehensive Conservation and Management Plan established a series of action plans to protect coastal waters, including stormwater pollution reduction, toxic pollution reduction, oil pollution reduction, wastewater management, and land use management action plans. https://www.mass.gov/files/documents/2016/08/si/revisedccmp.pdf

FUNDING SOURCES

The Centers for Disease Control and Prevention Safe Water for Community Health (Safe WATCH) program supports drinking water programs at health departments to address problems with private drinking water systems in their communities. These systems include private (or household) wells, cisterns, water storage tanks, and trucked water.

The U.S. EPA Water Infrastructure Finance and Innovation Act (WIFIA) program accelerates investment in our nation's water infrastructure by providing long-term, low-cost supplemental loans for regionally and nationally significant projects More information at: https://www.epa.gov/wifia

The U.S. EPA lists effective funding frameworks for water infrastructure at: https://www.epa.gov/waterfinancecenter/effective-funding-frameworks-water-infrastructure

The Wisconsin DNR well compensation grant program provides funding to eligible landowners or renters to replace, reconstruct or treat contaminated private water supplies that serve a residence or provide water to livestock. To be eligible, family income may not exceed $65,000 for the prior calendar year. More information can be found here: https://dnr.wi.gov/aid/wellcompensation.html

PRIORITY AREA #2

Prevent Washouts & Mitigate Flood Hazards

	CRITERIA	SYMBOL
✔	High confidence of climate change effects	
✔	Highly valued CBA community asset may be affected	
✔	One or more vulnerable populations may be affected	
✔	Community priority planning topics are involved	
✔	Non-climate stressors could exacerbate impacts	
	Vulnerability of assets **to be determined** by communities	

climate change effects

- In the U.S. Great Lakes, the heaviest 1 percent of rain events already increased by 31 percent during the 1958-2007 period.
- Looking forward, model averages indicate that by 2090, the CBA will experience 13 more days per decade of 1-inch rains, 4.4 more days per decade of 2-inch rains, and 1.3-1.5 more days per decade of 3-inch rains.
- The 100-year rainfall estimates are expected to change by 11-15 percent in the Chequamegon Bay Area by mid-century, compared with the 1961-2000 average.
- During heavy rain events, water accumulates on land more quickly than it is able to percolate into the soil. This results in excess runoff and flooding.
- Floods damage homes and threaten lives and human health. Housing might be susceptible to flood damage, and transportation infrastructure, such as roadways and bridges, could be subject to more overflows and washouts, particularly in places where infrastructure designs are based on outdated rainfall data.
- Similarly, public infrastructure, such as wastewater treatment facilities, could be physically damaged by flooding.
- Increases in heavy rain events could lead to a general increase in natural disasters, whereby emergency response services will need to be prepared for impacts on vulnerable populations and disruptions in access and evacuation routes.
- Furthermore, wetlands will continue to be stressed by climatic changes. Given that wetlands act as flood storage areas to attenuate the effects of heavy precipitation, it will be important to preserve and protect remaining wetlands, and to restore wetlands in key locations.
- Heavy rain events will lead to more flooding, which will change floodplain boundaries.
- Increases in heavy rains will also threaten healthy soil necessary for agricultural production. Farmers will increasingly need to be prepared for managing stormwater on their land.
- Improved stormwater management will help prevent damage to roadways, homes, and other properties and will help protect the health and safety of vulnerable populations.

▶ See Section A and Appendix A for more on climate change effects

▶ See Section C for more on planning topics

PRIORITY AREA #2

Prevent Washouts & Mitigate Flood Hazards

vulnerable populations

- Lower-income households are more vulnerable to floods if homes are structurally compromised.
- More remote households and those located on reservations may have reduced access to evacuation routes and emergency services during flood events and washouts.
- Children can experience trauma from natural disasters.
- Older adults may have difficulty evacuating or finding shelter, and persons with disabilities or chronic medical conditions may have increased emergency response needs and require access to uninterrupted utilities.
- Occupational groups, such as first responders, may be exposed to physical and psychological hazards.
- In terms of preparedness for heavy rain events, almost all households in the CBA report that they know when a weather advisory is in effect (see Vulnerable Populations for more information).
- However, almost 30 percent are unprepared to deal with a prolonged power outage, and over 7 percent of households who live in the countryside do not have multiple routes to the places they need to go.
- Almost 30 percent of households with income under $25,000 do not have adequate resources to deal with property damage.
- Over 10 percent of lower income households and over 8 percent of American Indian households do not have enough food in their home to last a week.

community asset

- Aspects of quality of life that would be affected by more frequent heavy rain events include impacts to soil and local food.
- Quality of life would decline for 78 percent of the population if soils wash away.
- Quality of life would decline for 53 percent of the population if travel routes are affected by road construction.

planning priorities

- Transportation infrastructure is a top three community planning priority for 43 percent of the population. This is the third most cited planning priority behind jobs development and renewable energy and efficiency.
- Considering that low impact development and building green infrastructure will support green jobs, improving stormwater management works toward several planning priorities as identified by households, including jobs development and the natural environment (see Section C, Land Use for more information about green infrastructure).

non-climate stressors

- Historical land use change (i.e., forest clearing, compromised wetlands) reduces the land's ability to absorb heavy rains.
- Culvert sizing, design, and placement may increase the tendency for heavy rain events to lead to washouts.
- Impervious surfaces reduce the land surface's ability to absorb heavy rains.
- Clay soils common in the CBA are slow to absorb water, leading to more runoff during heavy rains.

IMPLEMENTATION

Prevent Washouts & Mitigate Flood Hazards

GOAL

Improve built and natural infrastructure to mitigate the effects of more frequent heavy rain events

Question for guiding discussion and coordinated effort toward goal:

- How can we coordinate actions throughout the CBA to increase resilience to heavy rain events?

RESOURCES

- FEMA developed a guide for communities to reduce damage from localized flooding: https://www.fema.gov/media-library-data/20130726-1446-20490-0539/FEMA511-complete.pdf
- The U.S. EPA provides several informational resources for managing flood risks:
  - » Guides and modeling resources for managing flood risks: https://www.epa.gov/green-infrastructure/manage-flood-risk
  - » Green Streets, Green Jobs, Green Towns (G3) Program https://www.epa.gov/G3
  - » Guide and Toolkit for Community Solutions for Voluntary Long-Term Stormwater Planning: https://www.epa.gov/npdes/stormwater-planning

Subgoal 1

Prepare communities for increased flood risks

Questions for guiding discussion and coordinated effort toward goal:

- Are residents and businesses prepared for flood events?
  - » Are homeowners aware of flood safety steps?
  - » Do homeowners have sufficient flood insurance for new conditions?
  - » Do homeowners know how to flood proof their homes?

RESOURCES

- City of Cedar Falls, Iowa outlines homeowner safety tips: http://www.ci.cedar-falls.ia.us/DocumentCenter/View/4385/SW-Brochure-2016
- The City of Bellevue, WA developed a guide for homeowners that describes actions to take regarding flooding: https://utilities.bellevuewa.gov/manage-your-utility-services/stormwater/flood-protection-information/actions-to-take-with-rain-and-flooding

IMPLEMENTATION

Prevent Washouts & Mitigate Flood Hazards

Subgoal 2

Implement stormwater management practices that can adapt to changing precipitation patterns

Questions for guiding discussion and coordinated effort toward goal:

- Do our floodplain maps account for future hazards and risk?
- Are our culvert crossing designs and sizing methods appropriate for new conditions?
  - » Are we using the most up-to-date expected rainfall data?
  - » Would more culverts in certain locations reduce erosion and overflow?
- Do we have sufficient overflow inlets to drain excess rain during large storm events?
- Are catch basins well maintained?

RESOURCES

- The Northwest Regional Planning Commission completed a Flood Impact Study that estimated potential economic losses from 100-yr and 500-yr flood events. Their results could indicate where assets are vulnerable. The report and data are available at: http://www.nwrpc.com/CivicAlerts.aspx?AID=178
- The Wisconsin Coastal Management Program and Land Information Program is working to form a community of practice to improve coastal hazard planning and policy development, with an initial focus on culvert mapping in the region.
- The Bad River Watershed Association initiated the Culvert Restoration Program to conduct a watershed wide, quantitative road-stream crossing inventory and identify specific sites that are priorities for remediation: http://www.badriverwatershed.org/index.php/restore

Subgoal 3

Ensure effective emergency response systems are in place for excess runoff and flooding scenarios

Questions for guiding discussion and coordinated effort toward goal:

- Do we have an effective flood early warning system?
- Are emergency response services prepared for increased hazards to roads and homes?
  - » Have we mapped multiple routes for first responders and evacuation?
  - » Do we have a plan for evacuating those who are most at risk?
  - » Are residents aware of health concerns related to flooding?
  - » Do homeowners have an exit plan and evacuation check-list?

RESOURCES

- The National Weather Service StormReady program guides communities through the process of establishing early warning systems and maintaining community preparedness: https://www.weather.gov/StormReady

IMPLEMENTATION

Prevent Washouts & Mitigate Flood Hazards

Subgoal 4

Increase resilience of the land surface to the harmful effects of heavy rains (erosion, washouts, floods)

Questions for guiding discussion and coordinated effort toward goal:

- Have we developed priorities for wetland protection and restoration?
  - » How can we incentivize wetland restoration in priority areas?
  - » What can we do to protect existing wetlands in key locations?
- How can we incentivize riparian/upland forest restoration?
- Are on-farm best management practices (BMPs) appropriate for new conditions?
  - » How can we encourage application of agricultural BMPs?
  - » How can we encourage on-farm water management?
- Are we using the full suite of low impact development practices within municipalities?
  - » How can we preserve, restore, and create green space to infiltrate, evapo-transpirate and/or recycle runoff?
  - » Do our green infrastructure projects take into account the most up-to-date rainfall data? (see Section C, Land Use for more information about green infrastructure)
  - » Can we incorporate more rainwater harvest techniques?
  - » How can we improve site design to reduce connected impervious surfaces?
  - » How can we ensure that site development maintains natural drainage patterns?
- Do homeowners have information and resources to manage stormwater on-site?
  - » Are downspouts disconnected from the sewer system?
  - » How can we encourage use of rainwater harvesting systems, site grading, creation of permeable areas, and native landscaping?

RESOURCES

Wetlands:

- The Wisconsin Wetlands Association developed a publication to help staff and local officials that represent counties, cities, villages, towns, and tribes to better understand the benefits provided by wetlands and how to protect and restore wetlands to meet community goals: https://wisconsinwetlands.org/wp-content/uploads/2016/09/Putting-Wetlands-to-Work.pdf
- The DNR Wisconsin Wetland Inventory maps show graphic representations of the type, size, and location of wetlands in Wisconsin. https://dnr.wi.gov/topic/wetlands/inventory.html
- The Nature Conservancy and the Wisconsin DNR have created an online tool and report Wetlands by Design to help Wisconsin citizens find the best wetland sites to restore and protect: http://maps.freshwaternetwork.org/wisconsin/# and http://maps.freshwaternetwork.org/wisconsin/plugins/wetlands-watershed-explorer/assets/WetlandsByDesign_FinalReport.pdf

Forests:

- The Wisconsin DNR provides forest management information to 'slow the flow' of runoff on Lake Superior's south shore: https://dnr.wi.gov/files/pdf/pubs/fr/FR0385.pdf

IMPLEMENTATION

Prevent Washouts & Mitigate Flood Hazards

GOAL

Improve built and natural infrastructure to mitigate the effects of more frequent heavy rain events

Question for guiding discussion and coordinated effort toward goal:

- How can we coordinate actions throughout the CBA to increase resilience to heavy rain events?

Subgoal 4 cont.

Farms:

- Small farmers share information about sustainable water management: https://permacultureapprentice.com/permaculture-water-management/
- Many on-farm practices can help to slow the flow of heavy rains. Learn more in this guide from the University of Wisconsin Extension Office: Farmland Conservation Choices: A Guide to Environmentally Sound Practices for Wisconsin Farmers (1998) http://runoffinfo.uwex.edu/pdf/farm.lofarmla.pdf
- Farm Ponds can provide additional stormwater storage. Here is a guide to the many benefits of farm ponds: https://www.umesc.usgs.gov/documents/reports/2002/farmponds.pdf

Urban areas:

- The EPA has developed a guide Enhancing Sustainable Communities With Green Infrastructure: https://www.epa.gov/sites/production/files/2016-08/documents/green-infrastructure.pdf
- The U.S. EPA provides information for Low Impact Development (LID) in their guide Reducing Urban Runoff through Low Impact Development: https://www.epa.gov/nps/urban-runoff-low-impact-development
- The Minnesota Pollution Control Agency gives examples of stormwater management using low-impact development and green infrastructure: https://www.pca.state.mn.us/water/stormwater-management-low-impact-development-and-green-infrastructure

Subgoal 5

Develop stormwater management strategies based upon current scientific knowledge

Question for guiding discussion and coordinated effort toward goal:

- Can stormwater management policies respond quickly to changing information about climate conditions and best practices?

RESOURCES

- While there is no standard of practice for considering climate change in the production of Precipitation Frequency Estimates (PFE), there is a need to utilize the most up-to-date data. The National Oceanic and Atmospheric Agency (NOAA) has re-calculated PFEs and provides them in their Atlas 14 data set, easily accessible through their Precipitation Frequency Data Server: https://hdsc.nws.noaa.gov/hdsc/pfds/. It is notable that this server also provides upper and lower 90 percent confidence limits on the PFE estimates.
- Exploring the relationship between wetlands and flood hazards in the Lake Superior Basin, Wisconsin Wetlands Association, June 2018: https://wisconsinwetlands.org/wp-content/uploads/2018/06/WetlandsFloodHazards_WWA_web.pdf

IMPLEMENTATION

Prevent Washouts & Mitigate Flood Hazards

GOAL

Improve built and natural infrastructure to mitigate the effects of more frequent heavy rain events

Question for guiding discussion and coordinated effort toward goal:

- How can we coordinate actions throughout the CBA to increase resilience to heavy rain events?

WHAT COMMUNITIES ARE DOING

A group of organizations partnered with the Sheboygan, Wisconsin, County Planning and Conservation Office and the City of Plymouth, Wisconsin, to analyze wetlands based on five classifications to identify locations that would be ideal for restoration to reduce pollution, and flooding and erosion. http://greatlakesresilience.org/case-studies/habitat-environment/prioritizing-locations-wetland-restoration

The city of Toledo, Ohio, partnered with Office for Coastal Management (EPA), the Association of State Floodplain managers, USACE, and the Eastern Research Group (Inc) to develop a guide for identifying local flooding issues and possible management approaches through natural approaches. http://greatlakesresilience.org/case-studies/infrastructure/green-infrastructure-guidance-flood-reduction

Economic assessments of stormwater management pilot studies incorporating green infrastructure have been conducted in communities across the Great Lakes Region: https://coast.noaa.gov/data/digitalcoast/pdf/climate-change-adaptation-pilot.pdf

The city of Milwaukee, Wisconsin, has developed a Downspout Disconnection Program: https://www.mmsd.com/what-you-can-do/downspout-disconnection

Communities in the Puget Sound, Washington, have initiated a program to create 12,000 rain gardens: http://www.12000raingardens.org/

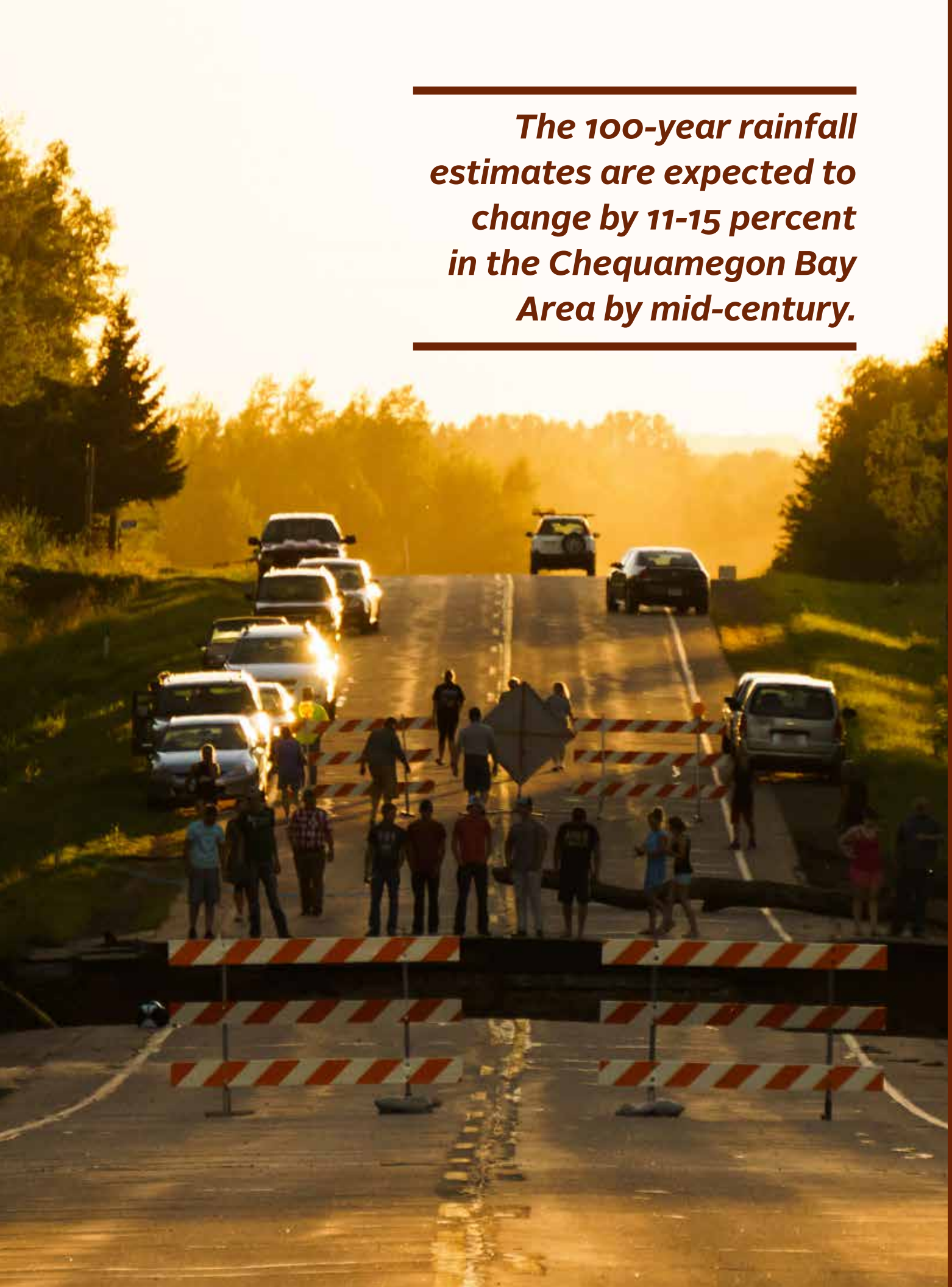
The town of Shoreville, Minnesota, is using pervious concrete in lieu of storm sewers: https://www.pwmag.com/roadways/designing-pervious_o

FUNDING SOURCES

The EPA recommends community-based public-private partnerships to help communities who are struggling to meet the demands of stormwater management requirements: https://www.epa.gov/G3/financing-green-infrastructure-community-based-public-private-partnerships-cbp3-right-you

The EPA lists a variety of federal, state, and local funding sources available for projects that incorporate green infrastructure: https://www.epa.gov/G3/green-streets-green-jobs-green-towns-g3-funding-opportunities

The Wisconsin Department of Administration (DOA) administers WCMP grants in collaboration with the Wisconsin Coastal Management Council (WCMC) and the Office for Coastal Management (OCM) available for coastal wetland protection and habitat restoration, and coastal resource and community planning, among other research areas: https://doa.wi.gov/Pages/LocalGovtsGrants/CoastalGrants.aspx



The 100-year rainfall estimates are expected to change by 11-15 percent in the Chequamegon Bay Area by mid-century.

PRIORITY AREA #3

Prepare for Variable Recreation & Tourism Conditions

	CRITERIA	SYMBOL
✔	High confidence of climate change effects	
✔	Highly valued CBA community asset may be affected	
✔	One or more vulnerable populations may be affected	
✔	Community priority planning topics are involved	
	Non-climate stressors could exacerbate impacts	
	Vulnerability of assets **to be determined** by communities	

climate change effects

- There is a high level of confidence that the duration and extent of ice cover on Lake Superior have changed and will continue to change, leading to an additional 1-2 months reduction in ice cover duration by the end of this century.
- These changes will continue to affect the ice road that connects the town of La Pointe and the city of Bayfield, ice fishing in Chequamegon Bay, and the frequency and regularity of tourist attractions such as the Bayfield peninsula sea caves and the Book Across the Bay event.
- The snow-covered period of the year has already shortened, and there is a medium level of confidence that snow is expected to decrease due to increases in the frost-free period. This change could impact winter activities such as snowmobiling, skiing, and others.
- During the summer, beach closures are likely to be more common. There is high confidence that waters will be warmer and there will be more frequent heavy rain events which might lead to water quality decreases caused by algal blooms, microbial contamination from sewer overflows, and increased sediment, nutrient, and pollution from runoff.
- In aquatic systems, cold water species such as cisco and lake trout will lose habitat, and they will likely be replaced by warm water species, such as bass and carp, as lake temperatures warm and the extent and duration of ice cover changes. Other species such as brown trout, chinook salmon, coho salmon, northern pike, rainbow trout, and walleye are recognized to be potentially at risk.[33] [34]
- Loss of habitat for brook trout is likely over the coming decades and will be particularly harmful for recreation and tourism in the CBA.[35]

▶ See Section A and Appendix A for more on climate change effects

▶ See Section C for more on planning topics

[33] For more information see Huff and Thomas (2014) p. 60: https://www.michigan.gov/documents/deq/Lake_Superior_Climate_Change_Impacts_and_Adaptation_445176_7.pdf

[34] Possible changes to fish consumption advisories will be dependent on the relative magnitude of climate change effects, how those changes interact, and the properties of the contaminant.

[35] For more information about expected climate change impacts on coldwater fish and fisheries see: https://www.wicci.wisc.edu/report/coldwater-fish-and-fisheries.pdf. There may be a temporary increase in tourism with the northward shift of brook trout habitat.

PRIORITY AREA #3

Prepare for Variable Recreation & Tourism Conditions

community asset

- Summer recreation is valued by 84 percent of community members, and winter recreation is valued by 66 percent of the population.
- Fishing opportunities are valued by 57 percent of community members.
- Quality of life would fall for 72 percent of community members if beaches were closed more often, and an additional 4 percent would leave the area in response to more beach closures.
- If the integrity of trout streams were to decline, quality of life would be affected for 58 percent of the population, and an additional 1 percent would leave the area.
- 19.3 percent of employment in Ashland and Bayfield counties is travel and tourism related.[36]

vulnerable populations

- Maintaining safety for swimmers, boaters, and those who spend time on the ice will require effective programs for providing water quality and ice safety information and education to the public.
- Emergency response personnel could be exposed to more frequent and dangerous ice rescue scenarios.
- Children, pregnant women, and older adults are especially vulnerable to water-borne illness.
- In terms of preparedness, over 10 percent of the population in the CBA does not know how to find information about beach closures.
- The livelihoods of those who rely on winter and summer tourism could be affected.
- Although the effects of climate change on fish consumption hazards are inconclusive, it is worth noting that indigenous populations, and children and pregnant women are particularly vulnerable to any possible increases in contamination.

planning priorities

- Business and jobs development is a top-three planning priority for 56 percent of households in the area.
- Therefore, sustaining a strong tourism industry as conditions change will be important for economic development in the region.

[36] http://headwaterseconomics.org/eps

IMPLEMENTATION

Prepare for Variable Recreation & Tourism Conditions

GOAL

Promote safe outdoor recreation and a resilient tourism industry as conditions become more variable

Subgoal 1

Ensure travel and recreational safety as ice conditions become more variable

Questions for guiding discussion and coordinated effort toward goal:

- How can we monitor and effectively communicate ice conditions?
  - » Should we consider developing a regional ice monitoring system?
- Are sport fishermen aware of potentially more variable ice conditions?
- Are emergency response personnel prepared for more frequent and advanced ice rescue scenarios?
- How can we prepare for continued variability in ice road conditions between Bayfield and Madeline Island?
  - » What are the economic impacts to residents and businesses of variable ice road conditions?

RESOURCES

The Wisconsin DNR offers ice safety tips: https://dnr.wi.gov/topic/outdoorrecreation/activities/icesafety.html

Subgoal 2

Ensure safe use of beaches

Questions for guiding discussion and coordinated effort toward goal:

- How can we best disseminate up-to-date information regarding beach health, particularly following large rain events?
- How can we effectively communicate beach health on-site?
- Can we communicate beach safety in a way that does not turn away visitors?
- Are residents and visitors aware of potential water-borne illnesses?
- Are health professionals prepared to recognize and treat a variety of water-borne illnesses?

RESOURCES

The Center for Rural Communities at Northland College makes recommendations for how to reduce risky swimming: https://www.northland.edu/wp-content/uploads/2019/04/MaslowskiBeachReport_FINAL.pdf.

See resources for reducing water quality impacts under Priority Area for Coordinated Action: Protect Drinking Water Quality.

The U.S. EPA evaluated the monitoring and notification program Beaches Environmental Assessment and Coastal Health Act and provides recommendations: https://www.epa.gov/sites/production/files/2015-09/documents/assessing-effectiveness-of-beach-act-notification-program.pdf

Prepare for Variable Recreation & Tourism Conditions

Subgoal 3

Develop a diverse and resilient tourism economy

Questions for guiding discussion and coordinated effort toward goal:

- Do we offer a wide array of amenities and activities for visitors so there is always something to do no matter the conditions?
  - » How can we continue to enhance a variety of amenities to attract tourists?
  - » Can we develop complementary events that run simultaneous with ice or precipitation dependent events?
  - » How can we promote multiple uses of recreational areas and trails so that visitors can enjoy the area under variable conditions year round?
  - » Can we provide alternatives for visitors when beaches are closed?
- Can we develop a cultural economy to attract visitors?
  - » How can we develop and promote the non-recreational winter tourism sectors, such as arts, culture, well-being, and local food sectors?
- How can we help tourism-based businesses prepare for more variability in conditions?
  - » How can we support entrepreneurial endeavors to create additional sources of income for those who are employed in tourism?
- Can we improve integration with larger economies and communities to attract visitors?
- How can local government, community organizations, and businesses collaborate?

RESOURCES

A recent study assesses potential winter weather changes and implications for tourism in the U.S. Great Lakes: https://www.sciencedirect.com/science/article/pii/S2214581818301277

Arts Wisconsin presents a Creative Economy Development Initiative: https://www.artswisconsin.org/actioncenter/creative-economy-development-initiative/

The Durango, Colorado, tourism office created a guide for what to do when there's no snow, which could be used as a model and adapted for each season: https://www.durango.org/blog/post/what-to-do-when-theres-no-snow

IMPLEMENTATION

Prepare for Variable Recreation & Tourism Conditions

GOAL

Promote safe outdoor recreation and a resilient tourism industry as conditions become more variable

Subgoal 4

Anticipate changing fisheries and potential tourism impact

Questions for guiding discussion and coordinated effort toward goal:

- How can we maintain a viable sport fishing industry?
  - » Can we help sport fishermen understand and respond to changing conditions and species availability?
- Are we prepared to monitor and manage the viability of commercial fishing operations?[37]
- Are we prepared to shift local stocking and fisheries management from cold water fish (e.g., trout) to cool water fish (e.g., walleye)?[38]

RESOURCES

The Wisconsin Initiative on Climate Change Impacts provides adaptation strategies for coldwater fish and fisheries: https://www.wicci.wisc.edu/coldwater-fish-and-fisheries-working-group.php#strategies

Subgoal 5

Create sense of place and well-being as culturally significant outdoor activities change

Questions for guiding discussion and coordinated effort toward goal:

- Do we offer year-round cultural events and activities for residents that are not temperature or precipitation dependent?
- Are there plenty of indoor recreational opportunities to provide access to year-round activity and socializing?

RESOURCES

University of Wisconsin Extension offers programming in community vitality and placemaking: https://blogs.ces.uwex.edu/community/

FUNDING SOURCES

The Ashland Area Development Corporation (AADC) and Bayfield Economic Development Corporation assist businesses with modifying business plans and financing needs.

The Wisconsin Arts Board offers grants through its Creative Communities Program and its Woodland Indian Arts Initiative: https://artsboard.wisconsin.gov/Pages/Community/CCP.aspx

[37] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

[38] Ibid.

Summer recreation is valued by 84 percent of community members.

Planning Topics

Climate change effects and hazards are wide-ranging and touch every aspect of community planning. This section provides a summary of common objectives for each planning topic included in municipal, county, and tribal planning documents, along with a description of projected climate change effects and how they might impact those objectives. Populations of concern and potential impacts to quality of life relevant to each planning topic are also noted, as are non-climate stressors that could exacerbate climate change impacts. Please reference Table 1 in the introductory section of this guide to determine how tribal Integrated Resource Management Plan areas correspond to the following planning topics.

There are seven main planning topics, each with several sub-topics, shown at right. Look for main take-away points for each sub-topic throughout this section.

Housing

- Flooding Damages
- Fouling of Wells
- Waterfront Home Vulnerabilities
- Cooling Needs

Transportation

- Damage to Roadways
- Reduced Ice Cover
- Lake Depth Changes
- Vehicle Emissions

Utilities and Community Facilities

- Increased Runoff and Flooding Damages
- Drinking Water Stresses
- Stresses to Human Health
- Increased Emergency Response Demands

Agricultural, Natural, & Cultural Resources

- Natural Ecosystems
- Food/Forage Crops & Livestock
- Recreation

Economic Development

- Affected Industries
- Development Opportunities

Land Use

- Wetland Changes
- Floodplain Changes
- Green Infrastructure

Waterfront & Coastal Resources

- Stresses to Beaches/ Waterfront Access
- Shoreline Changes
- Ports, Harbors, & Marinas
- Coastal Wetlands

Housing

Many communities in the Chequamegon Bay Area aim to provide sufficient and quality housing for the full diversity of community members. Common challenges to this goal include sufficient housing for year-round residents and tribe members; excess degraded or damaged properties; sufficient housing for elderly, disabled, and poor people; and vacant lots needing development. Moreover, many communities aim to improve the appearance of their residential areas and protect their surrounding environmental areas from the impacts of sprawling development.

As these communities seek to guide additional housing development and to improve their existing housing, we suggest that they consider four key impacts that climate change will likely have on area housing: increasing damages from flooding and runoff, increasing fouling of wells, increasing vulnerabilities to waterfront homes, and increasing cooling needs during summers.

Flooding Damages

Climate change effect confidence level: Medium (more floods)

Populations of concern: Low-income households

Non-climate stressors: Historical land-use changes; increased impervious surfaces; development on clay soils

Precipitation is likely to increase slightly in the Chequamegon Bay Area, with most change estimates varying within -1 and 4 inches/year by mid-century. Perhaps more importantly, the area has experienced an increase in heavy rain events that is expected to continue. For example, in the U.S. Great Lakes, the heaviest 1 percent of rain events already increased by 31 percent during the 1958-2007 period.[39] Looking forward, model averages indicate that by 2090, the CBA will experience 13 more days/decade of 1-inch rains, 4.4 more days/decade of 2-inch rains, and 1.3-1.5 more days/decade of 3-inch rains.[40] (For more information on changes in precipitation patterns, see Appendix A.)

During heavy rain events, water accumulates on land more quickly than it is able to percolate into the soil. This results in excess runoff and flooding. Floods damage homes and threaten lives and human health. In the United States during 1984-2014, floods caused an average of $7.96 billion in damages/year and 82 fatalities/year.[41]

Floods pose the greatest threat to structurally compromised homes. In areas with clay soils, floods are more likely to crack foundations of homes. Wood-framed homes may need to be cleaned and dried after floods, or mold can develop in warm, moist areas. Of course, floods can also damage the contents of homes, such as flooring, furniture, appliances, and personal belongings.

Take Away

Heavy rain events will continue to be more frequent, likely leading to more flood damages to homes.

[39] Karl, T.R., J.M. Melillo and T.C. Peterson (eds.). 2009. Global climate change impacts in the United States. Cambridge University Press., NY, USA.

[40] Kucharik, C., D. J. Vimont, K. Holman, E. Hopkins, D. Lorenz, M. Notaro, S. Vavrus, and J. Young. "Wisconsin Initiative on Climate Change Impacts Climate Working Group Report: Climate Change in Wisconsin." University of Wisconsin-Madison. Madison, Wisconsin (2010).

[41] National Oceanic and Atmospheric Agency, National Weather Service http://www.nws.noaa.gov/hic/, accessed 10/12/18.

Fouling of Wells

Climate change effect confidence level: High (more microbial activity)

Populations of concern: Low-income households; indigenous peoples; children and pregnant women; older adults

Quality of life: 86 percent of the population lives here because they value access to clean water

Preparedness: 10 percent of the total population and 6 percent of households who live in the countryside do not know where to find information about the quality of their drinking water

Non-climate stressors: Improper siting and completion of wells; improper disposal of hazardous substances

Household wells will be threatened by two aspects of climate change in the CBA: increased temperatures (high confidence) and increased frequency and intensity of heavy rains (high confidence). Rising temperatures (3-9 degrees F by mid-century) lead to warmer waters in wells. In warm waters, microbial activity increases, and thus water quality decreases and wells will more easily become fouled.[42] Wells will also be more frequently exposed to contamination during heavy rain events. Erosion caused by heavy rains will bring more nutrient and sediment loading to surface waters. These excess loadings contaminate wells where they are not properly protected by infilling of boreholes.[43] Contamination during floods can also come from septic systems that are sited too near to wells or surface waters. During a 2008 flooding event in Southern Wisconsin, 28percent of the 2,500 private wells that were tested had been contaminated.[44] In some cases, this contamination can spread beyond the wells, into the groundwater, via inundation.

Take Away

As temperatures continue to rise, wells will experience more microbial activity, posing dangers to rural residents. Also, heavy rain events will continue to be more frequent, likely leading to more frequent contamination of wells by sediment and pollutants in runoff or flood waters.

[42] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

[43] Betz, C. R., T. Asplund, and J. Hurley. "Water Resources Working Group Report. Wisconsin Initiative on Climate Change Impacts." (2010).

[44] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

Waterfront Home Vulnerabilities

Climate change effect confidence level: Medium (variable lake levels); low (more waves); low (more erosion); high (more microbial activity)

Quality of life: Quality of life would decline for 75 percent of the population if shoreline erosion increases

Non-climate stressors: Loss of natural vegetation on shorelines

Waterfront homes will experience several increasing threats during this century due to climate changes: variable lake levels (medium confidence), increased wave action on shorelines (low confidence), increased erosion (low confidence), and increased microbial activity (high confidence). The variable nature of lake levels could bring both flooding (during lake level highs) and erosion (during lake level lows) to waterfront properties. These changes can impact shorelines, structures, water accesses, wells, septic systems, and roads.[45] Shorelines will also be affected by increasing wave activity, which hastens shoreline recession and can damage structures, especially those built without adequate setback or protective barriers (structural or vegetative). Storm impacts will exacerbate these effects of increasing wave action. Shorelines, as elsewhere, will also see increases in erosion due to heavy rain events. This could lead to changes in shorelines and recession of bluffs.

Finally, waterfront homes will be exposed to decreases in water quality along their shores. This will come from erosion during heavy rains bringing excess sediment and nutrient loads into the water, as well as increased lake temperatures increasing microbial activity. The result could be increases in harmful algal blooms, decreasing fish habitat and threatening human health.

Take Away

Waterfront homes will experience more climate change impacts than most inland homes, due to expected increases in wave activity, decreases in water quality, and possible changes in lake levels.

[45] MN DNR https://www.dnr.state.mn.us/climate/waterlevels/lakes/landownerinfo.html accessed 10/16/18.

Cooling Needs

Climate change effect confidence level: Medium (more cooling needs)

Populations of concern: Low-income; children and pregnant women; older adults; occupational groups; persons with chronic medical conditions

Preparedness: 20 percent of lower-income households are unable to currently keep their home cool in the summer; 24 percent of the population thinks their current utility rates are unaffordable

Non-climate Stressors: High rates of chronic disease; limited social support, financial resources, and education

By mid-century, warmer summers and more variable temperatures will result in more days above the 95th percentile for heat, and more associated hospital admissions[46] (for more information on temperature changes and associated heat waves, refer to Appendix A). Heat waves have greatest impact on vulnerable populations, such as the elderly, young, poor, and chronically ill. High relative humidity increases the harmful impacts of heat waves, because sweating is less efficient at cooling the human body under high humidity.[47] In the Chequamegon Bay Area, around the year 2000, no days experienced the combination of heat and humidity that is likely to be lethal to vulnerable individuals. However, under a high-emissions, business-as-usual scenario, the CBA will experience about 3 days/year of lethal conditions by 2055 and 10 days/year of lethal conditions by 2075.[48] Even with moderate mitigation of emissions, the CBA will experience more frequent deadly heat waves, reaching about 2 days/year by 2075.[49]

However, communities can protect these populations from the negative effects of heat waves by developing policies that (1) establish or maintain effective heat warning systems, (2) provide cool refuges, (3) reduce home cooling needs through strategic maintenance of green spaces, and (4) ensure that everyone can meet their home's cooling needs. It is worth noting that many communities already maintain cool refuges, yet vulnerable populations may lack access due to limited knowledge, lack of transportation, or cultural barriers. Limited financial resources can prevent individuals from accessing appropriate home cooling, especially if they have been unable to pay their heating bills from the winter.[50] Additionally, a common barrier to cooling one's home is a lack of understanding of how to properly operate cooling devices.[51] Finally, to avoid exacerbating the hazards of heat waves, we recommend that communities secure renewable sources of electric power for air conditioning, such as wind or solar power.

Take Away

As temperatures rise, indoor spaces will require more cooling in summertime. Communities can provide access to culturally-appropriate cool refuges to buffer vulnerable populations from the dangers of heat waves.

[46] Patz, J., K. Malecki, S. McLellan, S. Shaw, and S. Vavrus, (2011). Wisconsin Initiative on Climate Change Impacts Human Health Working Group Report

[47] Mora, Camilo, Bénédicte Dousset, Iain R. Caldwell, Farrah E. Powell, Rollan C. Geronimo, Coral R. Bielecki, Chelsie WW Counsell et al. "Global risk of deadly heat." Nature Climate Change 7, no. 7 (2017): 501.

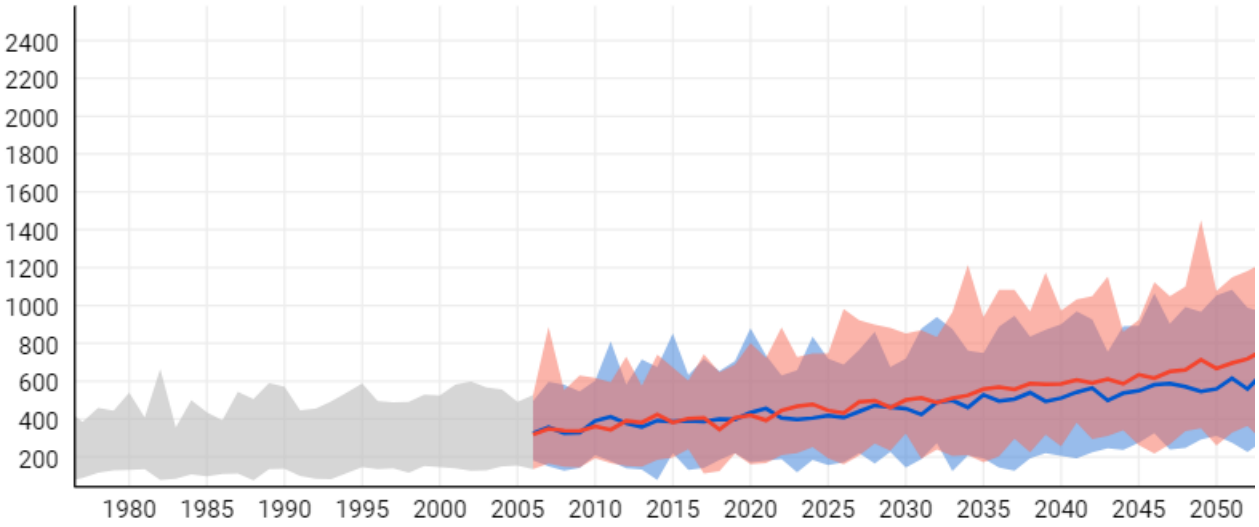
[48] https://maps.esri.com/globalriskofdeadlyheat/# accessed 10/17/18.

[49] Ibid

[50] Sampson, N. R., Gronlund, C. J., Buxton, M. A., Catalano, L., White-Newsome, J. L., Conlon, K. C., ... Parker, E. A. (2013). Staying cool in a changing climate: Reaching vulnerable populations during heat events. Global Environmental Change : Human and Policy Dimensions, 23(2), 475–484. http://doi.org/10.1016/j.gloenvcha.2012.12.011

[51] Ibid

Figure 6. Number of cooling degree days in Ashland County, 2008-2050



Source: U.S. Climate Resilience Toolkit Climate Explorer
Note: Bayfield County projections are almost identical to those for Ashland County

Transportation

Many communities in the Chequamegon Bay Area aim to promote a development density that limits transportation needs, improve trail networks for motorized and non-motorized transport, decrease vehicular emissions, and maintain community access to water transportation. Common challenges to this goal include conflicting priorities among modes of transport, conflicting desires to protect wetlands and species' habitat, and desire to promote economic development. As these communities seek to encourage transportation that aligns with their communities' needs and values, we suggest that they consider four key impacts that climate change will likely have on area transportation: increasing stresses to roadways, reduced ice cover on Lake Superior, variable lake levels, and increasing effects from vehicle emissions.

Damage to Roadways

Climate change effect confidence level: Medium (more floods)

Populations of concern: Persons with chronic medical conditions; occupational groups

Preparedness: 6.1 percent of the total population and 7.4 percent of those who live in the countryside do not have multiple routes to the places they need to go

Quality of life: Quality of life would decline for 53 percent of the population if road construction is more common

Non-climate stressors: Historical land-use change; insufficient stormwater management practices

While changes to total annual precipitation in the Chequamegon Bay Area are still somewhat uncertain, it is clear that heavy rain events are increasing in frequency. For example, in the U.S. Great Lakes, the heaviest 1 percent of rain events already increased by 31 percent during the 1958-2007 period.[52] Looking forward, model averages indicate that by 2090, the Chequamegon Bay Area will experience 13 more days/decade of 1-inch rains, 4.4 more days/decade of 2-inch rains, and 1.3-1.5 more days/decade of 3-inch rains.[53] (For more information on changes in precipitation patterns, see Appendix A.)

Transportation infrastructure is vulnerable to heavy rain events. While stormwater infrastructure is designed to withstand heavy rain events, these designs are based on outdated data and methods. When determining the magnitude of a heavy rain event, historic rainfall data are typically used without any consideration of changing precipitation regimes.[54] If the historic rainfall data were representative of current rainfall patterns, then the Chequamegon Bay

[52] Karl, T.R., J.M. Melillo and T.C. Peterson (eds.). 2009. Global climate change impacts in the United States. Cambridge University Press., NY, USA.

[53] Kucharik, C., D. J. Vimont, K. Holman, E. Hopkins, D. Lorenz, M. Notaro, S. Vavrus, and J. Young. "Wisconsin Initiative on Climate Change Impacts Climate Working Group Report: Climate Change in Wisconsin." University of Wisconsin-Madison. Madison, Wisconsin (2010).

[54] Potter, K. W., D. S. Liebl, Z. Schuster, and V. Cottle. "Wisconsin Initiative on Climate Change Impacts Stormwater Working Group Report: Stormwater Management n a Changing Climate: Managing High Flow and High Water Conditions in Wisconsin." University of Wisconsin-Madison. Madison, Wisconsin (2010).

Area would typically expect to experience damages from rain storms less than once in a century (i.e. infrastructure is designed to manage rain events with 1 percent probability, or "100-year" storms). However, the CBA is experiencing flood-related damages more frequently due to an increasing frequency of heavy rains. This trend is expected to continue: the 100-year rainfall estimates are expected to change by 11-15 percent in the Chequamegon Bay Area by mid-century, compared with the average from the 1961-2000 period.[55]

In both 2016 and 2018, the Chequamegon Bay Area experienced historic flooding, causing major damages to transportation infrastructure, especially roadways and bridges. The 2016 flooding occurred in July, affecting the Bad River Reservation, Ashland and Bayfield counties, and six other counties in northern Wisconsin. The resulting damages to roads and public infrastructure cost an estimated $25 million to repair.[56] At least six counties in northern Wisconsin were again affected by flooding in June 2018, damaging roads and bridges in the CBA, and causing more than $13 million in damages to roads and public infrastructure.[57] Ten days after the 2018 floods, the Chequamegon-Nicolet National Forest contained 51 miles of closed roads and 3 miles of closed motorized trails. Even in November of 2018, the USFS reported 6 road segments closed due to the 2016 flood, as well as 10 road segments, one motorized trail, and 3 non-motorized trails closed due to the previous summer's flood.[58]

Roadways could also experience more damages from changes in temperatures. Asphalt roads are stressed when the temperature fluctuates above and below the freezing point of water. With warmer winters expected, the CBA will see more fluctuations around freezing-point temperatures, potentially increasing stress to roadways and thus raising maintenance costs.

Roadways near bluffs are especially sensitive to climate impacts. If total precipitation increases as expected in the CBA (most change estimates vary within -1 and 4 inches/year by mid-century), then erosion will also increase. Even if precipitation remains constant, bluffs could be increasingly destabilized by periods of dry weather punctuated by heavy rain events. Temperature changes could also destabilize bluffs by increasing exposure to freeze-thaw events. Any erosion near bluffs will threaten the nearby roadways, possibly requiring re-routing.

Take Away

Roadways will experience more stress and damage from heavy rain events, freeze-thaw cycles, and erosion.

[55] Potter, K. W., D. S. Liebl, Z. Schuster, and V. Cottle. "Wisconsin Initiative on Climate Change Impacts Stormwater Working Group Report: Stormwater Management n a Changing Climate: Managing High Flow and High Water Conditions in Wisconsin." University of Wisconsin-Madison. Madison, Wisconsin (2010).

[56] https://www.wpr.org/northern-wisconsin-receives-federal-disaster-declaration accessed 11/5/2018

[57] https://walker.wi.gov/press-releases/governor-walker-announces-federal-disaster-declaration-june-flooding-northwestern accessed 11/5/2018

[58] https://www.fs.usda.gov/detail/cnnf/home/?cid=fseprd584045 accessed 11/5/2018 and https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd584288.pdf accessed 11/5/2018

Reduced Ice Cover

Climate change effect confidence level: High (less ice cover)

Populations of concern affected: Island residents with low income and chronic medical conditions; occupational groups; recreational users

Quality of life: 66 percent of the population values winter recreation; 57 percent of the population values fishing opportunities

Ice cover on Lake Superior follows a seasonal pattern, typically beginning to form in early winter, reaching its peak in March, and decreasing soon after. However, the duration and extent of ice cover on Lake Superior have changed and will continue to change. For example, the duration of ice cover near Bayfield, Wisconsin, decreased by 3 days/decade during 1857-2007, equating to a total reduction of 45 days.[59] Also, during the 20th century, a significant reduction in Lake Superior ice extent was observed and this trend is expected to continue during the 21st century, leading to an additional 1-2 months reduction in ice cover duration.[60]

The ice season on Lake Superior is an important time for transportation in the region. In particular, when ice coverage connects the town of La Pointe on Madeline Island to the city of Bayfield on the mainland, the ferry service is discontinued and an ice road is used instead. This allows time for maintenance and repair of ferry boats and it frees travelers from the restrictions of ferry schedules. Since the ice road is an important connection between these communities, reductions in the duration of ice cover could have both economic and social impacts.

Take Away

As ice cover on Lake Superior continues to diminish, the ice road connecting La Pointe on Madeline Island with Bayfield on the mainland will be less frequent, affecting area residents and businesses, including the ferry service.

[59] Howk, Forrest. "Changes in Lake Superior ice cover at Bayfield, Wisconsin." Journal of Great Lakes Research 35, no. 1 (2009): 159-162.

[60] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

Lake Depth Changes

Climate change effect confidence level: Medium (variable lake levels)

Quality of life: Quality of life would decline for 61 percent of the population if lower lake levels reduce boat access

Long-term changes in Lake Superior water levels are possible, but uncertain. Studies generally agree that water levels will continue to fluctuate, as they have historically. Communities should prepare for prolonged periods of both high and low water levels. For more information, see Appendix A, Combined Effects, Lake Superior Water Level.

As communities prepare for continued variability in Lake Superior water levels, transportation planning may particularly consider the possibility of lower lake levels, as they could create problems for transportation on the lake. Shipping vessels must lighten their loads when lake levels drop, reducing their profits. Ferries, research vessels, sightseeing boats, and recreational boats can encounter problems docking when lake levels are low. For example, during low water conditions in 2007, University of Wisconsin-Superior's research vessel, the L. L. Smith, Jr., was unable to dock at marinas in Ashland or Washburn.[61]

Take Away

Lake levels will remain variable, making low lake levels at times likely. This will affect marine traffic, especially docking.

Vehicle Emissions

Climate change effect confidence level: Low (more air pollution)

Populations of concern: Older adults; children and pregnant women; lower-income; persons with chronic medical conditions

Non-climate Stressors: Pollutants in vehicle emissions

Vehicular traffic emits pollutants that contribute to smog and air quality reductions, such as volatile organic compounds (VOCs), particulate matter (PM), and nitrous oxide (NOx). Changes in climate are likely to affect atmospheric chemistry, increasing the harmful effects of vehicular emissions. For example, rising summer temperatures will interact with pollutants in the lower atmosphere to increase smog prevalence, while warmer winters and more water vapor in the atmosphere could increase the concentration of particulate matter in the air. Both smog and particulate matter degrade public health: smog worsens asthma and chronic lung diseases and particulate matter inhalation can lead to lung disease, asthma, emphysema, or heart disease.

Several communities in the Chequamegon Bay Area aim to reduce vehicle emissions, as stated in their existing comprehensive plans. Traffic congestion compounds the harmful effects of vehicular traffic on public health by increasing emissions per miles traveled,[62] so communities are wise to focus efforts on reducing or avoiding congestion.

Take Away

Pollutants in vehicle emissions will interact with the warmer and more moist atmosphere to increase smog and particulate matter in the air. People with asthma and chronic lung diseases will be especially affected by the reduced air quality.

[61] http://www.seagrant.umn.edu/newsletter/2007/08/readers_want_to_know.html accessed 10/30/2018

[58] Zhang, Kai, and Stuart Batterman. "Air pollution and health risks due to vehicle traffic." Science of the total Environment 450 (2013): 307-316.

Utilities and Community Facilities

The communities in the CBA recognize the importance of maintaining sufficient and quality services in order to preserve their vitality and identity. Most communities feel that their current services and facilities are adequate, but that they must monitor them and predict changes in community needs to stay current. Also, they are actively pursuing improvement in key arenas, such as energy efficiency and independence, refining stormwater management, improving outdoor recreation spaces, and improving cellular service availability. As communities formulate their policies for maintaining and update their community facilities and utilities, we suggest that they consider four primary areas of climate change impacts: increases in damages from flooding and runoff, increases in stresses to drinking water services, increases in stresses to human health, and increases in demands on emergency response systems.

Take Away

Heavy rain events will continue to be more frequent, likely increasing flooding and runoff damages to public infrastructure and recreational areas, and stressing stormwater and wastewater systems.

Increased Runoff & Flooding Damages

Climate change effect confidence level: Medium (more floods)

Quality of life: Quality of life would decline for 72 percent of the population if Lake Superior becomes polluted and 21 percent report that they would leave the area

Non-climate stressors: Historical land-use change; insufficient stormwater management practices; more impervious surfaces; development on clay soils

Heavy rain events have been increasing in frequency in the Chequamegon Bay Area, and they are expected to continue increasing throughout this century. In the U.S. Great Lakes, the heaviest 1 percent of rain events already increased by 31 percent during the 1958-2007 period.[63] Looking forward, model averages indicate that by 2090, the Chequamegon Bay Area will experience 13 more days/decade of 1-inch rains, 4.4 more days/decade of 2-inch rains, and 1.3-1.5 more days/decade of 3-inch rains.[64] (For more information see Appendix A.) With these heavy rain events will inevitably come increased runoff and flooding, as heavy rains do not allow precipitation enough time to soak into soils.

Public infrastructure, services, and recreational areas will be vulnerable to the excessive runoff and flooding from heavy rains. To handle this, communities will require larger and more costly stormwater management and flood mitigation facilities. If impoundments, levees, and stormwater detention ponds are designed for smaller rain events, they will fail. If sanitary sewers are susceptible to seepage from stormwater inflow and groundwater infiltration, they will be overtaxed by these heavy rains and untreated wastewater will overflow into surface waters. Moreover, wastewater treatment facilities could be physically damaged by flooding and treatment capacity could be interrupted or require additional maintenance.

[63] Karl, T.R., J.M. Melillo and T.C. Peterson (eds.). 2009. Global climate change impacts in the United States. Cambridge University Press., NY, USA.

[64] Kucharik, C., D. J. Vimont, K. Holman, E. Hopkins, D. Lorenz, M. Notaro, S. Vavrus, and J. Young. "Wisconsin Initiative on Climate Change Impacts Climate Working Group Report: Climate Change in Wisconsin." University of Wisconsin-Madison. Madison, Wisconsin (2010).

Drinking Water Stresses

Climate change effect confidence level: High (more microbial activity, due to higher temperatures); high (more heavy rains); high (less ice cover); medium (variable lake levels)

Populations of concern: Lower-income; indigenous peoples; children and pregnant women; older adults

Preparedness: 10 percent of the total population and 15 percent of lower-income households do not know where to find information about drinking water quality

Quality of life: 86 percent of the population lives here because of access to clean water

Non-climate stressors: Improper disposal of hazardous materials

Communities' abilities to provide clean drinking water to their public could be increasingly stressed by expected changes in temperature and precipitation in the Chequamegon Bay Area. Specifically, drinking water provision infrastructure and services could be stressed by an increase in harmful algal blooms, variable lake levels, and changes in groundwater discharge and recharge rates.

As climate changes, more algal blooms are likely, due to more heavy rains, warmer waters, reduced ice cover, and possibly also lower lake levels.[65] Algal blooms near water intakes could contaminate source waters and drinking water treatment facilities with toxins, interfere with drinking water treatment, or produce unpleasant taste or odor. Lake water treatability could be affected by increased water temperature and changes in contaminant and sediment loads from runoff. For example, recent research at the Environmental Protection Agency (EPA) found that while current water treatment methods are likely sufficient to handle harmful algal blooms safely, facilities will need to use vigilance and proper dosing of treatment agents, such as potassium permanganate and powdered activated carbon, in order to account for differences in the pH and turbidity of the water.[66]

Water infrastructure sited along shorelines could also be affected by increased erosion and changing lake levels. Alternatively, if communities rely on groundwater for drinking water supply, they should be prepared for changes in discharge and recharge to affect that supply. See Priority Area for Coordinated Action: Protect Drinking Water Quality for more information.

Take Away

As surface waters continue to warm even more than air, algal blooms are expected to be more frequent. More heavy rain events could bring more contaminants and sediment into source waters. Changes in shorelines (from increased wave action), lake levels, and groundwater levels could affect water intakes.

See Priority Area for Coordinated Action: Protect Drinking Water Quality for more information.

[65] For more information, see Appendix A. Combined Effects, Algal Blooms

[66] https://www.epa.gov/sciencematters/keeping-water-flowing-helping-water-treatment-facilities-handle-harmful-algal-blooms accessed January 31, 2019

Stresses to Human Health

Climate change effect confidence level: Low (more air pollution); low (more vector-borne disease); high (more microbial activity)

Populations of concern: Lower-income; children and pregnant women; older adults; persons with chronic medical conditions

Preparedness: 14.7 percent of the population is currently unable to avoid exposure to ticks or other harmful insects

Quality of life: Quality of life would decline for 82 percent of the population if there are more ticks, pests, and insects, and an additional 3 percent would leave the area

Related planning priorities: 34 percent of households think social and public services should be a planning priority for their community

Non-climate stressors: Pollutants in vehicle emissions; high rates of chronic disease; historical land-use change; insufficient stormwater management practices; increased impervious surfaces; development on clay soils

While health care facilities in the Chequamegon Bay Area are generally considered adequate for meeting people's current needs, climate change impacts could produce increasing demands on these services. For example, hospitals may see more asthma admissions due to increased smog, particulate matter, and pollen in the air (see Transportation section for more information). Increased temperatures could produce more outbreaks of some vector-borne diseases, such as West Nile virus. People could also be affected by harmful bacteria and viruses spread during floods, producing more gastrointestinal illness and respiratory effects, especially when sewer systems overflow.

Tick-borne illnesses, such as Lyme's disease, are of great concern to residents of the Chequamegon Bay Area. However, the future of tick-borne illnesses in the area is unclear as the science is currently developing on this topic. Species range shifts could cause Lyme's disease to be less prevalent in Wisconsin by 2100, favoring cooler areas to the north. However, moisture availability also influences Lyme's disease prevalence, so changes in precipitation patterns could alter this prediction. Importantly, non-climate stressors such as land use patterns will also affect Lyme's disease prevalence. So, while future changes in Lyme's disease infection rates are unknown, health care facilities would be wise to prepare for possible increases or decreases in the disease.

Take Away

Health facilities could be stressed by increased demands, including more asthma-related hospital admissions and more vector-borne diseases, bacterial and viral illnesses. Climate change's effect on Lyme's disease in this region is uncertain.

Increased Emergency Response Demands

Climate change effect confidence level: Medium (more floods); low (other disasters)

Populations of concern: Lower-income; older adults; persons with chronic medical conditions; occupational groups; children and pregnant women; persons with disabilities

Preparedness: 29.5 percent of the population is unprepared for a prolonged power outage; 4.3 percent do not have enough food in their home for a week; 7.6 percent do not have shelter in case of emergency. Only 1.1 percent do not know when a weather advisory is in effect; and only 0.3 percent do not know who to call if they have an emergency

Related planning priorities: 34 percent of households think social and public services should be a planning priority for their community

Increases in climate variability, atmospheric moisture, and heavy rain events could lead to a general increase in natural disasters. Not all communities in the Chequamegon Bay Area include disaster response systems in their comprehensive planning process, but they will likely need to in coming years. For example, incident command systems that can coordinate multiple emergency response services may be needed to adequately manage natural disasters. Additionally, increases in wave action from climate change could increase Lake Superior communities' needs for water rescue.

Take Away

Emergency response systems may need more resource to coordinate for natural disasters and handle increasing water and ice rescues.

Agricultural, Natural, and Cultural Resources

The importance of the agricultural, natural, and cultural resources of the Chequamegon Bay Area are emphasized throughout the area's city and county comprehensive plans and tribal integrated resource management plan. Though the plans discuss a wide variety of goals and considerations under this topic, some commonalities include: protecting water quality, preserving wetland areas, preserving farmland from development, preserving Lake Superior shoreline, protecting ecosystems from invasive species, and identifying and preserving historic places and buildings, as well as acquiring or re-using them. We discuss the challenges that climate change may present to these goals in the following three subsections: Natural Ecosystems (Hunting, Harvesting, and Fishing), Food and Forage Crops and Livestock, and Recreation.

Natural Ecosystems 

(Hunting, Harvesting, and Fishing)

Climate change effect confidence level: Medium (habitat shifts); medium (phenology disruptions); low (more pests and invasive species); medium (more floods); low (more drought); high (less ice cover); high (more microbial activity)

Populations of concern: Low-income; indigenous peoples

Quality of life: Quality of life would decline for 77 percent of the population if native tree, plant, and animal species were fewer; 92 percent of community members value the natural beauty of the area; hunting opportunities are valued by 52 percent of community members; quality of life would decline for 63 percent of the population if subsistence harvest of resources such as wild rice and venison were to decline

Related planning priorities: 35 percent of the population agrees the natural environment should be a top three priority

Non-climate stressors: Historical land-use changes; habitat loss; fragmented habitat; invasive species introductions

The Chequamegon Bay Area's natural ecosystems are among its premium assets. In a recent survey, 78 percent of households chose the natural environment as a most valued aspect of living here, ranking it higher than any other consideration.[67] Chequamegon Bay's residents value these natural areas for their ecosystem services (e.g. clean water), food provision (e.g. hunting, fishing, and foraging), recreational opportunities, and natural beauty. Most communities focus their planning on protecting these natural areas from competing demands such as development pressure and hazardous waste. In the coming decades, communities will have to additionally consider how to increase the resilience of their natural ecosystems to the effects of climate change. Specifically, they will

[67] Kemkes, R., A Tochterman, and B. Hofstedt (2018). Chequamegon Bay Area Community Climate Change Study: Ashland, Bayfield, Red Cliff, Washburn.

need to consider the impacts of shifting species ranges, disruptions in phenology, vulnerability to pests and invasive species, damage from extreme events, and changes in hydrology.

As temperatures rise, the areas of most suitable habitat for plant and animal species are shifting polewards.[68] In the north woods these northwards species range shifts will cause habitat loss for key species. Moreover, species that are unable to migrate as quickly as their range shifts, due to habitat fragmentation, niche environments, or slow seed dispersal, will be critically threatened. Habitat losses will have impacts to commerce, recreation, spirituality, and quality of life. On land, the most threatened species include boreal trees (black spruce, balsam fir, paper birch), along with the lichens, birds, and invertebrates dependent upon them.[69] Lowland tamaracks are particularly sensitive to these range shifts, due to their reliance on high soil moisture on snow cover. Meanwhile, hickory and black oak trees will expand their suitability in Wisconsin. Terrestrial animal species that may no longer survive in Wisconsin include spruce grouse, the American marten, and snowshoe hare.[70] At the same time, species range shifts will benefit some species, such as the gray squirrel, white-tailed deer, European starling, and Canada goose, with possible environmental effects.[71] In aquatic systems, cold water species such as cisco and lake trout will lose habitat, and they will likely be replaced by warm water species, such as bass and carp. Loss of habitat for brook trout is likely[72] and will be particularly harmful for recreation and tourism in the CBA.

As the Chequamegon Bay Area experiences warmer temperatures in the late winter and spring, plants and animals are beginning their spring growth and reproduction cycles earlier. However, these changes in phenology, or the timing of recurring natural events, affect species in different ways, depending on their unique sensitivity to temperature, day length, or other ecological events. As species respond differently to warming, some ecological dependencies, such as pollination, are being disrupted through desynchronization. These changes are expected to have particular impact on barrens and wetlands.[73]

Water temperatures are rising along with air temperatures, sometimes at twice the rate.[74] This warming of Lake Superior waters is lengthening the stratification season, and may also cause a faster spring warm-up. These changes will affect the ecology of the lake, including reduced phytoplankton populations and more dead zones in the bottom of the lake. Both of these effects will reduce habitat and food sources for cold water fish species.

As temperatures rise and growing seasons lengthen, pests and invasive species may find new opportunities to thrive in the natural ecosystems of the Chequamegon Bay Area. Specifically, warmer waters in Lake Superior will create a more favorable environment for sea lampreys, zebra mussels, and quagga mussels. Forests will also be more vulnerable to attacks by pests, as they will be under stress from prolonged heat and drought,[75] while pests may benefit from warmer temperatures and longer growing seasons that allow for more life cycles per year. Some specific pests and pathogens of concern to the north woods of Wisconsin include the emerald ash borer, nonnative gypsy moths, earthworms, hemlock wooly adelgid, and Diplodea pinea. Whether on land or in water, invasive species will be well suited for growth in

[68] Chen, I-Ching, Jane K. Hill, Ralf Ohlemüller, David B. Roy, and Chris D. Thomas. "Rapid range shifts of species associated with high levels of climate warming." Science 333, no. 6045 (2011): 1024-1026

[69] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

[70] Ibid.

[71] Ibid.

[72] Ibid.

[73] Ibid.

[74] Austin, Jay A., and Steven M. Colman. "Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback." Geophysical Research Letters 34, no. 6 (2007).

[75] Swanston, Chris, Maria Janowiak, Louis Iverson, Linda Parker, David Mladenoff, Leslie Brandt, Patricia Butler et al. "Ecosystem vulnerability assessment and synthesis: a report from the climate change response framework project in northern Wisconsin." (2011).

a warmer and carbon-dioxide-rich environment. They will take advantage of disturbances from floods, droughts, and pest attacks, increasing their colonization.[76] Flooding, in particular, will increase opportunities for invasive species by connecting waterways that would otherwise be isolated and bringing sediments and nutrients to lakes that may reduce habitat for some native species.

Extreme weather events, increasing in frequency, will affect natural ecosystems on land and water. Heavy rains and resulting erosion will threaten fisheries and have a mixture of harmful and beneficial effects on fish habitats. Flooding that increases pollutant runoff, however, will lead to more fish consumption advisories. More frequent freezing rain events could damage forests, especially conifers due to their vulnerability to trunk damage.

Several changes in the hydrology of the Chequamegon Bay Area will affect natural ecosystems. Increases in evapotranspiration, and associated reductions in soil moisture, will add stress to lowland conifers and amphibious species. However, soil structure could be improved by increases in the number of freeze-thaw cycles during winter, allowing for an increase in water infiltration. Changes in groundwater discharge and recharge, in concert with droughts and floods, will bring more high-flow and low-flow conditions to aquatic stream fisheries, threatening fish populations.

Lake Superior ecosystems will experience a number of additional impacts from climate change. Nearshore fish-spawning habitat could be degraded by lower water levels and stronger wave action. High water levels could uproot vegetation and redistribute structural features of the lake bottom. Reductions in ice cover will threaten nearshore fisheries, as well as impacting access to ice fishing. Finally, changes in algal composition due to warmer waters and changing water chemistry could reduce light penetration, affecting habitat for plants and birds.

Take Away

Terrestrial and aquatic ecosystems will be disrupted by species range shifts, disrupted phenological relationships, more pests and diseases, more invasive species, and more damages from extreme weather events.

[76] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

INVASIVE ZEBRA MUSSEL

Place Matters

SOLASTALGIA

The term 'solastalgia' is similar to the term 'nostalgia', meaning melancholy or sickness caused by the inability to return home, however, 'solastalgia' is the pain experienced when there is recognition that the place where one resides and that one loves is changing for the worse.[81] It can affect a person's sense of belonging to a particular place and result in a desire for the place where one lives to be maintained in a state that gives comfort or solace. Understanding solastalgia is one way to think about the emotional effects of climate change on people living in the Chequamegon Bay Area.

Place Matters

CULTURALLY SIGNIFICANT LANDSCAPES AND RESOURCES

Cultural landscapes reveal our relationship with place[73] and cultural resources are sites, objects, landscapes, or structures of significance to a group of people who traditionally associate with them.[78] Climate change threatens north woods plant and animal species, ecosystems, and culture. Many cultural connections to the natural world are changing or disappearing. For example, to the Ojibwe, manoomin (northern wild rice) is considered a special gift from the Creator that ties them to this plant both spiritually and culturally.[79] Manoomin is highly to extremely vulnerable to the effects of climate change. The pristine wilderness, clean water, forests, and seasons are culturally significant for many people who live in the Chequamegon Bay region.[80] These aspects of place contribute to health, well-being, spirituality, relationships, and subsistence.

Place Matters

PRESERVING CULTURE

The Great Lakes Indian Fish and Wildlife Commission has developed a seed bank project for culturally significant species like paper birch and ash. http://www.glifwc.org/ClimateChange/SeedBank.html.

Many indigenous groups are working to incorporate traditional lifeways into their responses to climate change. For examples, refer to Cultural Survival Quarterly, issue 42-4: Respecting our Science and Ways of Knowing: https://www.culturalsurvival.org/publications/cultural-survival-quarterly/42-4-respecting-our-science-and-ways-knowing.

[77] https://www.nps.gov

[78] https://www.nps.gov/acad/learn/management/rm_culturalresources.htm

[79] Climate Change Vulnerability Assessment, Integrating Scientific and Traditional Ecological Knowledge, Version 1, April 2018. Great Lakes Indian Fish and Wildlife Commission.

[80] Center for Rural Communities at Northland College CBA Community Climate Change Study 2018: https://www.northland.edu/wp-content/uploads/2018/08/CBA-Climate-Change-Study-2018.pdf

[81] Albrecht, G., Sartore, G. M., Connor, L., Higginbotham, N., Freeman, S., Kelly, B., ... & Pollard, G. (2007). Solastalgia: the distress caused by environmental change. Australasian psychiatry, 15(sup1), S95-S98.

Livestock & Crops (Food/Forage)

Climate change effect confidence level: Low (more erosion); low (more freeze-thaw cycles); low (more drought); medium (species range shifts); medium (varied phenology shifts); policy-dependent (more carbon); low (more pests); low (more diseases); high (longer frost-free period); medium (more spring rain)

Populations of concern: Occupational groups (farmers)

Quality of life: Quality of life would decline for 70 percent of the population if agricultural soil washes away

Non-climate stressors: Land and soil degradation; declines in pollinator populations (uncertain cause); economic risks of small-scale farming

Agriculture is a key element of the landscape and economy of the Chequamegon Bay Area. In Ashland and Bayfield counties, over 129,000 acres of land are used for agricultural production. Much of this land is used for grass and hay production (forage), and indeed meat and dairy products comprise the highest value of agricultural sales in Ashland County. Near Bayfield, Wisconsin, orchards producing apples and berries contribute to the economy through production and tourism. Agricultural lands in Ashland and Bayfield counties also include 739 tillable acres, about half of which are typically used for production. Row crops in the area include fruits and vegetable, small grains, sunflowers, and grass and legume seed. Additional agricultural income comes from maple syrup, honey, eggs, and value-added products. These food producers are valued by area residents. In a recent survey, 57-69 percent of area residents reported that they agree or strongly agree with the statement: "I live here because [of the] local food producers."

Healthy soil is necessary for agricultural production. However, increases in heavy rains, especially in the spring before crops have taken root, threaten to increase erosion and remove critical topsoil from agricultural lands. There is also a possibility that soil structure will improve due to more freeze-thaw cycles in the winter, allowing for greater water infiltration.

As air temperatures rise, so will evaporation and transpiration, transferring more moisture out of soil and into the atmosphere. Drier soils and more moisture in the air will have numerous effects on crops. It is likely that moisture stress will be more common, including more frequent droughts. This could increase irrigation needs, decrease crop yields, increase stress on livestock, and increase costs to farmers. The higher humidities will also lead to warmer nights in the summer, which could further stress crops and livestock, reducing their productivity.

In addition to encouraging crop plant growth, farmers also strive to maintain pollinator populations (for crops that require pollination) and reduce the presence of weeds, pests, and diseases. Therefore, climate change impacts on these other lifeforms will affect the nature of farming in coming years. Wild pollinators, already stressed in some areas, could be further stressed by shifts in habitat range. Phenological changes in response to earlier onset of spring could also interfere with pollination of crops. While some crop plants will increase productivity due to higher concentrations of CO2 in the atmosphere, weeds will also grow more vigorously in the high-carbon air. Weeds, including invasive species, could also benefit from warmer temperatures and longer growing seasons. While herbicide use could increase to combat greater weed growth, it would also increase threats of resistance developing and environmental damage occurring off-site (for which farmers could be charged). Crop pests will be more prevalent due to warmer temperatures, especially warmer winters, and longer growing seasons that could allow them to over-winter or reproduce more in a year. Such pest increases would reduce crop yields and increase costs to farmers. Crop diseases and fungus could also benefit from climate changes, especially the higher humidity that will accompany a warmer atmosphere.

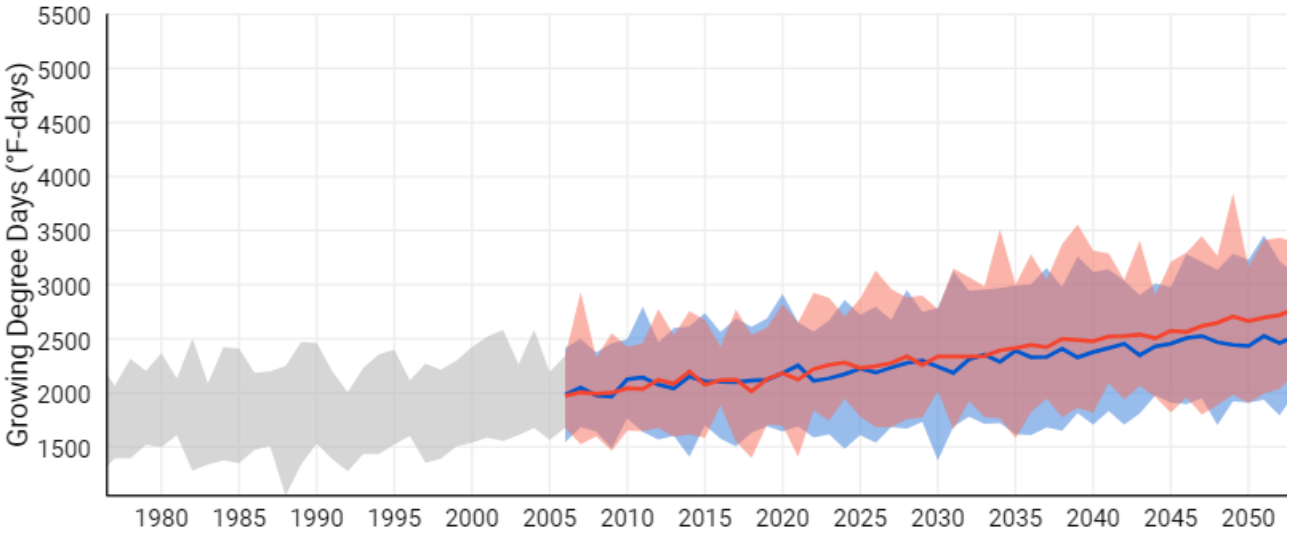
Farmers will be challenged to manage risks and rewards in this increasingly complex and unpredictable environment. Farmers will need to respond to the changing context as they make decisions such as crop types and cultivars to plant, when to plant, how much forage to

produce or purchase and how to store forage for livestock in the winter. As the growing season lengthens (Figure 7), farmers may profit from new crop choices or higher-yielding genetics, and will need to stay alert to these opportunities. If spring rains increase, as some models predict, farmers will be challenged to plant crops at typical times. Marketing decisions may also increase in risk as climatic variability increases.

Take Away

Farmers will be affected by more unpredictability in the future climate. Soils will be more affected by moisture changes and erosion from heavy rains. Interactions with natural ecosystems, such as pollinators and weeds, will change. Farmers will need flexibility and quality information to make profitable decisions.

Figure 6. Growing degree days in Ashland County, 2008-2050



Source: U.S. Climate Resilience Toolkit Climate Explorer
Note: Bayfield County projections are almost identical to those for Ashland County

Recreation

Climate change effect confidence level: High (longer frost-free period); high (less ice cover); low (decreased water quality); medium (more floods)

Populations of concern: Lower-income populations; children and pregnant women; and older adults are vulnerable to water-borne illness; occupational groups such as fishermen and first responders

Preparedness: 10.1 percent of the population does not know where to find information about beach closures; only 1.1 percent do not know when a weather advisory is in effect

Quality of life: 51 percent of residents value outdoor activities and recreation; quality of life would decline for 76 percent of the population if beaches are closed more often

Related planning priorities: 19 percent of residents identified recreation and alternative transportation as a planning priority, business and jobs development is a priority for 56 percent of residents, and changes to recreation could affect the tourism industry

Non-climate stressors: Forest and wetland loss; improper disposal of hazardous materials; increased impervious surfaces; insufficient stormwater management practices

In the Chequamegon Bay Area, 51 percent of residents "outdoor activities and recreation" as a most-valued aspect of where they live. Common activities include skiing, biking, hiking, boating, camping, fishing, hunting, swimming and beach-going, snowmobiling, and ATVs. In each community in the survey (Ashland, Bayfield, Red Cliff, and Washburn), over half of residents agreed or strongly agreed with the statements "I live here because [of the] summer recreation" and "I live here because [of the] winter recreation." Outdoor recreation also draws tourists to the Chequamegon Bay Area, generating revenue for area businesses. Each year, at least 283,000 travel from Minneapolis/St. Paul to Wisconsin for outdoor recreation, many of them coming to the nearby northwest region including Ashland and Bayfield counties.[82] The most popular outdoor activities for these tourists are sightseeing, picnicking, and wildlife-viewing. Swimming in lakes and streams is the fourth most-popular activity that draws tourists from the Minneapolis area to Wisconsin, including 195,000 people per year. For the area's residents and its tourism-dependent businesses, safe and accessible outdoor recreation is a valuable asset that warrants careful protection.

Several climatic changes expected in the Chequamegon Bay Area will affect outdoor recreation opportunities: changes in seasons, decreases in water quality, and extreme weather events. The impacts will be greatest to water-, snow-, and ice-based recreation activities. One of the foremost impacts will be a lengthening of the frost-free period that will reduce opportunities for winter recreation such as skiing, snowmobiling, and ice fishing while increasing opportunities for summer recreation such as boating, fishing, and swimming.[83] As the timing of the frost-free period onset and completion change, people and businesses affected may need to access new sources of information to safely plan for recreation opportunities. For example, additional information on ice safety and likelihood of a thawing period may be needed for ice- and snow-sport enthusiasts and businesses. While water-sport and swimming opportunities may increase with the increased frost-free period, they may also be more frequently affected by decreases in water quality. Warmer waters and more frequent heavy rains will lead to water quality decreases including algal blooms, microbial contamination from sewer overflows, and increased sediment, nutrient, and pollution from runoff. Maintaining safety for swimmers, boaters, and fishers will require effective programs for providing water-quality information and education

[82] Wisconsin Outdoor Recreation Demand and Usage, https://dnr.wi.gov/topic/parks/planning/scorp/pdfs/WIS_2005-10_SCORP_CHAPTER_2.pdf, accessed 11/30/2018

[83] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

to the public. Increases in extreme weather events could also decrease the safety of outdoor recreation in summer and winter, and increase demands on emergency response services. See Priority Area for Coordinated Action: Prepare for Variable Recreation and Tourism Conditions for more information.

Take Away

Water, snow, and ice-based recreation activities will be affected by changes in seasons, decreases in water quality, and frequency of extreme weather events. .

Economic Development

Climate change effect confidence level: Low to High (see Table 3 in Section A. Climate Change in the Chequamegon Bay Area for effects that could impact across industries)

Populations of concern: Occupational groups in the timber, fishing, farming, and tourism industries

Related planning priorities: Business and jobs development is a priority for 56 percent of the population; renewable energy and energy efficiency is a planning priority for 43 percent of the population

Non-climate stressors: Reliance on natural resource and temperature and precipitation dependent industries

Take Away

It will be important to anticipate impacts to specialized industries and to continue to innovate in areas such as renewable energy, local foods, and reuse/recycle businesses.

A climate-resilient economy is one that can withstand or recover quickly from climate impacts in the short and long terms. It can be difficult to translate potential climate change hazards and threats into an economic bottom line.[84] However, climate change will invariably affect some of the more specialized industries in the Chequamegon Bay Area, such as forestry, tourism, fisheries, and agriculture. It will be important to plan for changes in these industries in order to sustain them. It will also be important to diversify the regional and local economies in ways that create resilience to change, offer jobs in sustainable sectors, and protect valued natural assets. Transitioning to a green economy is one way of simultaneously working toward these objectives. Not only would such a transition align well with climate change adaptation measures by expanding renewable energy and building a strong local food economy, it also presents opportunities to create and attract new industries and to build on the CBA's growing reputation for sustainability.

Affected Industries

Farming, timber, and tourism are climate-vulnerable sectors.[85] Tourism employs 19.3 percent of the population in Ashland and Bayfield counties, timber employs 3.4 percent, and agriculture employs 3.1 percent.[86]

The timber industry generates revenues for both Ashland and Bayfield counties, a portion of which are transferred to townships that contain county forest land.[87] Timber revenues also enable the counties to maintain services without increasing county levies. Furthermore, the revenue generated by the logging industry supports jobs and, through the multiplier effect, generates additional revenues for the regional economy. The amount of revenue generated is dependent on markets and weather conditions, both of which are difficult to predict.[88] Climate

[84] https://www.epa.gov/smartgrowth/planning-framework-climate-resilient-economy

[85] For more information, see: headwaterseconomics.org/dataviz/great-lakes-atlas/

[86] http://headwaterseconomics.org/eps

[87] Bayfield County Forestry & Parks Department Annual Work Plan 2018

[88] Ibid.

change exacerbates these uncertainties. For example, changing frozen ground conditions can make harvesting more difficult, and the impacts of pests such as the emerald ash borer are unknown. Further pressures, such as deer browse, are also affecting hardwoods. Foresters in the region are already working to better understand and mitigate some of these challenges.

In 2017, the tourism industry in Ashland and Bayfield counties provided employment to 1,164 people (about 1 in 5 jobs) and generated over $10 million in state and local taxes.[89] Climate change may begin to impact summer tourism if water quality in Lake Superior declines or if beaches are closed more often. Clear communication of closures, along with readily available information about alternative options, may help visitors navigate climate change impacts with minimal disruption. Winter tourism that is reliant on recreational activities that require snow and/or ice may be affected. Natural winter attractions such as the Bayfield peninsula sea caves may become rarer and more variable. Diversifying winter events and attractions beyond recreational activities that are weather and precipitation dependent will be important for sustaining a strong tourism industry.

Native fish species are likely to be affected by rising and falling lake levels, and both stream health and spawning areas may be impacted by more frequent and severe storm events. Steelhead and lake trout are preferred by sport fishermen who contribute to the tourism economy.[90] Fewer of these species would impact commercial and recreational fishing industries, in addition to subsistence harvest.

According to the 2012 USDA Census of Agriculture, Ashland County has 187 farms and Bayfield has 352. While some effects of climate change may extend the growing season, the higher frequency of both floods and drought, along with new pests, will require farmers to undertake adaptation measures.

In addition to economic industries being impacted by climate change effects, the Chequamegon Bay Area will need to prepare for increased infrastructure costs, such as road repair, and damages caused by erosion and fluctuating lake levels.

Development Opportunities

Climate change mitigation and adaptation present opportunities for green growth, that is, growth that is decoupled from carbon emissions and material and resource use. The Chequamegon Bay Area is well positioned to build on ongoing efforts toward energy independence, food sovereignty, and reuse/recycle businesses. These local industries will be important to buffer against potential shocks in the global food and energy markets. The region can leverage both its culture of sustainability and its relative climate stability to cultivate and attract new businesses that adhere to green economy principles of zero waste and just employment. Transitioning to this new economy will require some degree of reskilling of the existing labor force. Other strategies such as improving access to high speed Internet to attract small businesses and telecommuters will also help diversify the economy.[91] Attracting people to the area in these ways would have economic multiplier effects in the region. Tourism could be expanded beyond seasonal recreation and events to include a local food district, additional sustainable agritourism options,[92] a destination for health and well-being, and arts, crafts, and a variety of circular economy industries.

The U.S. EPA promotes a G3 (Green Streets, Green Jobs, Green Towns) approach that builds on the concept that green streets—that is, a stormwater management approach that incorporates vegetation, soil, and engineered systems to slow, filter, and cleanse stormwater runoff from impervious surfaces—provide an opportunity for sustainable development that protects the environment and generates a new industry for green jobs. Such investments

[89] Wisconsin Department of Tourism http://industry.travelwisconsin.com/research/economic-impact and https://www.bayfieldcounty.org/DocumentCenter/View/2081/Bayfield-Co-Tourism-Economic-Impact?bidId=

[90] https://www.glerl.noaa.gov/education/ourlakes/economy.html

[91] See the following for examples: https://broadbandnow.com/report/10-small-towns-with-blazing-fast-internet/#note-531-1; https://www.census.gov/library/visualizations/2013/comm/home_based_workers.html; https://www.flexjobs.com/blog/post/how-remote-jobs-can-help-employ-rural-america-success-in-kentucky/

[92] https://www.ers.usda.gov/amber-waves/2014/october/agritourism-farms-are-more-diverse-than-other-us-farms/

provide communities with an opportunity to update and enhance existing infrastructure, create demand for innovation, and become more adaptable to climate change.[93]

GREEN JOBS TRANSITION

A green economy decouples growth from carbon emissions and material and resource use.[94] It moves toward sustainability by focusing on reuse, recycling, remanufacture, and repair of goods. Green jobs in this new economy reduce the consumption of energy and raw materials, limit greenhouse gas emissions, minimize waste and pollution, protect and restore ecosystems, and enable enterprises and communities to adapt to climate change. Training and skills development programs are needed to help workers make this transition, which, if implemented, is expected to increase employment in North America by 2030.[95]

The key areas of the green economy are: [96]

1. Changes in energy production–a shift towards renewable energy sources and greater energy efficiency in buildings. Industries expected to experience job growth include construction, manufacturing of machinery and apparatus, production of electricity by solar photovoltaics, and retail trade, among others.
2. A shift to conservation agriculture–practices that rely on minimum or no soil tillage, crop rotation and soil cover. This approach is considered a sustainable alternative to conventional agricultural practices.
3. The circular economy–produce the reuse, recycling, remanufacture, rental, and repair of goods, and longer durability of goods. Industries expected to experience job growth include reprocessing of secondary materials (i.e., steel and wood material), retail trade, repair of personal and household goods, and recycling (i.e.,, plastics, glass, wood pulp).

CASE STUDIES

The following examples are located in urban areas, yet they may offer ideas that could be applied in CBA communities.

- The city of Austin, Texas, has a Recycling Economic Development Program to attract, retain, and grow zero waste businesses and entrepreneurs in order to create local jobs and foster a resilient zero waste ecosystem. http://austintexas.gov/recyclingecodev
- The U.S. Chamber of Commerce Foundation has a circular economy toolbox to help the private sector incorporate circularity into their core principles and business practices. https://www.uschamberfoundation.org/circular-economy-toolbox
- The Plant in Chicago is a net-zero, closed loop urban system for food production, energy conservation, and material reuse. https://www.ellenmacarthurfoundation.org/case-studies/synergistic-food-production-space

MENTAL HEALTH IMPACTS OF ECONOMIC TRANSITION

Researchers and mental health professionals point out that climate change mitigation can result in feelings of loss when economic ways of life are altered.[97] The occupational restructuring of the economy required to address climate change might be perceived as threatening to relationships, livelihoods, material wealth, status, and identity associated with historical economic conditions and opportunities. It will be important to acknowledge the grief resulting from these losses and to create opportunities for people to make use of their skills and to reinvest in a new way of life.

[93] Read more about the G3 approach and funding mechanisms at the U.S. EPA website: https://www.epa.gov/G3/green-streets-green-jobs-green-towns-g3-initiative-and-approach[81] For more information, see: headwaterseconomics.org/dataviz/great-lakes-atlas/

[94] International Labor Organization (ILO) definition

[95] https://www.ilo.org/weso-greening/documents/WESO_Greening_EN_web2.pdf

[96] https://www.ilo.org/weso-greening/documents/WESO_Greening_EN_web2.pdf

[97] Randall, R. (2009). Loss and climate change: The cost of parallel narratives. Ecopsychology, 1(3), 118-129.

Land Use

Land use plans reflect a delicate balance among multiple needs and goals that are often unique to each community. Among the communities of the Chequamegon Bay Area, land use decisions often reflect a desire to concentrate development within existing zones of utilities and services, preserve natural areas, promote economic and mixed-use development of downtown and waterfront areas, and protect Lake Superior water quality through management of waterways, ravines, riparian buffers, and forest-land practices. To accomplish these goals under a changing climate, communities will likely need to contend with changes to wetlands, floodplains, and green infrastructure.

Wetland Changes

Climate change effect confidence level: Medium (more evapotranspiration); medium (more drought); medium (more precipitation); high (more heavy rains); low (more erosion); medium (species range shifts); low (more invasive species)

Populations of concern: Indigenous people who rely on wetlands for food and cultural importance; populations affected by stresses to water quality (see Utilities and Community Facilities)

Quality of life: Quality of life would decline for almost 80 percent of the population if there are fewer north woods plant, tree, and animal species

Related planning priorities: 35 percent of the population cited the natural environment as a planning priority for their community

Non-climate stressors: Development on and near wetland areas

Wetlands play an important role in the hydrology of the Chequamegon Bay Area, acting as flood storage areas to attenuate the effects of heavy precipitation. Wetlands also provide a niche habitat for key species of plants and animals. Wisconsin's wetlands have been reduced by 50 percent since 1848[98] and continue to be threatened by development. Even when wetlands are protected from drainage and filling, they can be damaged by nearby development, which increases impervious surfaces that increase runoff into the wetland thereby reducing its benefits. Invasive plants and groundwater overuse also threaten wetlands in Wisconsin. There is general agreement among the communities of the Chequamegon Bay Area that the remaining wetlands should be preserved and protected. To do this, climate change impacts must be considered and planned for.

[98] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

Wetlands will continue to be stressed by climatic changes that affect the area's hydrology. Increased evapotranspiration due to a warmer atmosphere may decrease wetland areas by drying the land surface. Wetlands that are shallow or receive little groundwater inputs will be more affected by the drying of increased evapotranspiration. If droughts increase, wetlands could be exposed to further drying. Changes in precipitation patterns could bring changes in groundwater recharge rates. If groundwater recharge is reduced, existing wetlands could dry up; if groundwater recharge increases, existing wetlands could convert to lakes. Either way, the unique species of the wetland ecosystems would lose critical habitat. Increases in runoff from heavy rain events, especially in spring, could also affect wetlands by increasing wetland area or depth. If spring runoff erodes stream banks, making streams wider and deeper, wetland could drain more easily and lose important functions like trapping sediment and nutrients. Wetlands will also be affected by species range shifts and invasive species, possibly leading to reductions in biodiversity.

As pressures on the area's wetlands increase, so does our awareness of their critical role in managing hydrologic flows. To increase wetland benefits, communities may consider undertaking efforts to improve the functionality of damaged or degraded wetland areas. The Wisconsin Department of Natural Resources maintains a database of Potentially Restorable Wetlands (PRW)[99] that could assist communities in incorporating these efforts into their land use planning processes.

Take Away

The need to restore and protect wetlands is intensifying. Climate changes will impact area hydrology, creating shifts in where wetlands can be sustained.

Floodplain Changes

Climate change effect confidence level: High (more heavy rains); low (more high groundwater)

Populations of concern: Low-income households and occupational groups with businesses located in flood-prone areas and emergency responders

Preparedness: 16.8 percent of the population do not have adequate resources to deal with property damage

Related planning priorities: transportation infrastructure is a planning priority for 37 percent of residents

Floodplains are flat areas adjacent to rivers that experience periodic flooding. The Federal Emergency Management Association maintains maps of floodplains, called Flood Insurance Rate Maps, or FIRMs, which are utilized for land use planning and designating flood insurance requirements. As the heaviest rain events grow heavier in the changing climate, greater areas may experience regular flooding. In this way, floodplain boundaries may change and grow, in ways that are not captured by the FIRMs. If areas also experience increases in groundwater recharge, then groundwater flooding could also increase, further changing floodplain boundaries.

As communities work to maintain and utilize up-to-date information regarding floodplain boundaries in their land-use planning processes, they should note that much of the FEMA floodplain maps in the Chequamegon Bay Area are already significantly outdated. The Ashland County maps, specifically, were produced in the 1970's and 1980's, and thus do not account for recent changes in precipitation and area hydrology brought on by climate change. The Ashland and Bayfield county maps are currently in the process of being updated, as part of the Great Lakes Coastal Flood Study.[100] However, the process for generating FIRMs considers only historic flooding, and does not account for future

[99] http://www.greatlakescoast.org/great-lakes-coastal-analysis-and-mapping/ accessed Jan 31, 2019

[100] International Labor Organization (ILO) definition

changes in flooding due to climate change. The Technical Mapping Advisory Council (TMAC) advised FEMA to incorporate climate science and future conditions into their mapping programs, and FEMA responded by agreeing to include future conditions only in the Flood Insurance Study (FIS) report, and only at the request of the community.[101] Therefore, the updated FIRMs, when complete, will not represent floodplains under future climate. Instead of relying upon the FIRMs, communities should work with state and regional engineers and floodplain managers to best determine future conditions for hydrology and incorporate these into their representations of floodplains used for planning purposes.

Take Away

Floodplain boundaries may change due to changes in area hydrology brought by climate change.

Green Infrastructure

Climate change effect confidence level: High (more heavy rains); low (more high groundwater

Populations of concern: Low-income households who do not have resources to properly implement green infrastructure

Preparedness: 16.8 percent of the population do not have adequate resources to deal with property damage

Quality of life: Quality of life would decline for 93 percent of residents if Lake Superior becomes polluted

The communities of the Chequamegon Bay Area often embrace the use of green infrastructure for stormwater management. According to the U.S. Environmental Protection Agency, "Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments. At the city or county scale, green infrastructure is a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, stormwater management systems that mimic nature soak up and store water."[102] As heavy rains increase in the area, such green infrastructure will become increasingly important in mitigating the impacts of flooding and runoff. However, if soils are exposed to prolonged periods of saturation, such as the case of groundwater flooding, then rain gardens and other biofiltration practices could be more prone to failure. Therefore, up-to-date data and methods will be critical in designing sustainable green infrastructure that can adapt to changes in area hydrology.

Take Away

As the need to incorporate green infrastructure into development intensifies, it will also be important to use up-to-date data and methods to be sure it can adapt to changes in area hydrology.

[101] https://www.fema.gov/media-library-data/1454954261186-c348aa9b1768298c9eb66f84366f836e/TMAC_2015_Future_Conditions_Risk_Assessment_and_Modeling_Report.pdf and https://www.fema.gov/final-guidelines-using-future-conditions-hydrology both accessed Jan 31, 2019

[97] https://www.epa.gov/green-infrastructure/what-green-infrastructure

Waterfront & Coastal Resources

Wisconsin State Law does not require communities to include waterfront and coastal resources in their comprehensive plans. However, these resources are highly valued by all of the communities in the Chequamegon Bay Area, and one community (Washburn) elected to include an additional section in their plan to specifically address management of these resources. Indeed, all of the communities highlight the importance of preserving the water quality in nearby Lake Superior, maintaining the aesthetic nature of the waterfront areas, and providing waterfront access for recreation and economic uses. In this section, we detail some unique challenges that coastal areas will face under the changing climate, such as increased beach closures, shoreline changes, variable lake levels, and stressed coastal wetlands.

Stresses to Beaches/ Waterfront Access

Climate change effect confidence level: High (warmer temperatures); high (more heavy rains); high (more microbial activity); medium (variable lake levels)

Populations of concern: Lower-income populations; children and pregnant women; and older adults are vulnerable to water-borne illness

Preparedness: 10.1 percent of the population does not know where to find information about beach closures

Quality of life: Quality of life would decline for 76 percent of the population if beaches are closed more often

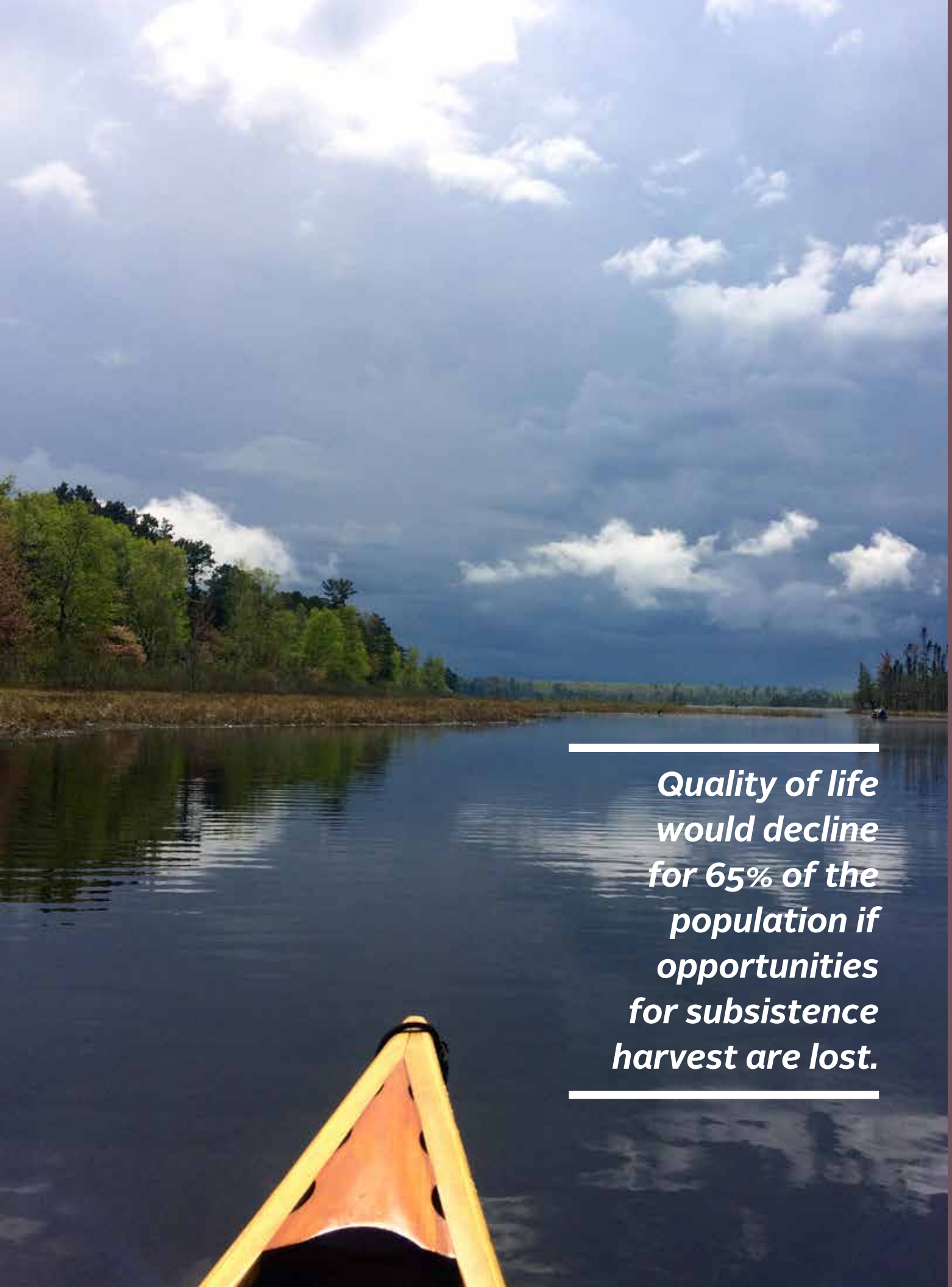
Non-climate stressors: Historical land-use changes; improper disposal of hazardous materials; aging sewer infrastructure

While increased summer heat will draw more beach goers and boaters to Lake Superior and the inland lakes, additional challenges could interfere with waterfront access. Beach closings are likely to be more frequent due to climate change impacts. Heavy rain events may bring pollutant runoff from the land surface, requiring beach closures. Stormwater runoff following heavy rains could also bring bacterial contamination, especially if sewer overflows are triggered, also requiring beach closures. Algal blooms could also increase, due to heavier rains, warmer water and less ice cover.[103] So far, algal blooms near the Chequamegon Bay Area have been non-toxic, but if toxic algae are detected, beach closures will be necessary. Finally, if lake levels become more variable, this could challenge waterfront access.

Take Away

Beach closures may be more frequent due to pollutant runoff, bacterial contamination, and algal blooms.

[103] see Appendix A. Combined Effects, Algal Blooms for more information



Quality of life would decline for 65% of the population if opportunities for subsistence harvest are lost.

Shoreline Changes

Climate change effect confidence level: High (less ice cover), Low (more winds), Medium (variable lake levels), High (more heavy rains), Low (more freeze-thaw)

Quality of life: Quality of life would decline for 75 percent of the population if shoreline erosion increases

Non-climate stressors: Loss of natural vegetation near shorelines

Lake Superior shorelines could be exposed to more degrading forces in coming decades. As ice cover decreases, shorelines are losing winter-time protection from wave exposures. In addition to this prolonged wave exposure, shorelines could also experience bigger, stronger waves, due to increased winds. Finally, if lake levels are lower, shorelines will be more vulnerable to these degrading forces. During lake-level lows, the lake bed could experience down cutting, where the lower portions are stripped away by wave action, reducing support of the higher portions of the lakebed. When lake levels rise again, the upper portions of the lakebed would then be more vulnerable to erosion by waves, eventually allowing the waves to reach farther inland.

Bluffs are especially susceptible to erosion, and will unfortunately experience additional impacts as temperature and precipitation regimes shift. Heavy rainfalls that follow periods of dryness, anticipated to be more common in coming decades, will decrease bluff stability. Bluffs could also be destabilized by more frequent cycling between freezing and thawing temperatures that is expected to accompany warmer winters.

Take Away

Lake Superior shorelines will be exposed to more degrading forces due to increased winds, reduced ice cover, and possibly lower lake levels. Bluffs will be additionally affected by changes in temperature and precipitation patterns.

Ports, Harbors, & Marinas

Climate change effect confidence level: Medium (variable lake levels)

Populations of concern: Occupational groups, populations who are vulnerable to water quality stresses (see Utilities and Community Facilities)

Quality of life: Quality of life would decline for 63 percent of the population if lower lake levels reduce boat access

Non-climate stressors: Historic improper disposal of hazardous materials

Variability in lake levels could affect the functionality of the Chequamegon Bay Area's ports, harbors, and marinas. During low lake levels cargo transport will be reduced, boat bottoms will be exposed to damage, and high docks at marinas can pose hazards to people. If water levels are low enough to require dredging, contaminated sediments could pose risks to water quality. During high lake levels, waves could damage or destabilize structures.

Take Away

As area hydrology changes, lake level lows and highs could pose additional risks to ports, harbors, and marinas.

Coastal Wetlands

Climate change effect confidence level: High (warmer waters); low (more erosion); medium (variable lake levels)

Populations of concern: Indigenous people who depend on wetlands for subsistence and cultural importance; populations affected by stresses to water quality (see Utilities and Community Facilities)

Quality of life: Quality of life would decline for almost 80 percent of the population if there are fewer north woods plant, tree, and animal species; quality of life would decline for 65 percent of the population if opportunities for subsistence harvest are lost, and for 74 percent if important cultural areas are damaged or changed

Related planning priorities: 35 percent of the population cited the natural environment as a planning priority for their community

Non-climate stressors: Boat traffic; introduction of invasive species

Northern Wisconsin's coastal wetlands provide rich habitat for plants and animals, including migratory and nesting birds, as well as spawning fish. The plants of coastal ecosystems hold sediments in place, providing aquatic habitat. Therefore, the ecosystems of many lakes, including Lake Superior, are dependent upon their nearby coastal wetlands. They are also home to wild rice beds that are of great cultural importance to the Native American communities of the Chequamegon Bay Area.

Coastal wetlands will experience changes due to increased water temperatures, increased erosion, and possibly decreased lake levels. Surface waters are warming at about twice the rate of the atmosphere, leading to a 2.5 degree-C increase in summertime water temperatures in Lake Superior between 1979 and 2006.[104] Warming of the waters in the Chequamegon Bay Area is expected to continue, with Lake Superior temperatures projected to be 8-12 degrees-F warmer (annual average) by 2100.[105] Warmer waters could bring altered food webs such as changes in phytoplankton composition, a loss of boreal species, decreases in biodiversity of both plants and fish, and more invasive species. Changes in lake levels are less certain, but lower lake levels are often predicted, and this could lead to disconnection of some wetlands from lakes and streams or a lakeward movement of wetland locations. Finally, erosion in Wisconsin is increasing and is expected to double the 1990 erosion-rate by mid-century. Increased erosion will bury the aquatic communities of coastal wetlands with sediment and lead to wetland loss and siltation.

Take Away

Coastal wetlands provide a critical source of fish spawning habitat and wild rice growing area, but they will experience changes due to increased water temperatures, increased erosion, and possibly decreased lake levels.

[104] Austin, J.A. and S.M. Colman. 2007. Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback, Geophys. Res. Lett., 34, L06604, doi:10.1029/2006GL029021. http://onlinelibrary.wiley.com/doi/10.1029/2006GL029021/pdf

[105] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

Implementation of Adaptation

While the process of incorporating adaptation into planning should be community-directed, some principles are universally helpful in guiding this work. We outline these ideas here, with some references for further reading.

- Climate change adaptation can be **mainstreamed**, or incorporated into routine planning processes and decision-making as a way to manage climate risks.[106] This makes it possible to use existing resources, to limit cost, and to overcome barriers to build adaptive capacity. Mainstreaming can also help initiate coordination of disconnected efforts across siloed planning topics and jurisdictions, and to uncover budget overlaps. A more **transformative approach** would seek to address the drivers of vulnerability, such as concurrent climatic and non-climatic stressors by changing underlying ideas, interests, and institutions.
- Uncertainty about future climate is unavoidable, and should be considered when choosing adaptation actions. Specifically, communities should favor actions that yield benefits regardless of what the climate is in the future. In this way, communities may **build their resilience to climatic uncertainty**.[107]
- Communities may find that some climate hazards bring high risk. **Proactively addressing these hazards**, even if they have low probability, may be justified. This 'better safe than sorry' approach can protect highly-valued community assets or vulnerable populations. The United States Climate Resilience Toolkit provides guidance for identifying resources and assets that are most at risk: https://toolkit.climate.gov[108]
- In the face of limited resources and many adaptation goals, communities will likely be faced with difficult choices about which actions to pursue. Communities may then wish to identify the specific actions that have potential to bring the most benefit, and put aside lower-benefit actions. This **triage approach** can help communities avoid sinking resources into any lost causes or systems that could be resilient without additional management.[109]
- Because there is a mismatch between governance jurisdictions and the geographic extent of climate change effects, adaptation will require **cooperation and collaboration**.

[106] For more information about mainstreaming, see 'Rising to the Challenge Together' p. 43: https://kresge.org/sites/default/files/library/rising_to_the_challenge_together_linked_0.pdf

[107] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

[108] Ibid.

[109] Ibid.

It is time to be proactive about planning for climate change given that preventive measures are more cost-effective than reactive disaster response.

Appendix A

Many of the ongoing and expected climate change impacts to the Chequamegon Bay Area are a result of changes in temperature and precipitation. For example, events and trends observed across the Great Lakes basin from December 2016 to November 2017 included higher than average seasonal temperature and precipitation, flooding, and low ice cover.[110] In the following sections, we list some specific findings regarding how climate has changed in the Chequamegon Bay Area in recent decades, and how it is expected to change in the coming decades. We divide these findings into two sections: Temperature (including a few direct results of increased air temperatures) and Precipitation. Brief descriptions of these and many more climate change impacts are available in Table 3 of the main text.

Temperature

Historical data show that average annual temperatures in Ashland and Bayfield counties have risen 0.75-1.5 degrees-F in the past half-century (1950-2006).[111] The change has been greatest in winter, with 1.5-2.25 degrees-F of warming, while summer and fall have warmed by 0.5-1 degree-F.[112] Nighttime temperatures have risen more than daytime temperatures in Wisconsin. By 2006, nighttime temperatures below 0 degrees-F were occurring 8-12 days/year less often than in 1950.[113] Very hot days have also increased in frequency, with most of Ashland and Bayfield counties experiencing about 2 more days over 90 degrees-F per year in 2006 than in 1950.1[114] As a consequence of this warming, the frost-free season, also known as the growing season, has lengthened. Over the 1950-2006 time period, the growing season increased by 8-16 days in Ashland and Bayfield counties. This correlates with a shortening of the snow-covered period of the year.

Based on global climate models which have been downscaled to the county level, the following graphs show projected conditions for two possible futures over the coming decades: one in which humans reduce and stabilize global emissions of heat-trapping gases (labeled Lower emissions), and one in which we continue increasing emissions through the twenty-first century (labeled higher emissions). These scenarios represent two plausible futures and a range within which decision-makers might plan. We can see that the average maximum daily temperature in Ashland County is expected to rise (projections for Bayfield County are similar, therefore only Ashland data is included here) (see Figure A1), and the region will likely experience fewer days when the temperature falls below freezing (Figure A2).

Most projections predict that by 2055 the annual temperature in Ashland and Bayfield counties will be between 3 and 9 degrees-F warmer than it was in 1980,[115] which is significantly more warming than the 0.75-1.5 degrees-F change seen in the past half-century. Associated trends are expected to continue, such as nighttime warming exceeding daytime warming, many fewer nights below freezing, some increase in very hot days, and a lengthening of the frost-free season and reduction of the snow-covered season.

Warming in the atmosphere leads to warming in surface waters, often at about twice the rate. Lake Superior summer surface water temperatures (July–September) have increased approximately 2.5 degrees-C (1979-2006), significantly in excess of regional atmospheric

---

[110] Environment and Climate Change Canada and the U.S. National Oceanic and Atmospheric Administration. 2017 Annual Climate Trends and Impacts Summary for the Great Lakes Basin. 2018. Available at binational.net.

[111] https://nelson.wisc.edu/ccr/resources/wisconsin/index.php

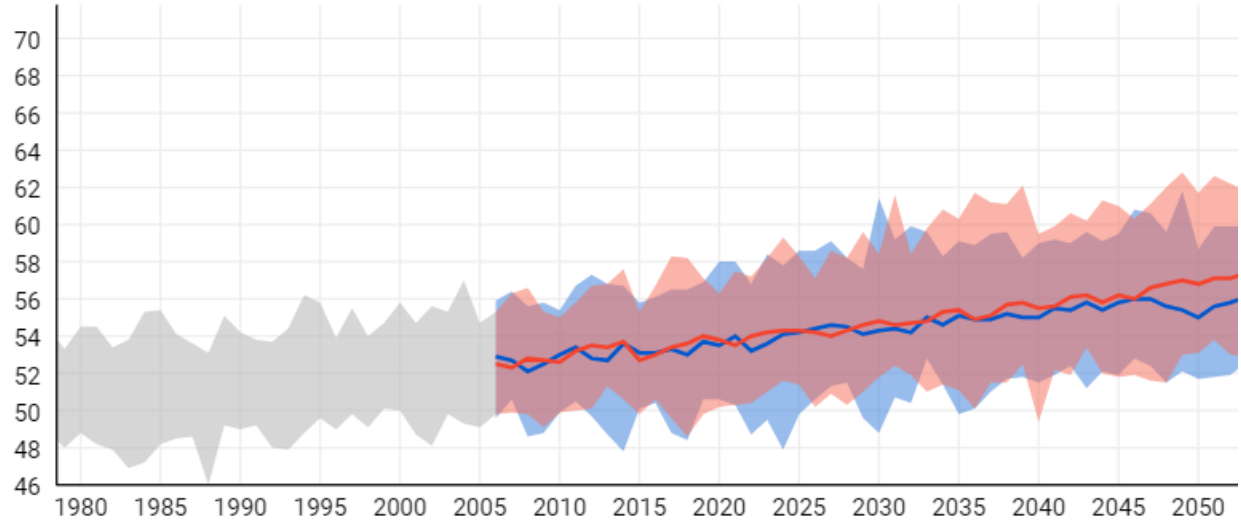
[112] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin. (ranges describe spatial variation over Ashland and Bayfield counties)

[113] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

[114] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

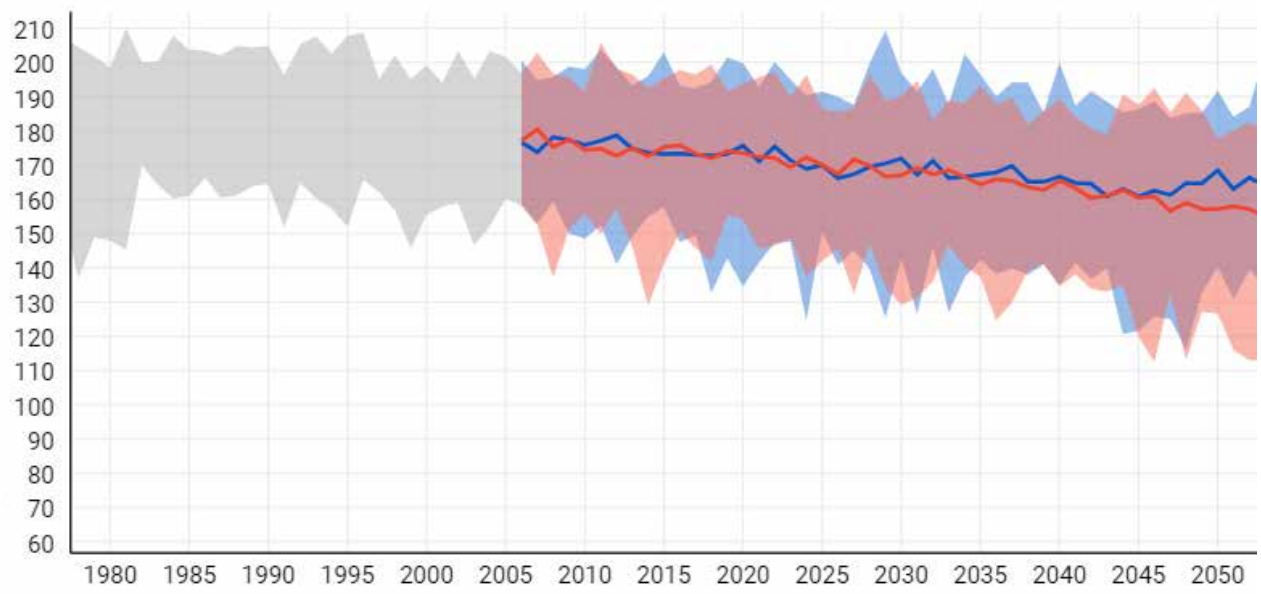
[115] https://nelson.wisc.edu/ccr/resources/wisconsin/index.php

Figure A1. Average Annual Maximum Daily Temperature for Ashland County, 2008-2050



Source: U.S. Climate Resilience Toolkit Climate Explorer
Note: Bayfield County projections are almost identical to those for Ashland County

Figure A2. Days with minimum temperature <32 degrees F in Ashland County, 2008-2050



Source: U.S. Climate Resilience Toolkit Climate Explorer
Note: Bayfield County projections are almost identical to those for Ashland County

warming during the same period.[116] Ice cover has also reduced, which contributes to the quick warming of surface waters. The duration of ice cover on Lake Superior measured at Bayfield, Wisconsin, during 1857-2007 decreased by 3 days/decade.[117] Indeed, Great Lakes maximum ice cover for December 2016 through April 2017 was 40 percent below the long-term average.[118] These trends are also expected to continue. Annual average water temperature in Lake Superior is expected to increase by 8-12 degrees-F by 2100 and ice cover duration will decrease by another 1-2 months.[119]

[116] Austin, Jay A., and Steven M. Colman. "Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback." Geophysical Research Letters 34, no. 6 (2007).

[117] Howk, Forrest. "Changes in Lake Superior ice cover at Bayfield, Wisconsin." Journal of Great Lakes Research 35, no. 1 (2009): 159-162.

[118] 2017 ANNUAL CLIMATE TRENDS AND IMPACTS SUMMARY FOR THE GREAT LAKES BASIN (2017) GLISA.

[119] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

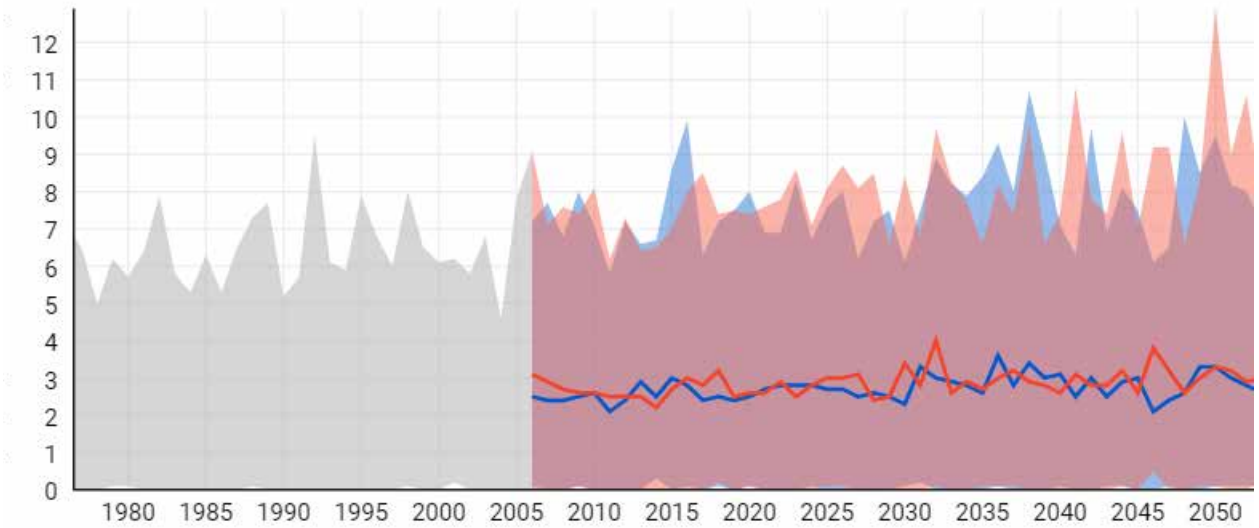
Precipitation

The patterns of precipitation in the Ashland and Bayfield counties changed in the past half-century (1950-2006), with annual average precipitation increasing by about 1 inch in the northern part of the Bayfield peninsula and about 7 inches in the southern portion of the counties.[120] The precipitation increases have been greatest in fall (2.5-5 inches) and winter (1-2 inches), whereas spring and summer precipitation changes have been mixed. The concentration of rain events may also be changing, though a longer data record may be needed to determine statistical significance. Indeed, when considering all rain events in Wisconsin during this 56-year period, it is clear that heavy rain events have increased in frequency.[121] This appears to hold true for the Chequamegon Bay Area as well, but more monitoring may be necessary to determine it with certainty.

Model projections for 1980-2055 predict an increase in annual precipitation totals for Ashland and Bayfield counties with about 75 percent probability.[122] That is, in three-quarters of emissions scenarios and model runs, precipitation totals continue to increase into mid-century. Seasonal patterns in precipitation may also change: most projections foresee increases in winter, spring, and autumn precipitation and slight decreases in summer precipitation.[123]

There is substantial agreement that heavy rain events will increase in frequency in Ashland and Bayfield counties, beyond increases that may have already occurred. The average number of days per year with more than 1-inch of precipitation is expected to vary and increase overall compared to the historical average (Figure A3). Due to the intermittent nature of this phenomenon, it is even more clear when we consider a longer time horizon. Indeed, by comparing projections for 2090 with 1980 estimates, Ashland and Bayfield counties are expected to experience 13 more days/decade with 1-inch rains, 4.4 more days/decade with 2-inch rains, and 1.3-1.5 more days/decade of 3-inch rains.[124]

Figure A3. Days per year with more than 1-inch of precipitation in Ashland County, 2008-2050



Source: U.S. Climate Resilience Toolkit Climate Explorer
Note: Bayfield County projections are almost identical to those for Ashland County

[120] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

[121] Ibid.

[122] Ibid.

[123] https://nelson.wisc.edu/ccr/resources/wisconsin/index.php

[124] Kucharik, C., D. J. Vimont, K. Holman, E. Hopkins, D. Lorenz, M. Notaro, S. Vavrus, and J. Young. "Wisconsin Initiative on Climate Change Impacts Climate Working Group Report: Climate Change in Wisconsin." University of Wisconsin-Madison. Madison, WI (2010).

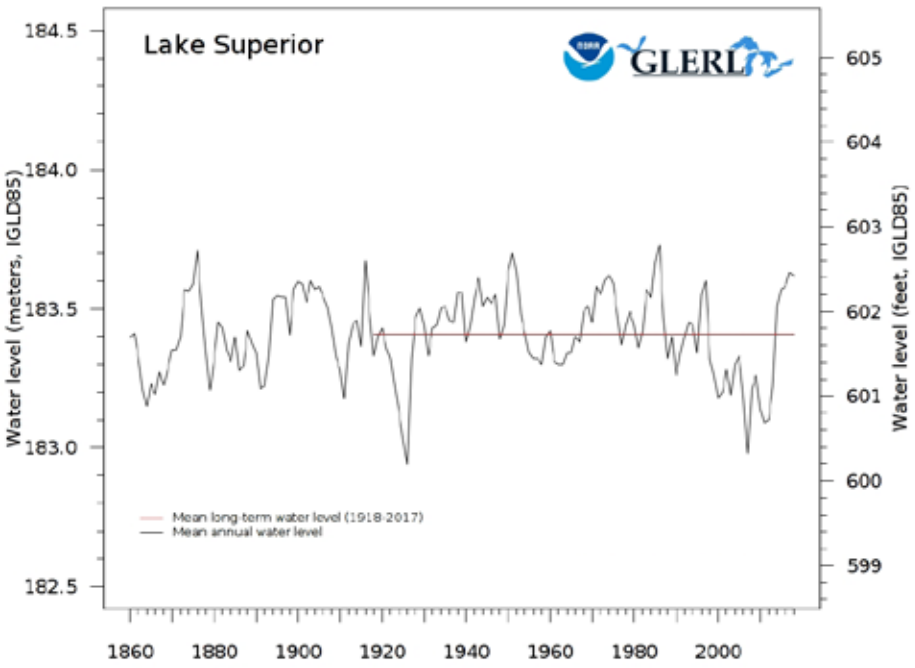
Combined Effects

Lake Superior Water Level

Coastal communities such as those of the Chequamegon Bay Area are greatly affected by changes in lake water levels. A great deal of ongoing research is aiming to predict the coming effects of climate change on water levels in the Great Lakes. At the time of this publication, much uncertainty remains. However, it is understood that water levels will continue to vary, and may even increase their volatility throughout this century.

Lake Superior water levels are characterized by significant year-to-year variability (see Figure A4). This variability reflects basin-wide climate variability that affects lake water storage.[125] Lake Superior water level is primarily controlled by basin-wide precipitation (water entering the basin) and evapotranspiration (water leaving the basin).[126] Winter-time water storage in snow, melting in spring, causes seasonal cycles in water level.

Figure A4: Long-term variability in water levels of Lake Superior



Source: https://www.glerl.noaa.gov/data/wlevels/#observations, accessed 10/30/2018

To minimize extremes in water level, control structures in St. Marys River have regulated outflow since 1914. This mechanism allows continued variability while somewhat increasing consistency.

After a record high in 1985, Lake Superior entered an extended period of low annual average water levels in the 1980s, coinciding with a period of low water levels throughout the Great Lakes which lasted 1999-2013. The polar vortex of January 2014 brought more ice cover to the lakes, reducing evaporation, and appeared to trigger a turnaround. That spring, all five Great Lakes saw significant water level rises. The Lake Superior low-level period culminated in such a rapid rise during 2013-2014 that it was record breaking in its magnitude and swiftness.[127]

Scientific methods for projecting evapotranspiration and precipitation are still evolving, and thus predictions of lake level changes are evolving as well. Studies agree that more water will be removed from the Lake Superior basin into the atmosphere via evapotranspiration. This is due to increases in air temperature as well as reductions in lake ice cover and increases in water temperature.[128] However, total precipitation may also increase and these changes are difficult to predict. If basin-wide total precipitation increases, this could somewhat offset the increases in evapotranspiration, keeping lake levels near their long-term average or even higher. Conversely, if precipitation decreases, lake levels will lower further.

---

[125] Wilcox, Douglas A., Todd A. Thompson, Robert K. Booth, and J. R. Nicholas. "Lake-level variability and water availability in the Great Lakes." U.S. Geological Survey Circular 1311 (2007).

[126] Huff, A. and A. Thomas. 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html.

[127] Annin, Peter. The Great Lakes Water Wars. Island Press, 2018.

[128] http://glisa.umich.edu/climate/lake-levels accessed January 31, 2019

Studies agree that water levels in the Great Lakes will continue to vary. Models disagree on the direction of change in long-term average water levels. Many studies have suggested that water levels will decrease on the whole, but updated methods for estimating evapotranspiration have led to more recent studies predicting averages that remain closer to historic norms, or even rising water levels. As scientific methods continue to evolve, communities should anticipate prolonged periods of either high or low water levels.[126]

Algal Blooms

Algae blooms are rapid expansions of populations of algae or cyanobacteria (which can look like algae to a casual observer). During an algal bloom, water is discolored by the pigments of the microbes. The blooms are unsightly, impacting recreation and tourism. Moreover, as the algae add dead organic matter to the water, the decay process consumes oxygen, leading to hypoxic conditions, harming ecosystems and possibly even causing fish die-off. Some forms of algae blooms also release toxins, harmful to wildlife, pets, and humans.

Surface waters generally contain a variety of phytoplankton and microalgae organisms in moderate amounts. These populations can form algal blooms when excess nutrients are added to the water. Excess nutrients can come from soils, sewage and septic waste, fertilizers (agricultural or residential), and household cleaners.[127] Often, the nutrients are washed into the lakes during heavy rain events. Warmer waters are more likely to experience algal blooms because they provide more favorable conditions for growth of algae and cyanobacteria. As climate changes, more algal blooms are likely, due to more heavy rains, warmer waters, reduced ice cover, and possibly also lower lake levels.

Algae blooms are a recent phenomenon in Lake Superior, first documented in 2012 and recurring since, especially with heavy rain events.[128] Ongoing research is aiming to describe the causes leading to these algal blooms. It appears that increased temperatures are providing favorable conditions the blooms. Indeed, Lake Superior chemistry has been altered by increased primary productivity associated with the lengthening of the growing season for phytoplankton, due to reduced ice cover and longer stratified seasons.[129] Since the blooms that have been observed in Lake Superior so far have followed heavy rain events, it is also likely that excess nutrients are entering the lake via erosion and runoff associated with the heavy rains.

[126] http://glisa.umich.edu/climate/lake-levels January 31, 2019

[127] https://www.glerl.noaa.gov/pubs/brochures/NOAA_HABs_in_Great_Lakes.pdf accessed January 31, 2019

[128] Lafrancois, Brenda, Kaitlin Reinl, Robert W. Sterner, Sandra Brovold, and Todd Miller (2018) Apostle Islands Nearshore Monitoring and Harmful Algal Blooms. Oral presentation at Lake Superior Collaborative Symposium, Ashland, Wisconsin, Oct. 24, 2018.

[129] O'Beirne, M. D., J. P. Werne, R. E. Hecky, T. C. Johnson, S. Katsev, and E. D. Reavie. "Anthropogenic climate change has altered primary productivity in Lake Superior." Nature communications 8 (2017): 15713.


TRAIL
CLOSED

Center for Rural Communities
NORTHLAND COLLEGE

The Northland College Center for Rural Communities applies research-based solutions to social and economic challenges, partners with community members to build on local knowledge, and promotes the long-term health and vitality of rural communities in the north woods region.

You can reach us at:
Center for Rural Communities
Northland College
1411 Ellis Avenue
Ashland, WI 54806
crc@northland.edu

northland.edu/sustainability/crc

CRC STAFF

Brandon Hofstedt
Director of the Center for Rural Communities and Associate Professor of Sustainable Community Development

Robin Kemkes
Faculty Research Associate

Sean Akerman
Faculty Research Associate

Meghan Salmon-Tumas
Faculty Research Associate