Climate Change Vulnerability Assessment and Adaptation Plan

1854 Ceded Territory Including the Bois Forte, Fond du Lac, and Grand Portage Reservations

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Recommended Citation

Stults. M., Petersen, S., Bell, J., Baule, W., Nasser, E., Gibbons, E., Fougerat., M., 2016. *Climate Change Vulnerability Assessment and Adaptation Plan: 1854 Ceded Territory Including the Bois Forte, Fond du Lac, and Grand Portage Reservations*. Duluth, MN: 1854 Ceded Territory.

Acknowledgements

This project was completed through a collaboration between the Bois Forte Band of Chippewa, Fond du Lac Band of Lake Superior Chippewa, Grand Portage Band of Lake Superior Chippewa, and 1854 Treaty Authority. It represents the collaborative effort of the more than 25 people who attended in-person workshops, participated in online webinars and conference calls, and reviewed written outputs of this project. Their participation is directly responsible for the success of this plan and will continue to be central to this ongoing effort to build climate change resilience for the 1854 Ceded Territory and reservations.

Thank You Core Team!

A "Core Team" of tribal staff were particularly valuable in the project as they helped refine and guide the effort. They participated in every aspect of the project including bi-weekly conference calls. Without their participation this project would not have been possible. Thank you to the Core Team, listed in alphabetical order by last name:

Name	Organization
Jamie Adams	Fond du Lac
Phil Defoe	Fond du Lac
Wayne Dupuis	Fond du Lac
Gabrielle Holman	Bois Forte
EJ Isaac	Grand Portage
Shannon Judd	Fond du Lac
Andrea Junker	Fond du Lac
Tyler Kaspar	1854 Treaty Authority
Shannon Kesner	Fond du Lac
Bill Latady	Bois Forte
Sonny Myers	1854 Treaty Authority
Seth Moore	Grand Portage
Nancy Schuldt	Fond du Lac
Linda Tibbetts-Barto	Bois Forte
Darren Vogt	1854 Treaty Authority
Margaret Watkins	Grand Portage
Joy Wiecks	Fond du Lac

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1. Executive Summary

To the Ojibwe, natural resources are cultural resources. There is no separation between how the bands manage and interact with a resource and how their culture endures: one is dependent on the other. Climate change, however, is threatening the very viability of many natural resources important to the Ojibwe. Warmer winters, increasing fall precipitation, increasing extreme precipitation events, more occurrences of drought, and earlier ice out dates across the 1854 Ceded Territory already are affecting flora and fauna that are imperative to the culture, history, well-being, and life-ways of the Ojibwe people.

Through this project, the Bois Forte Band, Fond du Lac Band, Grand Portage Band, and 1854 Treaty Authority partnered with Adaptation International, and the Great Lakes Integrated Sciences and Assessment Center at the University of Michigan. The purpose of the project was to investigate how changing climate conditions already are and could continue to affect the landscape and species within the 1854 Ceded Territory and the respective reservations. In addition to assessing changes, the partners also identified climate-related vulnerabilities and identified actions that could be taken to create more climate resilient systems.

1.1 Collaboration

Building resilience to changing climate conditions is a process, not an outcome. It takes strong multi-disciplinary, multi-sector, multi-organization collaboration and partnerships to continue to adapt as climate conditions change. This project lays the foundation for this ongoing collaboration. To develop the plan, more than 25 people from the 1854 Treaty Authority, the Bois Forte, Fond du Lac, and Grand Portage bands, and other partners used a collaborative process to truly integrate the best available climate science with local knowledge. They developed customized adaptation strategies that have a high likelihood of being implemented. This process also enabled the bands to enhance the personal and professional connections between project partners, partnerships that will be instrumental in helping the region continue to adapt to changing climate conditions.

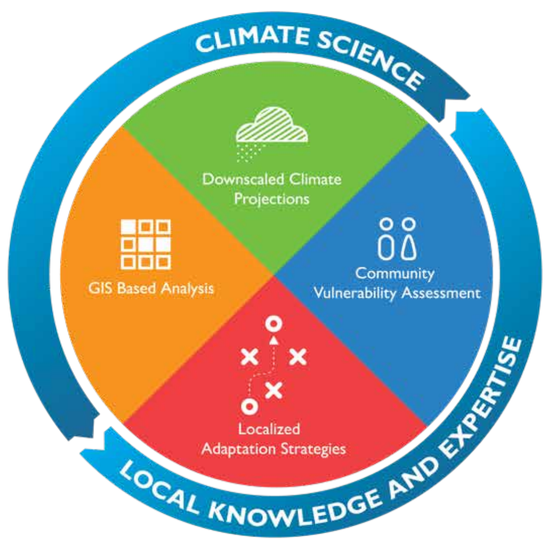

Figure 1: Collaborative Adaptation Planning integrates climate science with local knowledge

1.2 Climate Change Across the Region

One building block for climate resilience is a detailed understanding of how the climate is projected to change. The Great Lakes Integrated Sciences and Assessment (GLISA) program at the University of Michigan led the project team's effort to compile and analyze the most recent and detailed climate information available, including both historic information and downscaled regional climate projections. The 1854 Ceded Territory falls within two climate divisions, the Northeast Minnesota (NEM) and East Central Minnesota (ECM) (Table 1).

Table 1: Mid-Century (2041-2070) Climate Projections for the 1854 Ceded Territory. Projections include both Midwest averages and portions of two climate divisions: most of Northeast Minnesota (NEM) and the northeast corner of East Central Minnesota (ECM). Projections are for the higher (A2) emissions scenario.

		Mid Century Projections (2041-2070)
Annual	**Temp.**	Midwest ranges from 3-5°F warming with an average around 4.5°F for NEM/ECM, though areas directly along Lake Superior exhibit slightly less warming. Warming is consistent across most of the Midwest.
	Precip.	Midwest ranges from -7% to +12% change. NEM/ECM is projected to see increases in the range of +3% to + 12%.
Extremes	**Temp.**	Days below freezing are projected to decrease across NEM/ECM by about three weeks. Days below 10°F are projected to decrease by 3.5 weeks. Days above 95°F are projected to stay the same or increase by 0-10 days in NEM/ECM.
	Precip.	There is great uncertainty in extreme precipitation projections, but days with greater than 1" precipitation events are projected to increase (20% to 40%) in NEM/ECM and increase more in the northwest portion of the area. Most projections agree that the longest dry period for a year will decrease by 4-8 days in NEM/ECM.

These projections also include detailed analyses of future changes by season, since seasonal changes are often more important for determining impacts to species and habitats than annual averages (Figure 2). All changes (seasonal and annual) are based on projections of climate at mid-century (2041-2070) and use a higher (A2) emissions scenario (i.e., that humans continue to emit significant amounts of greenhouse gases) to generate the projections.

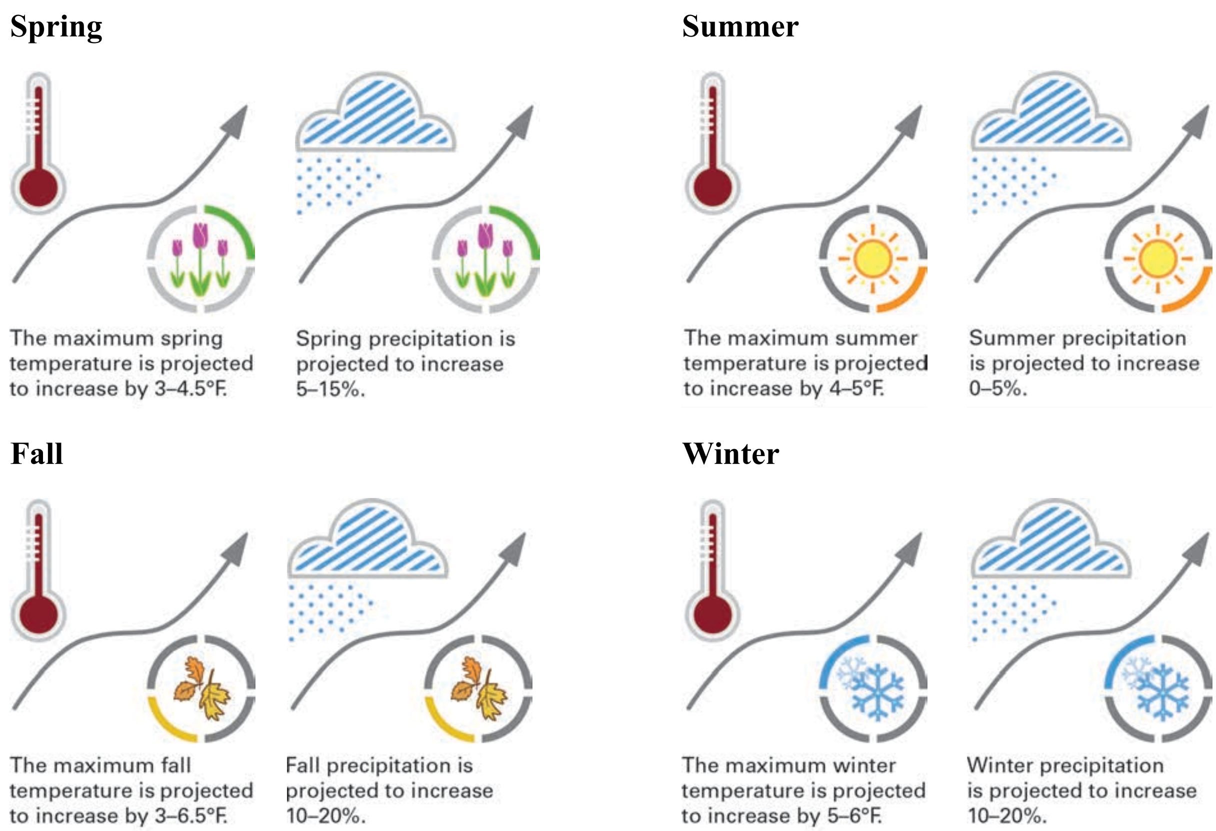

Figure 2: Projected mid-century (2041-2070) changes in climate for the 1854 Ceded Territory under a higher emissions scenario (SRES A2) by season. SRES Scenarios were selected over the RCP scenarios due to availability of dynamically downscaled climate data.

1.3 Vulnerability Assessment Results

Utilizing information gleaned from the climate change projections, the project team selected more than 30 different species, groups of species, and habitats that are of significant cultural importance and are likely to be impacted by climate change. These species/ecosystems represent a broad cross-section of the natural resources that the bands rely on across the region and broadly fall into one of nine categories: air quality, aquatic and terrestrial plants, culturally significant places, fisheries, forestry, resource access, water quality, wetlands, and wildlife. The vulnerability of all of these species/ecosystems was assessed by looking at their sensitivity as well as their ability to adapt to projected changes in climate. Due to project limitations, the project team selected 11 focus species/habitats (Figure 3: bold font) to develop an initial set of detailed and customized adaptation strategies. General adaptation strategies were developed for the remaining species/ecosystems.

Adaptive Capacity: High → Low		Sensitivity: Low → High: S0	S1	S2	S3	S4
	AC4	• Black Crappie	• Berries (w/o Bog Species) • White-Tailed Deer			
	AC3		• Bald Eagles • Wolves • Birds and Waterfowl (turkey, duck, pheasants, geese)	• **Air Quality** • **Walleye** • Northern Pike	• **Sturgeon** • Eastern White Pine • Furbearers (beaver, black bear, bobcat, coyote, fisher, fox, mink, muskrat, river otter,) • Northern Red Oak, Bass Wood, and Chokecherry	
	AC2			• **Culturally Significant Plants** • **Sugar Maple** • Black Ash • Resource Access • Shrub Wetlands	• **Wild Rice** • **Labrador Tea** • Berries (bog species)	• Quaking Aspen
	AC1			• Culturally Significant Places	• **Water Quality and Quantity** • Birds and Waterfowl (ruffed grouse, spruce grouse, loons, swans) • Cisco • Furbearers (lynx, American marten, snowshoe hare) • Lake Trout • Whitefish	• **Moose** • Brook Trout • Vernal Pools
	AC0					• **Paper Birch** • **Boreal Wetlands** • Northern White Cedar

Figure 3: Final relative vulnerability rankings. Green colors indicate lower vulnerability whereas red colors indicate greater vulnerability. Species and ecosystems shown in bold are the initial focus areas for the development of customized and detailed adaptation strategies.

1.4 Actions to Build Resilience

Initial adaptation strategies have been identified and developed for all species considered in this assessment. These general adaptation strategies provide a foundation which band members, staff at the reservations, and 1854 Treaty Authority can build on as time, resources, and funding becomes available. While all species/ecosystems have general adaptation strategies included in this plan, the project team developed 269 detailed and customized strategies for the 11 focus species/ecosystems (Figure 3: bold font). These strategies were created by combining promising practices being used by other organizations and in other locations with local stakeholder and expert input. For each of these species, adaptation actions were identified, customized, and grouped into one of five categories: collaboration; conservation, preservation, and maintenance; education; monitoring and assessment; and restoration.

Table 2: Example climate resilience strategies and total number of customized strategies developed for the focus species grouped by category of action.

Category	Number of Strategies for Focus Species	Example Strategies
Collaboration	45	▪ Enhance collaboration with local, county, state, and federal wetland management organizations to identify, monitor, and track wetlands throughout the region. *(Culturally Significant Plants)* ▪ Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on walleye. *(Walleye)*
Conservation Preservation Maintenance	98	▪ Assure future availability of wetlands and other habitats where moose are most secure from heat stress by undertaking wetland conservation initiatives such as conservation easements, mitigation banking, and others deemed viable. (*Moose)* ▪ Promote landscape water retention to protect against soil drying and overall drought stress. (*Paper Birch)* ▪ Protect remaining populations of wild rice, regardless of density. *(Wild Rice)*
Education	31	▪ Work with news media sources to inform and educate the public about moose and moose management programs in northeastern Minnesota. *(Moose)* ▪ Make sure that heat alerts are very clearly advertised to the public through venues such as websites, social media, and potentially an air quality flag system (e.g., EPA has a program). *(Air Quality*)
Monitoring Assessment	69	▪ Develop and maintain water quality database for reservation waters and for waters within 1854 Ceded Territory. *(Water Quality)* ▪ Inventory important sugar maple stands for climate protective site characteristics (e.g. north facing, deep, fertile soils, low drought stress) and work with partners to enhance and protect these areas. *(Sugar Maple)*
Restoration	26	▪ Resize new and existing culverts (e.g., retrofits) to ensure they can handle projected changes in precipitation. *(Boreal Wetlands)* ▪ Reduce non-climate stressors like pollution: expand the restoration or enhancement of riparian buffer zones around key lakes and streams to limit agricultural run-off or other non-point source pollution that would degrade water quality, ensure water quality standards are met and enforced. *(Sturgeon)*

Section 4 of this report highlights the specific vulnerabilities as well as potential adaptation strategies for each of the 11 focus species/ecosystems as well as general strategies for the other 24 species/ecosystems identified by the project team.

1.5 Next Steps

This plan represents the most recent step in the Bois Forte Band, Fond du Lac Band, Grand Portage Band, and 1854 Treaty Authority's efforts to prepare for climate change. The process used to create this plan can be repeated or expanded to assess the climate related vulnerability of additional natural, social, or physical resources or to develop customized adaptation strategies for other species.

A key next step is implementation of the strategies developed as part of this plan. For each action, it will be important to monitor and evaluate the effectiveness of that action in building resilience. Implementing these and other strategies, monitoring their success and the health and vitality of the natural resources they are designed to protect, and modifying or enhancing those strategies over time will be necessary to help the region build resilience. These efforts and the ongoing collaboration between the three bands and the 1854 Treaty Authority will help ensure that natural resources across the region and the lifeways of the Ojibwe people are preserved for many generations to come.

2. Introduction

2.1 Bands and Treaty Rights in the 1854 Ceded Territory

On September 30, 1854, a number of Native American bands entered into a treaty whereby the Chippewa tribe ceded to the United States ownership of their lands in what is now the northeastern portion of Minnesota while retaining their right to hunt, fish, and gather on those lands. These lands are referred to as the 1854 Ceded Territory (Figure 4). These treaty rights still exist today and are exercised by the Bois Forte Band of Chippewa, Fond du Lac Band of Lake Superior Chippewa, and Grand Portage Band of Lake Superior Chippewa. The bands remain involved in the preservation and protection of treaty rights, and also the management of natural and cultural resources on which meaningful exercise of these rights is based.

The 1854 Treaty Authority is an inter-tribal natural resource management organization that assists the Bois Forte Band of Chippewa and Grand Portage Band of Lake Superior Chippewa in managing their off-reservation hunting, fishing, and gathering rights in the territory ceded under the Treaty of 1854. The 1854 Treaty Authority is governed by a 10-member Board of Directors consisting of the duly elected officials of the Bois Forte and Grand Portage Tribal Councils. The Fond du Lac Band of Lake Superior Chippewa manages its own off-reservation treaty rights in the 1854 Ceded Territory but often works with the Treaty Authority on matters of mutual concern.

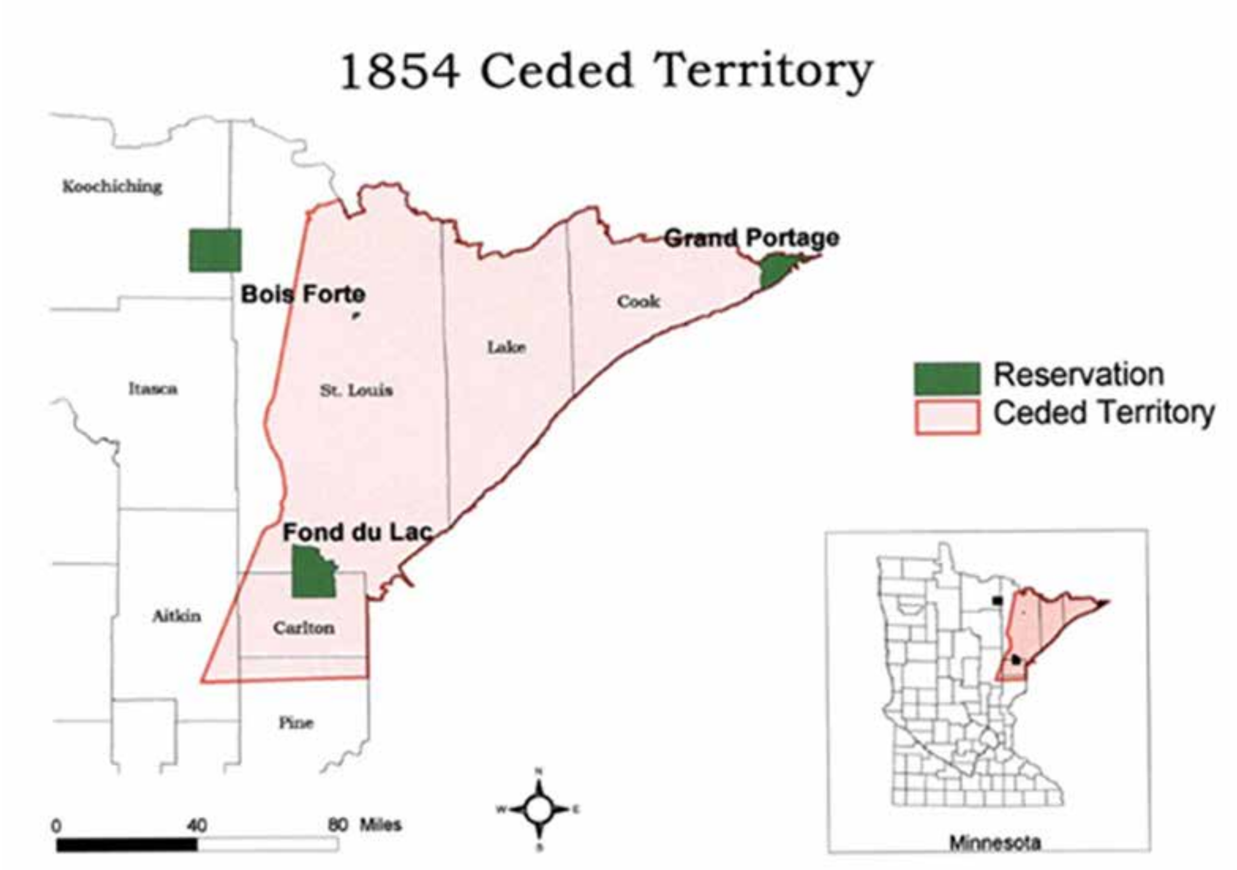

Figure 4: Map of 1854 Ceded Territory and reservations included in the project.

2.2 Reservations and the 1854 Ceded Territory

The 1854 Ceded Territory contains approximately 6,400,000 total acres. The land and water base includes 4,000,000 forested acres, 1,400,000 acres of Lake Superior shoreline, 500,000 acres of other lakes, 75,000 acres of wetlands, and 425,000 acres used for other purposes. The 1854 Ceded Territory encompasses portions of the watersheds for all three major river systems that originate in the state of Minnesota: the Rainy River, the Mississippi River, and the St. Louis River. The Minnesota Department of Natural Resources Division of Waters has subdivided the three major river drainage systems into 81 distinct watersheds, of which 13 are partly or wholly within the 1854 Ceded Territory. These watersheds include the Lake Superior (North and South), Cloquet River, Rainy River (Headwaters), Nemadji River, St. Louis River, Vermilion River, Mississippi River (Brainerd and Grand Rapids), Kettle River, Snake River, Rainy River (Rainy Lake), and Little Fork River.

In addition, within the 1854 Ceded Territory are reservations (or portions of reservations) for the Bois Forte, Fond du Lac, and Grand Portage bands.

The Bois Forte Reservation was established in 1866 and 1881 and is located within, and to the west of, the 1854 Ceded Territory. The reservation is comprised of three separate land holdings. The largest portion of the Bois Forte Reservation is the Nett Lake Reservation, which is over 104,000 acres. The Deer Lake Reservation is over 22,400 acres in size. The Lake Vermilion Reservation is the smallest reservation at just over 1,000 acres and is within the 1854 Ceded Territory[1].

The Fond du Lac Reservation was established by the La Pointe Treaty of 1854 and is located within the southern portion of the 1854 Ceded Territory. It is adjacent to the city of Cloquet, Minnesota, and 20 miles west of Lake Superior and Duluth, Minnesota. There are approximately 101,500 acres within the boundaries, 40 percent of which is tribally owned. The reservation is mostly forested, with approximately 44,000 acres of wetlands and 828 acres of wild rice waters.

The Grand Portage Reservation was also established by the La Pointe Treaty of 1854 and is located at the extreme northeast corner of Minnesota within the 1854 Ceded Territory. The reservation is approximately 56,000 acres with 38,239 acres in band and Tribal trust and an additional 1,897 acres recently purchased by the Grand Portage Tribal Council being put into Trust status.

2.3 Natural and Cultural Resources within the Ceded Territory

In the experience of the Ojibwe, natural resources are cultural resources. There is no separation between how the bands manage a resource and how their culture endures: one is dependent on the other. Since the Ojibwe migration to the Lake Superior region, cultural and natural resources have evolved in concert. A representation of this connection was seen through the seasonal movement of Ojibwe peoples. As the Minnesota Office of the State Archaeologist explains:

[1] Bois Forte Website http://www.boisforte.com/

Ojibwe villages were usually located on lakes and streams. In the summer, hunting and gathering took place within a 50-mile radius of the village. In the fall, camps were established near wild rice beds. In the early spring, wigwam camps were located near sugar bushes. Winter villages were located in sheltered areas near good hunting grounds. In the warm season, birch bark canoes provided rapid transportation over the waterways and were light enough to carry over the many portages. Snowshoes often were essential in the winter…Fishing and hunting were important during all seasons. Deer were an especially important food source in the winter. During the fur trade, trapping became an important activity mainly in the winter[2].

Natural resources are an intrinsic part of life on reservations and within the 1854 Ceded Territory. These natural resources are of deep cultural and subsistence importance to the bands that retain rights to hunt, fish and gather them. Any disruption to these systems has the potential to cause significant ramifications to the Ojibwe people. One factor of particular concern is climate change.

2.4 Climate Change and Resources

Large-scale environmental change in the form of human-driven alteration of the climate is here. Global emissions of greenhouse gases such as carbon dioxide (CO_2) have increased dramatically over the last 150 years. Researchers throughout the world agree that these changes can be attributed primarily to human activities such as the combustion of coal, oil, and natural gas. The resulting presence of these gases in the atmosphere has led to a number of changes in global, regional, and local climatic conditions. Some of the changes experienced to-date (from 1950-2012) across northeastern Minnesota and within the 1854 Ceded Territory include:

- Warming of annual temperatures by 3.7^{o}F;
- Warming of the minimum wintertime temperature by 6.8^{o}F;
- A 14.7% increase in precipitation occurring in the fall with significant decreases occurring in winter (-12%) and spring (-11%);
- Ice out dates occurring 2-5 days earlier on inland lakes;
- Longer freeze-free season.

The Ojibwe have noticed these changes and associated impacts to the ecosystems around the region. These observed changes are discussed in further detail throughout this report. Going forward, changes such as these are projected to continue and become more severe, possibly leading to detrimental impacts to the natural resources that are still central to the culture and lifeways of the Ojibwe people.

Given this, a need exists to understand the impacts climate change will have on resources in the 1854 Ceded Territory and within reservations, the resources that are most vulnerable to a changing climate, and what can be done to mitigate and/or adapt to the impacts. Climate change will disproportionately affect tribes because reservations and the 1854 Ceded Territory have geographically-defined boundaries that do not allow them to follow shifts or changes in the natural resources that may occur as the climate changes.

Developing a climate change vulnerability assessment for the 1854 Ceded Territory including the reservations helps identify which key resources (e.g. subsistence species) will be impacted by climate change. A climate change vulnerability assessment is an important step in developing adaptation strategies for each reservation and the 1854 Ceded Territory as it helps to determine which species or ecosystems are the most vulnerable to climate change. Once a vulnerability assessment is complete,

[2] Minnesota Office of the State Archaeologist. Contact Period. Website accessed 4.1.16: http://mn.gov/admin/archaeologist/public/mn-archaeology/contact-period

adaptation strategies can be created that outline how to adapt the most vulnerable treaty resources to projected changes in climate.

Given the importance of preparing for climate change, the 1854 Treaty Authority, Bois Forte Band of Chippewa, Fond du Lac Band of Lake Superior Chippewa, and Grand Portage Band of Lake Superior Chippewa engaged support from Adaptation International and the Great Lakes Integrated Sciences and Assessments to conduct a vulnerability assessment and aid in the development and customization of adaptation strategies. This report shares the results from this effort. Included within the report is an overview of observed and predicted climate changes (Section 3); an assessment of the risks to key natural resources (while realizing that all resources are important and interconnected) (Section 4); and a series of adaptation strategies to help species and ecosystems adapt to climate change (Section 4). The bands and 1854 Treaty Authority have an opportunity to continue to build on this project and ensure that all resources and people are more resilient to the projected changes in future climate.

3. Climate Change

3.1 Global Climate Change

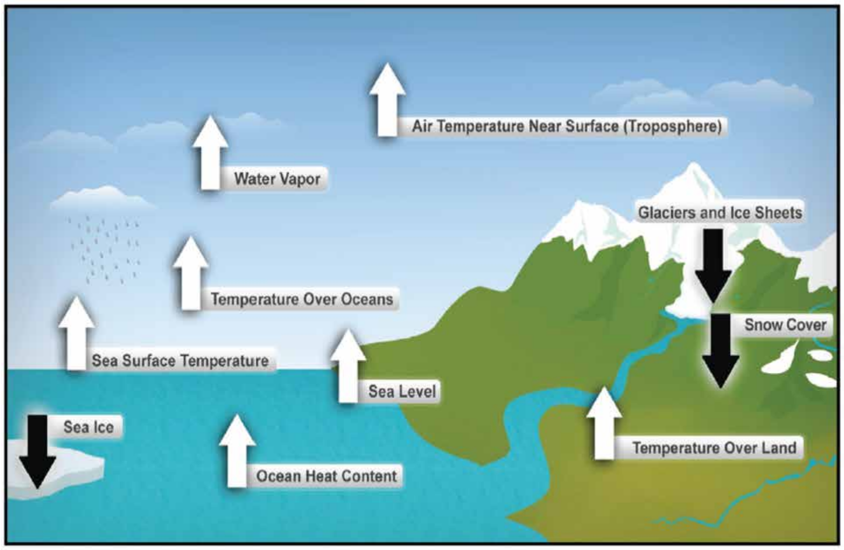

Figure 5: Some of the indicators showing that the Earth's climate is warming. White arrows indicate increasing trends while black arrows indicate decreasing trends.

Climate is a characterization of the long-term (typically several decades or longer) average weather for a particular area or region. When discussing climate and impacts to people and the lands they live on, scale matters. How climate is observed and experienced at global, regional, and local scales is very different, with different levels of certainty associated with projections of future change. Typically, when discussing climate at a global scale, one can speak with more certainty about trends and global-scale impacts.

According to the 2014 National Climate Assessment,[3] society is already observing many changes in the global climate. These changes are occurring from the top of the atmosphere all the way to the bottoms of the oceans, and everywhere in between. Globally, scientists and engineers have gathered evidence using a variety of platforms including: satellites, weather balloons, thermometers at surface stations, and many others to monitor the climate and weather of the planet. The sum of all these observations indicates that the planet is warming and that the warming experienced for at least the past fifty years, has been primarily due to human activities (Figure 5).[4, 5]

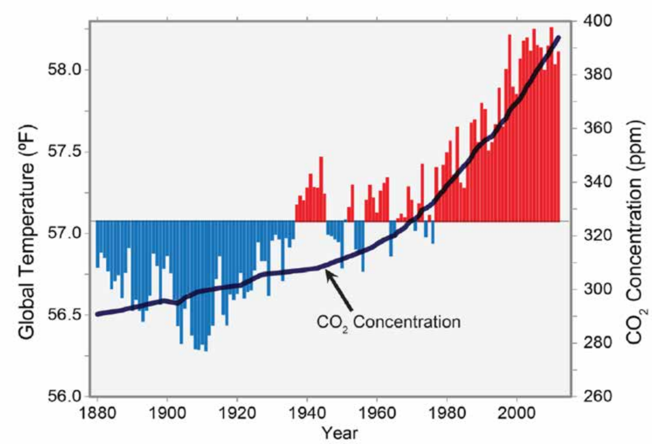

Figure 6: Variation in global temperature and CO_2 concentrations between 1880 and 2012. Red bars show temperature above the long-term average, while blue bars show temperatures below the long-term average. The black line shows atmospheric CO_2 concentrations in parts per million.

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[3] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

[4] ibid

[5] IPCC. 2007. Summary for Policymakers. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental *Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, Eds., Cambridge University Press, 1-18. [Available online at http://www.ipcc.ch/pdf/assessment-report/ ar4/wg1/ar4-wg1-spm.pdf]

Temperature

The most commonly discussed change in the global climate is annual average temperature. Between 1880 and 2012, global annual average air temperatures over land and oceans have increased by more than 1.5^{o}F (Figure 6*)*.[6, 7] This trend largely mirrors the rate at which carbon dioxide (CO_2) has been emitted into the atmosphere (Figure 6). Over the same period, an increase in water vapor in the lower atmosphere has been observed. This is expected in a warming climate, as a warmer atmosphere can hold more water.

Natural variations in short-term climate such as El Niño, La Niña, other ocean cycles, sunspot/solar cycles, and volcanic eruptions can affect global climate on timescales of up to a few decades. However, the changes observed in the past 50 years are far larger than can be accounted for by natural variability. Instead, greenhouse gas emissions from human sources are significantly affecting the global climate. The most common types of heat trapping gases and particulate matter altering the climate include: CO_2, methane, nitrous oxide, particulate matter such as black carbon(which have a warming influence), and sulfates(which have an overall cooling influence).[8]

Globally, climate is projected to continue to change over this century and beyond because of the quantity of greenhouse gases that have already been emitted. If all emissions from human-activities were to cease today, global mean temperatures would still increase by approximately 0.9°F over the next few decades.[9] Choices made today, however, will play a significant role in determining the amount of warming likely to be experienced in the later portion of the 21st century.[10] Given recent trends in global emissions, which have been rising, in this report we focus on a "high" emissions scenario (Special Report on Emissions Scenarios, Scenario A2: SRES A2) to help project what future climate conditions could be like (Figure 7). At this point in time, the high emissions scenario appears to be the most likely scenario through the 21st century, unless the present rates of global emissions are drastically curtailed.[11] Under this scenario, global mean temperature by mid-century is projected to increase by 3°F by 2050 and 7°F by 2100. Spatially, the greatest amount of warming is projected for the high latitude regions and the least in the equatorial regions and over the oceans.

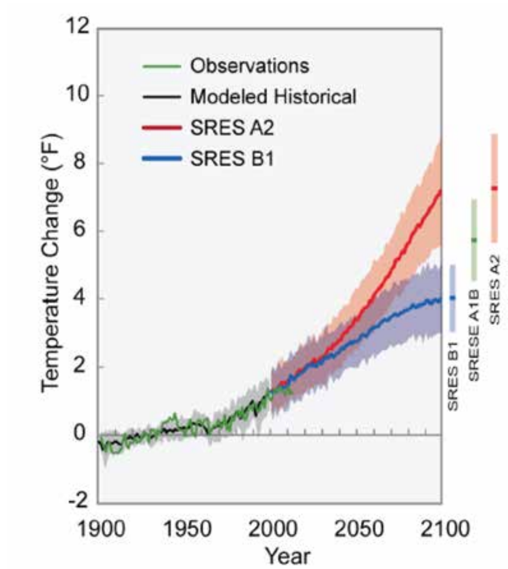

Figure 7: Global temperature change based on the amounts of heat trapping gases released to-date into the atmosphere and projections for future increases based on emissions scenarios. Until midcentury, there is little divergence between emissions scenarios in terms of projected temperature increases. In the last half of the 21st century, the SRES A2 scenario (high greenhouse gas emissions) shows global temperature increases of around 3^{o}F by 2050 and 7^{o}F by 2100 when compared to the average global temperature from 1901-1960.

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[6] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. V Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

[7] Karl, T. R., J. T. Melillo, and T. C. Peterson, Eds. 2009. Global Climate Change Impacts in the United States. Cambridge University Press, 189 pp. [Available online at http://downloads.globalchange. gov/usimpacts/pdfs/climate-impacts-report.pdf]

[8] Wigley, T. M. L., and B. D. Santer, 2013. A probabilistic quantification of the anthropogenic component of twentieth century global warming. *Climate Dynamics*, **40,** 1087-1102, doi:10.1007/s00382-012- 1585-8.

[9] Matthews, H.D. and K. Zickfeld, 2012. Climate response to zeriod emissions of greenhouse gases and aerosols. Nature Climate Change 2, 338-341.

[10] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

[11] Daniel Brown (GLISA), personal communication

Precipitation

Changes in precipitation are also projected over much of the globe under the various climate change scenarios (Figure 8). Globally, the increase in total precipitation is projected to be small by end of century, but there are projected to be substantial changes in how and where precipitation falls. Regions in the higher latitudes are projected to see increases, while much of the tropics (except for monsoonal areas, and the Inter Tropical Convergence Zone) are projected to see drier conditions. This is projected under both lower and higher emissions scenarios, though under the higher emissions scenario the changes are more amplified with more fluctuations in extremes.[12, 13]

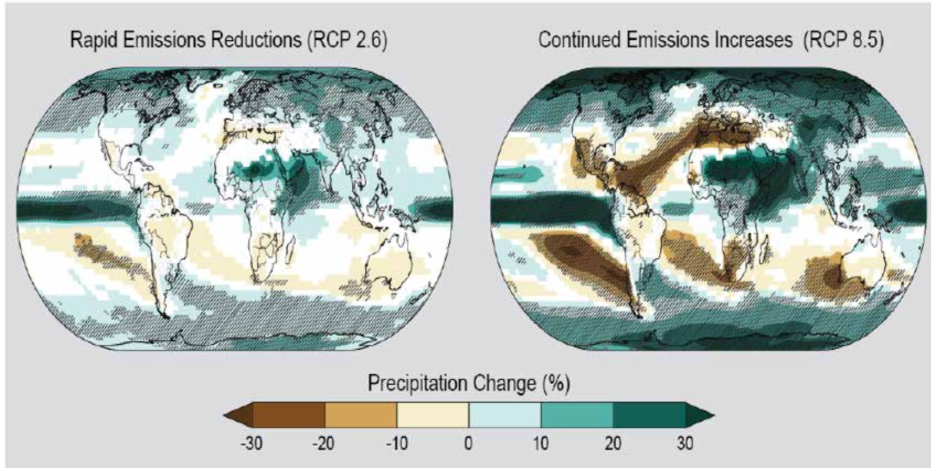

Figure 8: Projected changes in annual average precipitation over the period 2071-2099 (compared to 1970-1999), under a low emissions scenario (RCP 2.6; Representative Concentration Pathways) and a high emissions scenario (RCP 8.5). White areas on the maps are where projected changes may not be larger than those expected with natural variability. Note: The RCP scenarios are an update of the SRES (Special Report on Emissions Scenarios) scenarios primarily used in this report. The SRES scenarios are used here since the dynamic regional climate models have not yet incorporated RCP scenarios into their modeling.

3.2 Localized Climate Information for the 1854 Ceded Territory and Reservations

This section details historic and projected changes in climate for the 1854 Ceded Territory and the reservations. Importantly, there is often less certainty around climate trends at the local scale versus climate trends at regional or global scales. As such, projections at a local level should be viewed as having greater uncertainty than those at larger geographic regions. The 1854 Ceded Territory and Reservations cover portions of two climate divisions: most of Northeast Minnesota (NEM) and the northeast corner of East Central Minnesota (ECM).

Observed Temperature Trends

The area covered by the 1854 Ceded Territory has experienced notable increases in annual temperature, with marked variations between seasons (Table 3). Warming in the region has occurred across all seasons with the most significant warming occurring in the winter and spring. Annually, minimum temperatures over the area have increased faster than maximum temperatures. The difference in maximum and minimum temperature increase is most pronounced in the winter and summer seasons. During the fall and spring, maximum and minimum temperatures increased at approximately the same rate over the period 1950-2012. The rates of warming observed in NEM and ECM are generally faster than what has been observed over much of the Midwest, this is true for seasonal and annual trends.

[12] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

[13] Boberg, F., P. Berg, P. Thejll, W. Gutowski, and J. Christensen, 2009: Improved confidence in climate change projections of precipitation evaluated using daily statistics from the PRUDENCE ensemble. *Climate Dynamics*, 32, 1097-1106, doi:10.1007/s00382- 008-0446-y. [Available online at http://link.springer.com/content/ pdf/10.1007%2Fs00382-008-0446-y.pdf]

Table 3: Summary of observed climate change statistics for the Northeast and East Central climate divisions. Changes are for the period 1950-2012. Precipitation percentage is relative to the base period 1951-1980 (Data from NCEI Climate Divisions)

	Annual	Winter	Spring	Summer	Fall
Northeast Minnesota					
Avg. Temp.	+3.7°F	+5.8°F	+4.5°F	+2.1°F	+2.4°F
Max. Temp.	+3.5°F	+4.8°F	+4.6°F	+1.9°F	+2.4°F
Min. Temp.	+4.0°F	+6.8°F	+4.4°F	+2.4°F	+2.3°F
Precipitation	-2.3%	-12.0%	-11.0%	-5.4%	+14.7%
East Central Minnesota					
Avg. Temp.	+3.5°F	+5.9°F	+4.3°F	+1.5°F	+2.2°F
Max. Temp.	+3.2°F	+5.0°F	+4.4°F	+1.1°F	+2.1°F
Min. Temp.	+3.8°F	+6.7°F	+4.2°F	+1.9°F	+2.2°F
Precipitation	+6.1%	-2.4%	+7.1%	-3.6%	+27.2%

Observed Precipitation Trends

Annually, precipitation has decreased slightly in NEM, while it has increased in ECM (Table 4). Seasonally, precipitation has decreased during the winter, spring and summer in NEM. Fall in NEM has experienced a moderate increase in precipitation. ECM by contrast has experienced slight decreases in winter and summer precipitation; increases have been observed during spring and fall, with the latter being substantial. The observed changes in precipitation for NEM are different (i.e. decreasing annually, as opposed to increasing) than what much of the Midwest has experienced. Seasonally, the declines in spring for NEM and winter for NEM and ECM are opposite the regional trend.

While climate divisional data for snow are not available, Duluth, MN has one of the most complete snowfall/snow depth observation records in the region. Using this data, we find that Duluth has observed an approximate five-inch increase in annual snowfall since 1950. Seasonally winter and autumn have experienced increased total snowfall, while spring snowfall has declined. Average snow depth in Duluth has declined in winter and spring, while autumn snow depth has remained constant. The increases in snowfall seen in Duluth are less than areas directly downwind of Lake Superior in Wisconsin and Michigan (Figure 9).

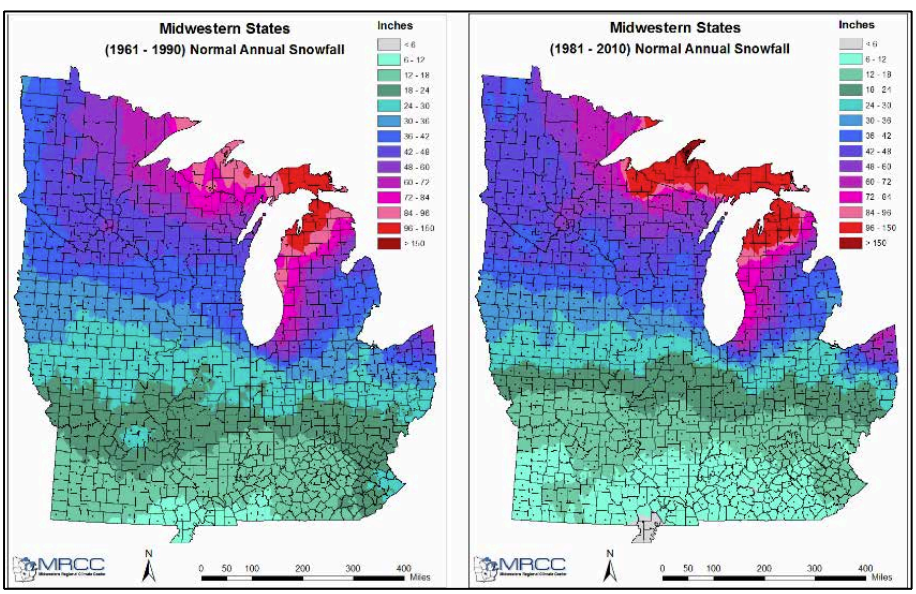

Figure 9: Mean season snowfall across the Midwest for 1961-1990 (left) and 1981-2010 (right). Image courtesy of the Midwest Regional Climate Center.

Increases in the intensity of extreme precipitation events (i.e., top 1% of all occurrences) have also been observed in recent decades across much of the Great Lakes region (Figure 10). This is of particular concern for urban environments with impervious land cover (i.e. asphalt and concrete) due to increased storm water and surface runoff. Due to the monthly time step of divisional data, extreme precipitation is difficult to discuss at the divisional level. Daily data from Duluth, MN comparing the period from 1951-1980 to 1981-2010, indicated no significant increase or decrease in the intensity and frequency of extreme precipitation events. Conversely, data from Cloquet, MN and near Grand Rapids, MN for the same period show that the intensity of extreme precipitation events has increased (14.2% and 10.2%, respectively). Overall, there is high spatial variability in the pattern of extreme precipitation trends in the region.

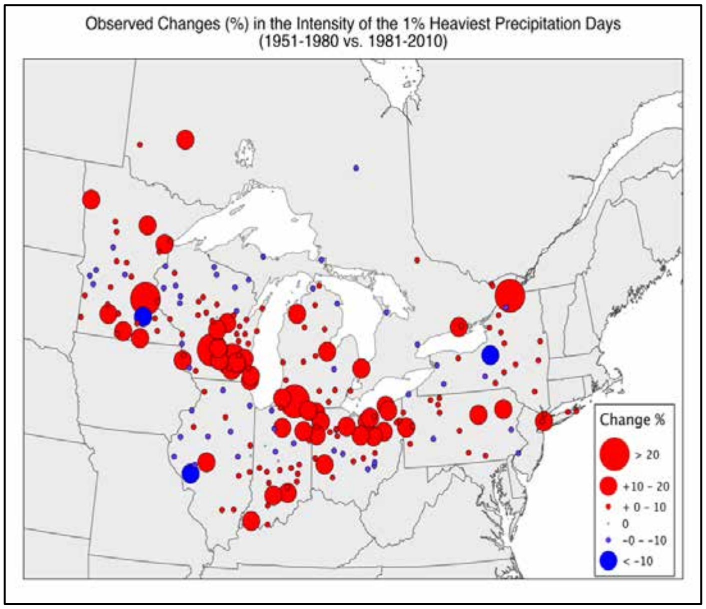

Figure 10:Map of extreme precipitation events. An analysis by the Great Lakes Integrated Sciences and Assessments found that the intensity of the top 1% of heavy rain events has increased in recent decades.

Observed Lake Trends

Great Lakes surface water temperatures have also risen in the region, most notably during the summertime (4.5°F from 1979-2006 for Lake Superior). Additionally, lake ice levels have declined during the winter (-76% areal coverage on Lake Superior from 1973-2010), though there is significant inter-annual variation.[14, 15] Increased water temperatures and ice cover declines have the potential to further alter the regional climate through increased evaporation and potential for increased lake effect snowfall, though these alterations are less intense on the windward side of the Great Lakes.[16] Inland lakes in the 1854 Ceded Territory have also seen earlier ice out dates in the spring with a study by the Minnesota State Climatology Office showing that, on average, ice out is occurring 2-5 days earlier in the 1854 Ceded Territory and that this trend has accelerated in recent decades (Figure 11).

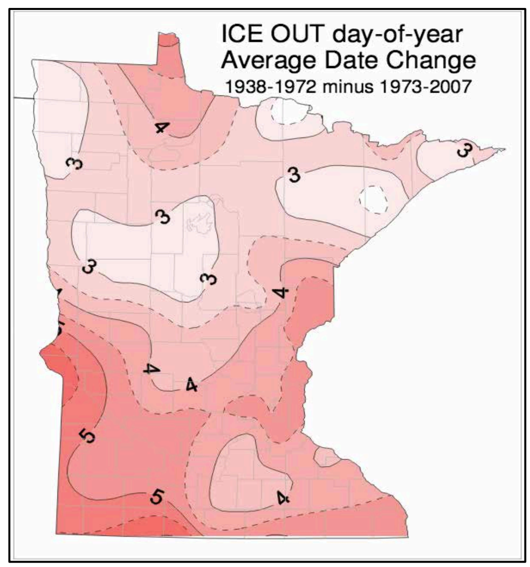

Figure 11: Observed change in average ice out date for Minnesota for 1973-2007 compared to 1938-1972. Image courtesy of the Minnesota State Climatology Office.

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[14] Wang, J., Bai X., Hu H., Clites A., Colton M., & Lofgren B. 2012. Temporal and Spatial Variability of Great Lakes Ice Cover, 1973-2010. Journal of Climate, 25, 1318-1329

[15] 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. *Geophysical Research Letters*, **34,** L06604, doi:10.1029/2006GL029021. [Available online at http://www.cee.mtu.edu/~reh/papers/pubs/non_Honrath/ austin07_2006GL029021.pdf]

[16] Lenters, J. D., J. B. Anderton, P. Blanken, C. Spence, and A. E. Suyker. 2013. Assessing the Impacts of Climate Variability and Change on Great Lakes Evaporation. In: *2011 Project Reports*. D. Brown, D. Bidwell, and L. Briley, eds. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center: http://glisaclimate.org/media/GLISA_Lake_Evaporation.pdf

Projections of Future Change

Projections of future climate for NEM/ECM are based largely on data from global and regional climate models. In the Midwest, the global climate models (GCMs) project a wider range of temperature and precipitation outcomes than the regional climate models (RCMs). Because no model perfectly simulates the physics that govern global, regional, and local climate, several models were consulted for this project (e.g., Coupled Model Intercomparison Project Phase 3 (CMIP3) and North American Regional Climate Change Assessment Program (NARCCAP) under SRES A2 emissions scenario) to describe potential climate changes in the Midwest and the 1854 Ceded Territory (Table 5). The SRES A2 scenario (high emissions scenario) was chosen for this analysis, since it is one of the most widely cited in the existing literature and because dynamically downscaled regional climate models for the Great Lakes are currently only available for the SRES scenarios. Using dynamically downscaled data in the Great Lakes is important, as it is the only way to truly take into account the physical properties of the Great Lakes in the model. As lake dynamics vary with temperature, this distinction is important in a warming climate, as lake-atmosphere interactions may be different in the future from what has been historically observed. Statistically downscaled models typically cannot do this, as they are based on historically observed relationships. Though statistically downscaled datasets that use the newer Representative Concentration Pathways (RCPs) are available, we chose the dynamically downscaled data for the previously stated reasons.

Table 4: Summary of projected climate changes for the Midwest with localized descriptions for the 1854 Ceded Territory. Projections include both Midwest averages and portions of two climate divisions: most of Northeast Minnesota (NEM) and the northeast corner of East Central Minnesota (ECM). Projections are for the higher (SRES A2) emissions scenario.

		Short Term (2021-2050)	Long Term (2041-2070)
Annual	**Temp.**	Midwest ranges from +1.5 to +4.5°F warming with an average around +3°F.	Midwest ranges from +3 to +5°F warming with an average around +4.5°F for NEM/ECM, though areas directly along Lake Superior exhibit slightly less warming. Warming is consistent across most of the Midwest.
	Precip.	Midwest ranges from -4% to +7% change.	Midwest ranges from -7% to +12% change. NEM/ECM is projected to see increases in the range of +3% to +12%.
Winter	**Temp.**	Midwest ranges from +2 to +5°F warming with an average around +3.5°F.	Midwest ranges from +3.5 to +7°F warming with the greatest warming in the north. NEM/ECM averages warming toward the top of that range (+5.0 to +6.0°F).
	Precip.	Midwest ranges from -3% to +15% change.	Midwest ranges from -3% to +17% change. Projections for the NEM/ECM project increases of +10% to +20%. Combined with temperature increases, more winter precipitation may fall as rain.
Spring	**Temp.**	Midwest ranges from +1 to +5°F warming with an average around +3°F.	Midwest ranges from +2 to +7°F warming. Spring has the smallest increases of any season. NEM/ECM averages +3.0 to +4.5°F, with the largest increases along the Lake Superior coast.
	Precip.	Midwest ranges from +2% to +10% change.	Midwest ranges from -5% to +15% changes in precipitation. NEM/ECM averages increases of +5% to +15%
Summer	**Temp.**	Midwest ranges from +1.5 to +5.5°F warming with an average around +3.5°F.	Midwest ranges from +2.5 to +9°F warming. The degree of warming for NEM/ECM is in the lower end of that range (+4 to +5°F). The least warming is projected in the NE portion of the 1854 Ceded Territory.
	Precip.	Midwest ranges from -13% to +11% change.	Midwest ranges from -23% to +19% changes in precipitation. NEM/ECM projections show little to no increase in projected summer precipitation (0% to +5%)
Fall	**Temp.**	Midwest ranges from +1.5 to +4.5°F warming with an average around +3°F.	Midwest ranges from +3 to +6.5°F warming. Projected warming for NEM/ECM is similar to much of the larger region (+4.5°F).
	Precip.	Midwest ranges from -4% to +7% change.	Midwest ranges from -8% to +12% changes in precipitation. NEM/ECM average increases between +10% to +20%. These are larger than much of the Midwest.
Extremes	**Temp.**		Days below freezing are projected to decrease across NEM/ECM by about three weeks per year. Days below 10°F are projected to decrease by 3.5 weeks. Days above 95°F are projected to stay the same or increase on average 0-10 days in NEM/ECM.
	Precip.		There is great uncertainty in extreme precipitation projections, but days with greater than 1-inch precipitation events are projected to increase (20% to 40%) in NEM/ECM and increase more in the northwest portion of the area. Most projections agree that the longest dry period for a year will decrease by 4 to 8 days in NEM/ECM.

Projected Temperature

On an annual and seasonal basis all models indicate warming temperatures, though models start to diverge from one another in mid- (2041-2070) to late-century (2070-2099) projections (Table 5 and Figure 12[17]). On average, annual temperatures across the Midwest are projected to increase by about 4.5°F by the mid-century. In the near term, temperature increases are projected to be less.

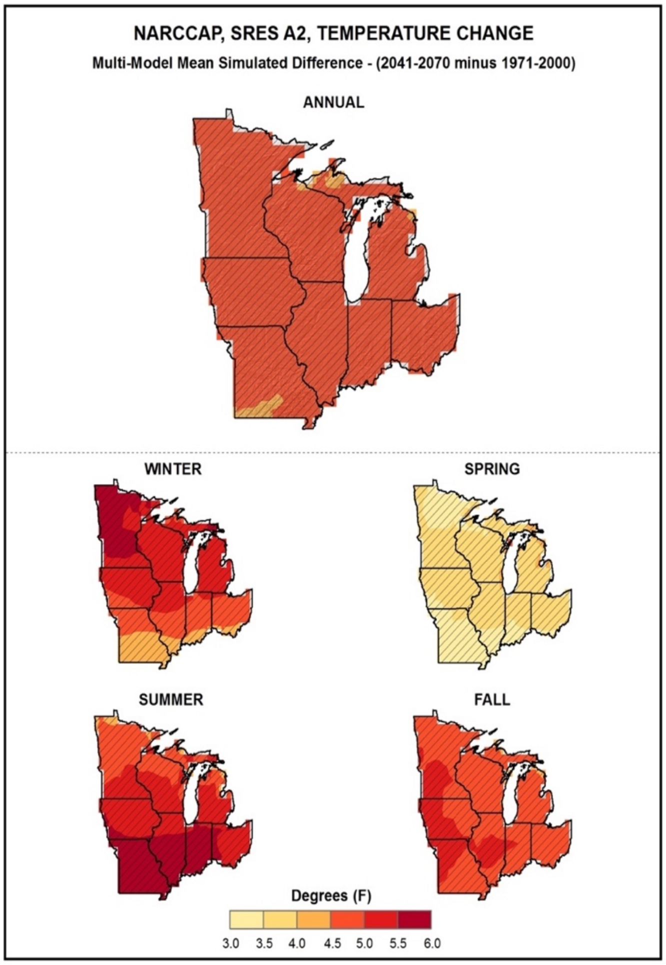

Figure 12: Projected annual and seasonal temperature changes for mid-century in the NARCCAP climate models. Cross-hatching indicates greater certainty in the projection, with hatched colors denoting more than 50% of the models used in the projections agree on a statistically significant change in the number of days and more than 67% of the models agree on the sign of the projected change.

Regional differences start to emerge when seasonal temperature changes are considered. In winter, the greatest warming is projected for the northern Midwest. Winter temperatures in NEM/ECM averaged across all regional models project an increase of about 5.5°F. Spring temperatures show the least amount of warming across the Midwest, but there is potential for slightly larger increases along many areas of the Lake Superior shoreline. Projected summer temperature increases across the Midwest range from 2.5°F to 9°F with the greatest increases in the south. Summer temperatures in NEM/ECM are projected to increase by 4.0°F to 5.0°F on average. Projected fall temperatures across the Midwest show increases of 3°F to 6.5°F. Fall increases in NEM/ECM average around 4.5°F.

In addition, the models project that there will be fewer cold days in the region with days below freezing projected to decrease by about three weeks in NEM/ECM by mid-century. Days with minimum temperatures less than 10°F are projected to decrease by three and a half weeks. The number of days with maximum temperatures above 95°F will likely either stay the same or increase in NEM/ECM by ten to fifteen days by mid-century. Larger increases are projected farther south in the Midwest. Consecutive days with maximum temperatures over 95°F are not projected to be a significant component of the climate in the 1854 Ceded Territory in the near future (e.g., next 15-20 years).

By mid-century the freeze-free season is projected to increase in NEM/ECM by about three weeks. These increases are slightly less than the Midwest average, particularly in the regions downwind of Lakes Michigan and Superior.

[17] Kunkel, K. E., M. A. Palecki, L. Ensor, D. Easterling, K. G. Hubbard, D. Robinson, and K. Redmond. 2009. Trends in twentieth-century U.S. extreme snowfall seasons. *Journal of Climate*, **22,** 6204-6216, doi:10.1175/2009JCLI2631.1. [Available online at http://journals.ametsoc.org/doi/pdf/10.1175/2009JCLI2631.1]

Projected Changes in Precipitation

Precipitation trends across the Midwest also vary depending on the season (Figure 13).[18] Northern parts of the Midwest, including the 1854 Ceded Territory, have the greatest projected average increase in precipitation. A major difference from the temperature projections discussed above is that the models are in less agreement about future precipitation amounts. Over most of the Midwest, less than half of the models agree on the direction (+/-) of precipitation changes. Model averages indicate increasing annual precipitation for NEM/ECM. Increases are projected for winter, spring, and fall, while summer precipitation is projected to be similar to present day or increase slightly; there is especially high uncertainty for summer projections. During summer the global climate models range from 20% reductions in precipitation to 20% increases in precipitation for the Midwest, and the regional models range from +/-10% changes. Fall projections have similar disagreements but to a lesser degree. Fall precipitation is projected to increase by 10% to 20% on average in NEM/ECM. Average spring precipitation projections across northern Minnesota show an increase of 5% to 15%.

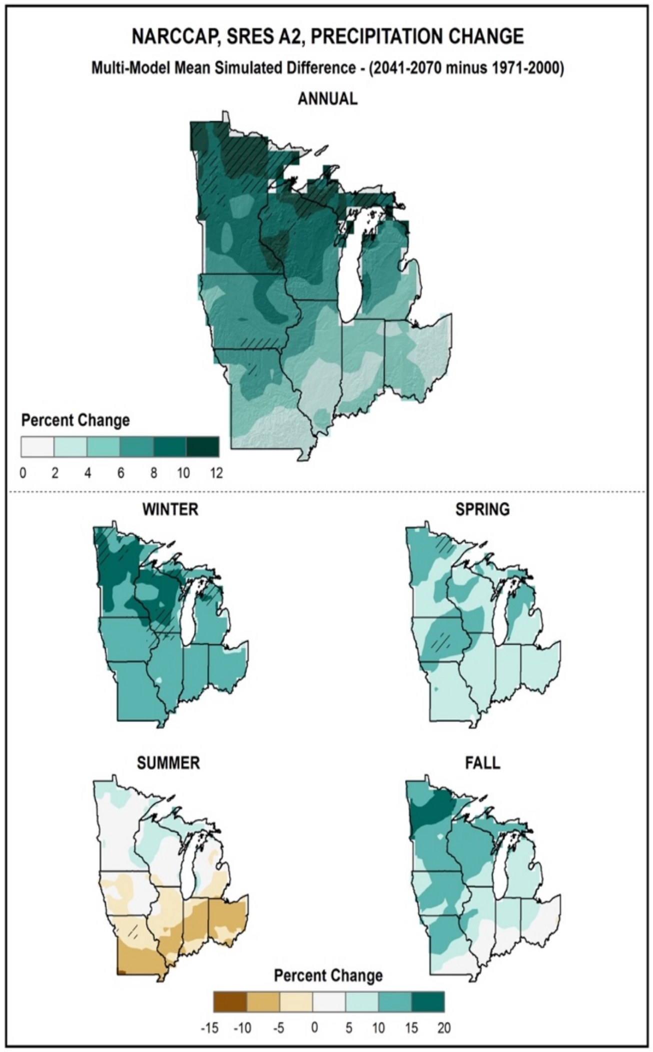

Figure 13: Projected annual and seasonal precipitation changes for mid-century in the NARCCAP climate models. Cross-hatching indicates greater certainty in the projection, with hatched colors denoting more than 50% of the models used in the projections agree on a statistically significant change in the number of days and more than 67% of the models agree on the sign of the projected change.

The last major projected change relates to extreme precipitation. However, projecting extreme precipitation events is challenging because the models do not simulate the intensity of individual events well. The majority of models agree that the number of days with greater than one inch of precipitation will increase in the future. The northeastern portion of Minnesota has a projected increase of 20-40% days with more than one inch of precipitation, which is greater than locations farther south in the Midwest (Figure 14).[19] In addition, most models agree that NEM/ECM is projected to experience a decrease in the number of consecutive dry days (4-8 fewer days) during the longest dry period in a given year. In contrast, central and southern portions of the Midwest are projected to see longer dry periods in the summer months.

[18] Kunkel, K. E., M. A. Palecki, L. Ensor, D. Easterling, K. G. Hubbard, D. Robinson, and K. Redmond. 2009. Trends in twentieth-century U.S. extreme snowfall seasons. *Journal of Climate*, **22,** 6204-6216, doi:10.1175/2009JCLI2631.1. [Available online at http://journals.ametsoc.org/doi/pdf/10.1175/2009JCLI2631.1]

[19] ibid

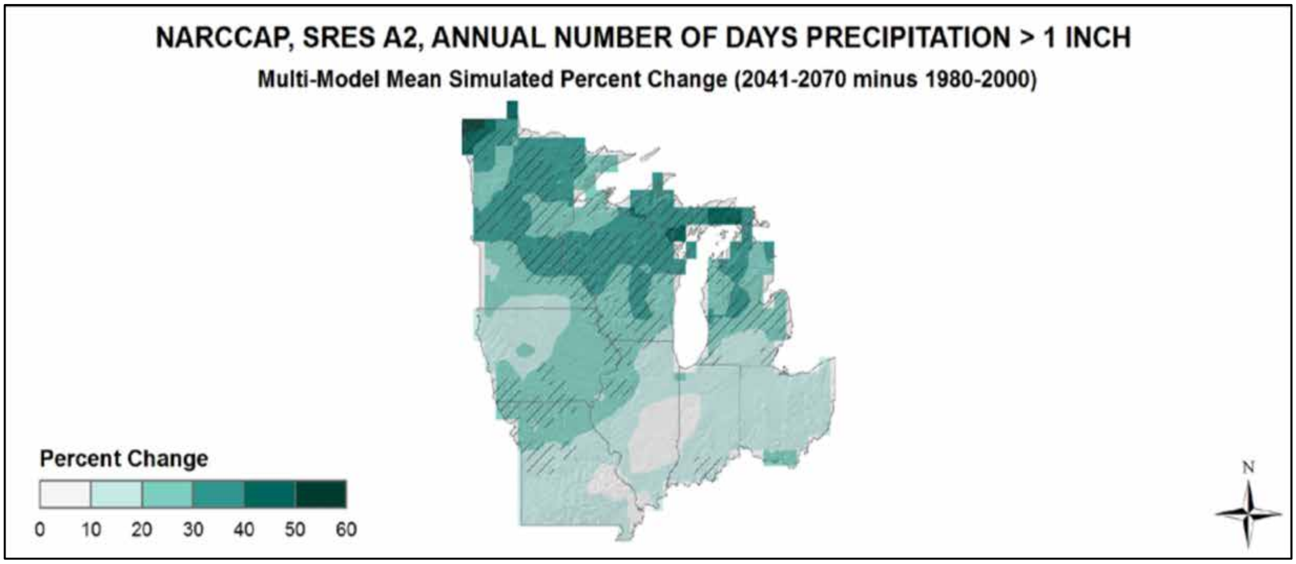

Figure 14: Projected change of days with greater than one inch of precipitation, NARCCAP SRES A2 Scenario for the2050s (2041-2070). Cross-hatching indicates greater certainty in the projection, with hatched colors denoting more than 50% of the models used in the projections agree on a statistically significant change in the number of days and more than 67% of the models agree on the sign of the projected change.

4. Vulnerability Assessment and Adaptation Actions

Understanding how the climate may change is a key step in determining what local impacts may occur and how best to prepare for those impacts. Using projected climate information discussed in chapter 3, this chapter explores how key natural resources within the 1854 Treaty Authority and the Bois Forte, Fond du Lac, and Grand Portage bands of Chippewa can be used to better prepare for those changes.

4.1 Vulnerability Assessment and Action Prioritization Process

A vulnerability assessment is a tool that allows decision-makers to make a comparison about how climate change could affect different systems or species of concern and prioritize areas for action. At its core, vulnerability is composed of three elements: *exposure*, *sensitivity*, and *adaptive capacity*. ***Exposure*** refers to the "nature and degree to which a system [or species] is exposed to significant climatic variations."[20] ***Sensitivity*** is defined as "the degree to which a system [or species] is affected, either adversely or beneficially, by climate-related stimuli."[21] ***Adaptive capacity*** refers to "the ability of a system [or species] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences."[22] The collaborative vulnerability assessment process used in this project was comprised of 14 steps:

1) A core team, composed of key tribal staff members from the 1854 Treaty Authority and the Bois Forte, Fond du Lac, and Grand Portage Bands of Chippewa, was created to help guide the project.
2) The core team identified 9 areas (discussed below) that would be the focus of this vulnerability assessment and adaptation plan.
3) Subject matter experts in each of the nine focus areas were identified from tribal staff and asked to serve as advisors to the project.
4) Calls were scheduled with subject matter experts to identify the key species or ecosystems within each of the nine categories (e.g., what species of fish did they want to be the focus of the assessment) and discuss: 1) how changes in climate and weather are already affecting these key species; 2) how projected changes in climate and weather could affect these key species; 3) what kind of capacity these key species have to adapt; and 4) what potential adaptation actions exist to help these key species adapt.
5) Results from the expert calls were combined with a literature review to identify how climate change could affect these species or systems of concern.
6) Building off the information gathered in steps 4 and 5, the core team participated in a day-long collaborative vulnerability assessment workshop. In this workshop, they identified the sensitivity and adaptive capacity of each key species or ecosystem of concern. Figure 15 presents the criteria used to score sensitivity and adaptive capacity.

Sensitivity Levels	
S0	System will not be affected by the impact
S1	System will be minimally affected by the impact
S2	System will be somewhat affected by the impact
S3	System will be largely affected by the impact
S4	System will be greatly affected by the impact

Adaptive Capacity Levels	
AC0	System is not able to accommodate or adjust to impact
AC1	System is minimally able to accommodate or adjust to impact
AC2	System is somewhat able to accommodate or adjust to impact
AC3	System is mostly able to accommodate or adjust to impact
AC4	System is able to accommodate or adjust to impact in a beneficial way

Figure 15: Climate sensitivity (left) and adaptive capacity (right) levels assigned to species and ecosystems of concern.

[20] Intergovernmental Panel on Climate Change. ND. Glossary. https://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf
[21] ibid
[22] ibid

7) The results from Step 6 were combined into a relative vulnerability ranking, which was then mapped for all species and ecosystems of concern (Figure 16).

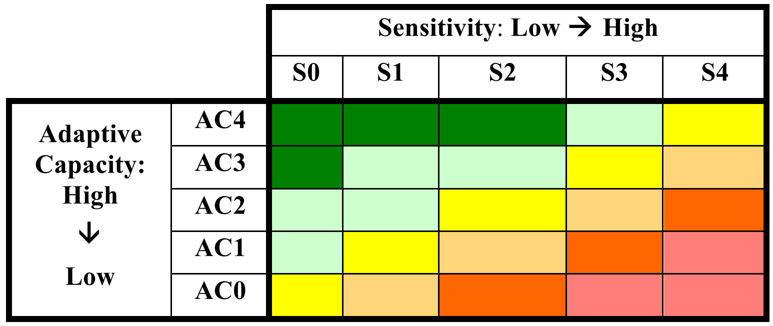

Figure 16: Relative vulnerability matrix based on climate sensitivity and adaptive capacity assessment. Warmer colors (orange and red) represent higher vulnerability and cooler colors (yellow and green) represent lower vulnerability.

8) Core team members and subject matter experts reviewed the relative rankings and provided edits as necessary.
9) A written summary of the historic and projected impacts and general adaptation strategies for each of the key species or ecosystems of concern were created (sections 4.3-4.12) and shared with core team members and subject matter experts for review and refinement.
10) The core team then selected 11 species or ecosystems to focus on for the development of customized adaptation actions that can be used to increase climate resilience. Project partners realize that all resources are important and inter-connected, but time and budget provided limitations on developing detailed adaptation strategies for all species. Adaptation actions have been provided for all resource categories but to varying levels of detail.
11) The core team along with subject matter experts and representatives from the Great Lakes Indian Fish and Wildlife Commission participated in another day-long collaborative workshop to develop detailed adaptation actions for each of these 11 species and ecosystems.
12) Detailed adaptation strategies drafted at the workshop were shared with a small subset of subject matter experts for review.
13) The final recommended actions for the 11 focus species or ecosystems were then developed (specifically for air quality, paper birch, boreal wetlands, lake sturgeon, culturally significant plants (two groups), moose, sugar maple, walleye, water quality and quantity, and wild rice) in order to provide detailed next steps for how to start building resilience to climate change within the 1854 Ceded Territory and reservations.
14) The final plan was shared with all core team members and subject matter experts for review and comment. Edits were integrated into this revised plan.

4.2 Key Focus Areas

Core team members and subject matter experts identified 31 species, groups of species, and ecosystems for the vulnerability assessment process. Based on the results of this assessment, four species were broken out of their primary category because of nuances in their relative vulnerability. These 4 species include: berries (broken into bog species and non-bog species), birds and waterfowl (broken into climate winners/neutral and climate losers), culturally significant plants (broken into Labrador Tea and all other plants), and furbearers (broken into climate winners/neutral and climate losers). Because of this, Figure 17 indicates the sensitivity and adaptive capacity and vulnerability of 35 species/ecosystems.

After completing the vulnerability assessment, the core team selected 11 species or ecosystems (including the two groupings of culturally significant plants) for which they developed detailed and customized adaptation strategies. While these 11 species (shown in bold in Figure 17) had more time and effort dedicated to the development of customized adaptation strategies, initial adaptation actions were identified for all species and ecosystems included in Figure 17.

		Sensitivity: **Low → High**				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity: High ↓ Low	**AC4**	• Black Crappie	• Berries (w/o Bog Species) • White-Tailed Deer			
	AC3		• Bald Eagles • Wolves • Birds and Waterfowl (turkey, duck, pheasants, geese)	• **Air Quality** • **Walleye** • Northern Pike	• **Sturgeon** • Eastern White Pine • Furbearers (beaver, black bear, bobcat, coyote, fisher, fox, mink, muskrat, river otter) • Northern Red Oak, Bass Wood, and Chokecherry	
	AC2			• **Culturally Significant Plants** • **Sugar Maple** • Black Ash • Resource Access • Shrub Wetlands	• **Wild Rice** • **Labrador Tea (Culturally Significant Plant)** • Berries	• Quaking Aspen
	AC1			• Culturally Significant Places	• **Water Quality and Quantity** • Birds and Waterfowl (ruffed grouse, spruce grouse, loons, swans) • Cisco • Furbearers (lynx, American marten, snowshoe hare) • Lake Trout • Whitefish	• **Moose** • Brook Trout • Vernal Pools
	AC0					• **Paper Birch** • **Boreal Wetlands** • Northern White Cedar

Figure 17: Relative vulnerability rankings for each of the 35 species and ecosystems analyzed as part of this project. Table ranges from low vulnerability (green) to high vulnerability (red). Bolded species and ecosystems were selected as the initial focus species for the development of detailed adaptation strategies as part of this project.

4.3 Air Quality – Focus Topic

Adaptive Capacity: High ↓ Low		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
	AC4					
	AC3			• Air Quality		
	AC2					
	AC1					
	AC0					

Ashkaaniman Biininesewin!
Let us breathe clean air!

The air quality of a region can be a measure of how a community is thriving. Efforts to improve air quality demonstrate how a community is protecting its most sensitive populations and the natural land, as well as how it attempts to balance economic growth and development with protection of public welfare. To this end, the Bois Forte, Fond du Lac, and Grand Portage bands and 1854 Treaty Authority within the 1854 Ceded Territory recognize the need to safeguard the natural land and people living in the region from the effects of exposure to poor air quality.

Despite efforts such as air quality monitoring and educational programs, vulnerability to poor air quality still exists within the 1854 Ceded Territory and reservations and is likely to become worse due to climate change. According to the National Climate Assessment, "*Because air pollutants and greenhouse gases share common sources, particularly from fossil fuel combustion, actions to reduce greenhouse gas emissions also reduce air pollutants*"[23]. Of specific concern in the 1854 Ceded Territory will be increases in wildfires, which will impact both visibility and human health; ozone pollution and associated cascading effects on human health and impacts to plant species; and extreme heat events resulting in impacts to public health. Acid rain, which has secondary linkages to climate change, is another air quality-related concern for the region.

These air quality impacts have cascading economic and cultural implications for the 1854 Ceded Territory and reservations. For example, decreasing visibility can change the cultural and historic connections to the land. The degradation of forests and plants resulting from acid rain or ozone further curtails the ability of band members to maintain subsistence lifestyles. Additional impacts on subsistence may occur as crops or first foods become degraded due to acid rain or increases in ground-level ozone.

From a human health perspective, climate change could significantly affect the most vulnerable populations in the 1854 Ceded Territory and on the reservations. The region's population is aging, with high levels of respiratory illness resulting from things such as substandard housing (mold, etc.) and other chronic conditions (asthma, chronic obstructive pulmonary disease).[24] While not pervasive, some elderly, youth, and other vulnerable populations within the 1854 Ceded territory and reservations have limited access to healthcare or air conditioning, which could be used to help decrease the effects of extreme heat events.[25] Finally, increases in particulates affecting visibility and ozone can cause significant health impacts to the most vulnerable band members such as youth, elderly, those with respiratory ailments, and outdoor workers or athletes.

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[23] Jacoby, H. D., A. C. Janetos, R. Birdsey, J. Buizer, K. Calvin, F. de la Chesnaye, D. Schimel, I. Sue Wing, R. Detchon, J. Edmonds, L. Russell, and J. West, 2014: Ch. 27: Mitigation. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 648-669. doi:10.7930/J0C8276J.

[24] Air quality subject matter experts within the 1854 Ceded Territory

[25] Air quality subject matter experts within the 1854 Ceded Territory

Visibility

Poor air quality impacts visibility because pollutants cause a "haze" due to the presence or formation of particles and other pollutants, which absorb and scatter sunlight.[26] Some of these particles are naturally formed (dust, particulates from wildfires) while others result from human activities (combustion of fossil fuels in cars or power plants, or industrial sources).[27] This particulate pollution can be emitted directly from wildfires in the form of organic carbon or can form as a secondary pollutant by interacting with sulfur dioxide (SO_2) and nitrous oxides (NO_x) emissions in the atmosphere.[28] According to the U.S. Environmental Protection Agency, "*The largest sources of SO_2 emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%).*"[29] Similarly, although NO_x is present in the atmosphere naturally, industrial/human activities are increasing its presence.[30] Thus, human activities are increasing the presence of SO_2 and NO_x in the atmosphere, meaning there is a greater likelihood of particulate pollution forming. Visibility is also affected by climate change during longer periods of drought and warmer temperatures, particularly during the summer where temperatures are projected to increase 4°-5°F by the middle of the century. These changes can also increase wildfire frequency, intensity, and size,[31] further increasing the presence of particulate pollution.

Figure 18: Air quality alerts were issued in the Duluth region in early May 2016 due to wildfires in Ontario. Source: northernlandsnewscenter.com

Of all the particulate matter, $PM_{2.5}$, or particulates 2.5 micrograms in diameter or smaller, are the largest regional contributor to reduced visibility.[32] $PM_{2.5}$ impacts human health because these tiny particles can bypass the body's natural systems of defense and move into the bloodstream, forcing the body to interact with the complex chemicals adhered to them.[33] Exposure to these micro-particles has been shown to increase morbidity and mortality, especially among sensitive populations, which include children who have decreased lung function,[34] people over the age of 65, people with existing lung or other chronic illnesses, low income populations, and those whose have outdoor occupations.[35] Although climate changes will decrease visibility, what will happen to levels of particulate matter, in particular relative to human health exposure, is less clear. Part of the reason for this uncertainty is that factors such as regional meteorology, local weather, land use patterns, socio-economic variables, and others directly interact to determine levels of local particulate pollution.[36]

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[26] National Park Service, 2016. Visibility Effects of Air Pollution. *Retrieved from:* http://nature.nps.gov/air/aqbasics/visibility.cfm

[27] United States Environmental Protection Agency, 2016. Visibility and Regional Haze. *Retrieved from:* http://www3.epa.gov/visibility/index.html

[28] Koerber M. January 31, 2007. Regional Haze in the Upper Midwest: Summary of Technical Information. Lake Michigan Air Directors Consortium. *Retrieved from:* https://www.pca.state.mn.us/sites/default/files/haze-0107-koerber.pdf

[29] United States Environmental Protection Agency, 2016. Sulfur Dioxide. *Retrieved from:* https://www3.epa.gov/airquality/sulfurdioxide/

[30] United States Environmental Protection Agency, 2016. Overview of Greenhouse Gases. *Retrieved from:* https://www3.epa.gov/climatechange/ghgemissions/gases/n2o.html

[31] Liu, Y., J. Stanturf, and S. Goodrick, 2010: Trends in global wildfire potential in a changing climate. *Forest Ecology and Management*, **259**, 685-697, doi:10.1016/j.foreco.2009.09.002

[32] Fond du Lac Band of Lake Superior Chippewa, 2016. Environmental Air Monitoring. *Retrieved from:* http://www.fdlrez.com/RM/airmonitor.htm

[33] American Lung Association, 2013. State of the Air Report. *Retrieved from:* http://www.stateoftheair.org/2013/health-risks/health-risks-particle.html#ref28

[34] Ostro B, Roth L, Malig B, and Marty M. The Effects of Fine Particle Components on Respiratory Hospital Admissions in Children. *Environmental Health Perspectives,* 2009, 117 (3), 475-480.

[35] American Lung Association, 2013. State of the Air Report. *Retrieved from:* http://www.stateoftheair.org/2013/health-risks/health-risks-particle.html#ref28

[36] Jacob, Daniel J., and Darrel A. Winner. 2009. Effect of climate change on air quality. Atmospheric Environment 43(1): 51-63.

Ozone

Ozone (O_3) formation and prevalence is affected by temperature.[37] With projections for the region of increases in average annual temperatures by 4°-5°F by the middle of the century, it is expected that ozone formation will also increase, leading to a number of potentially significant health implications. According to the Climate Change Resource Center, a collaboration between the U.S. Department of Agriculture and the U.S. Forest Service, ozone is considered "*the most important phytotoxic (directly toxic to plants) air pollutant affecting growth and health of forests and agricultural crops*."[38] Ozone affects the ability of plants and trees to produce and store food and injures their leaves resulting in visible damage to the plants. Further, plants are left more susceptible to other impacts such as insect infestations, increases in extreme weather and ecosystem changes,[39] all of which are projected to occur more frequently due to climate change.

The scientific community has recognized for years that ozone is a harmful contaminant to human health. According to the United States Environmental Protection Agency, exposure to ozone can:

> "*Make it more difficult to breathe deeply and vigorously; cause shortness of breath and pain when taking a deep breath; cause coughing and sore or scratchy throat; inflame and damage the airways; aggravate lung diseases such as asthma, emphysema, and chronic bronchitis; increase the frequency of asthma attacks; make the lungs more susceptible to infection; and continue to damage the lungs even when the symptoms have disappeared.*"[40]

As previously summarized for health effects of particulate matter, sensitive populations are more vulnerable to ozone exposures.

Extreme Heat Events

Extreme heat events are defined differently depending on the region of the country being considered. The US EPA defines extreme heat events as "*periods of summertime weather that are substantially hotter and/or more humid than typical for a given location at that time of year.*"[41] The public health effects of exposure to extreme heat are well understood and include:

- Increases in heat-related morbidity (cramps, rash, exhaustion, fainting, stroke); and
- Increases in heat-related mortality (cardiovascular disease, renal failure, respiratory deaths, strokes).[42]

When considering the public health impacts of exposures to extreme heat, protection of the most vulnerable populations is critical. Vulnerable populations include the elderly, young children, pregnant women, outdoor workers, the chronically ill, those without access to healthcare, low-income people, and homeless populations.

Acid Rain

Acid rain results when the by-products of combustion, namely SO_2 and NO_x, are released into the atmosphere and interact with other atmospheric gases. Eventually these particles dissolve in water and

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[37] United States Environmental Protection Agency, 2016. State and Local Climate and Energy Program. *Retrieved from:* http://www3.epa.gov/statelocalclimate/local/topics/air-quality.html

[38] Climate Change Resource Center, 2016. Air Pollution. *Retrieved from:* http://www.fs.usda.gov/ccrc/topics/air-pollution

[39] United States Environmental Protection Agency, 2016. Ecosystem Effects of Ozone Pollution. *Retrieved from:* https://www.epa.gov/ozone-pollution/ecosystem-effects-ozone-pollution

[40] United States Environmental Protection Agency, 2016. Ozone Pollution. *Retrieved from:* http://www3.epa.gov/ozonepollution/health.html

[41] Centers for Disease Control and Prevention, 2015. Climate Change and Extreme Heat Events. *Retrieved from:* http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf

[42] United States Environmental Protection Agency, 2015. Climate Impacts on Human Health. *Retrieved from:* http://www.epa.gov/climatechange/impacts-adaptation/health.html#impactsheat

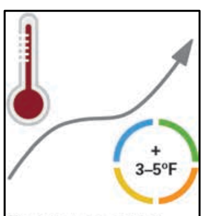
return to the earth in the form of precipitation (rain or snow).[43] SO_2 is typically a by-product of burning coal or oil in power plants, while nitrous oxides (NO_x) are generally the result of combustion of fossil fuels in transportation fuels. NO_x emissions are also a precursor to the formation of ozone as they interact with sunlight to form ground level ozone.

Acid rain affects infrastructure through the degradation of bridges and buildings, and it is generally understood that acid rain can cause injury or death to forest ecosystems and significantly degrade soil.[44] According to the Intergovernmental Panel on Climate Change, "*Policies and management techniques introduced to protect human health, improve visibility, and reduce acid rain will also affect the concentrations of aerosols relevant to climate*."[45] That is to say that although acid rain is not directly affected by a changing climate, efforts to decrease combustion of fossil fuels, which are also the primary causes of acid rain, help to limit climate change and decrease the prevalence of acid rain.

4.3.1 Climate Threats to Air Quality

Existing Conditions: According to discussions with subject matter experts, increasing temperatures have already exacerbated impacts to human health including increasing respiratory effects and heat stress for vulnerable populations. Additionally, increased ozone levels have caused and exacerbated asthma and other breathing issues among band members, especially those with preexisting conditions. Further, hot and dry weather has increased wildfire risk, leading to decreased air quality during wildfire events. Changes in weather have impacted growing seasons, which create longer pollen seasons in the region, and extreme precipitation events have increased flooding, resulting in increased exposure to indoor and outdoor molds.

Projected Climate Related Impacts: Annual temperatures are projected to increase 3°F to 5°F by the 2050s. Increasing temperatures will likely decrease visibility, increase ozone, and make extreme heat events more frequent. Visibility and ozone impacts will worsen because of the increase in temperature/heat available to interact with other pollutants to produce ground level ozone or "haze." Temperature and heat stress impacts will worsen as the number of days expected to be above 95°F increases. As temperatures increase so will the need for air conditioning, which could increase the demand and use of fossil fuels. The related increase in SO_2 and NO_x emissions could increase the amount of acid rain, greenhouse gases such as ozone, and particulate pollution. Concentrations of particulate matter can also be expected to increase, both due to emissions of organic carbon from forest fires and from the creation of secondary particulates from SO_2 and NO_x.



The average annual temperature is projected to increase by 3–5°F

4.3.2 Air Quality Vulnerability Assessment Results

Based on the collaborative discussion and analysis of this information, air quality will be somewhat affected (negatively) by changing climate conditions (S2) but band members will likely be mostly able to accommodate or adjust to those impacts (AC3). Thus, decreases in ***air quality are a low vulnerability*** for the band members within the 1854 Ceded Territory and on reservations.

[43] United States Environmental Protection Agency, 2016. Causes of Acid Rain. *Retrieved from:* http://www3.epa.gov/region1/eco/acidrain/causes.html
[44] United States Environmental Protection Agency, 2016. Effects of Acid Rain-Forests. *Retrieved from:* http://www3.epa.gov/acidrain/effects/forests.html
[45] Penner, J.E. *Aerosols and Their Direct and Indirect Effects*. Intergovernmental Panel on Climate Change, 2016. p. 292 Retrieved from: http://www.grida.no/climate/ipcc_tar/wg1/pdf/tar-05.pdf

4.3.3 Customized Adaptation Strategies for Air Quality

The following proposed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of the 1854 Ceded Territory and reservations.

<table>
<tr><th colspan="2">Adaptation Strategies to Address Climate Change Impacts to Air Quality</th></tr>
<tr><td>Collaboration</td><td>
• Collaborate with public health colleagues to ensure that they are aware of and planning for a climate-altered future (all categories of air quality impacts).
• Coordinate/network with agencies that are monitoring air quality so that air quality risks can be communicated directly to band members (all categories of air quality impacts).
• Make sure climate change is integrated into emergency response plans (all categories of air quality impacts).
• Continue to coordinate with state, federal, and tribal agencies to monitor and educate about regional haze (visibility, ozone).
• Increase coordination between and work with local, state, and federal agencies to monitor, regulate and enforce air pollution standards (all categories of air quality impacts).
• Modify emissions reduction plan (e.g., regional air quality attainment plans and the State Implementation Plan) to account for the increase in air pollution attributable to climate change (all categories of air quality impacts).
• Work to develop strategies/policies to decrease emissions with the U.S. EPA, state, and local representatives (all categories of air quality impacts).
</td></tr>
<tr><td>Conservation, Preservation, and Maintenance</td><td>
• Retrofit housing vulnerable to flooding to help eliminate the risk for flooding and risk of mold (indoor air quality).
• Secure clean-up capital/rehabilitation funding after a flood event and use it to invest in more resilient housing and businesses (indoor air quality).
• Conduct home inspections to assess the risk of mold and secure dollars from mold remediation, possibly from HUD (indoor air quality).
• Implement EPA's practical guidance for improving or maintaining indoor environmental quality during home energy upgrades or remodeling in single-family homes and schools. Details found: https://www.epa.gov/indoor-air-quality-iaq/protect-indoor-air-quality-your-home (indoor air quality).
• Establish a network of cooling stations (extreme heat).
  o Establish and staff air-conditioned buildings open to tribal members during extreme heat events.
  o Provide a free shuttle service from areas with identified vulnerable populations or from central public spaces (parks, libraries, etc.) to cooling centers.
  o Dispatch teams of mobile nurses or outreach workers to provide water and fans or other cooling equipment to members or areas identified as being especially vulnerable.
  o Create neighborhood-level communication network to inform residents of location and directions to the nearest cooling center, and coordinate transportation to those centers for limited-mobility residents during extreme heat events.
  o Collaborate with tribal members to identify suitable locations for cooling centers, develop effective messaging to notify members, conduct outreach, and plan appropriate activities for members at centers.
• Protect, maintain, and enhance the tree canopy (all categories of air quality impacts).
• Work to decrease point-source (i.e. coal-fired power plant or other smokestack) exposures in the region (all categories of air quality impacts).
• Intensify efforts to reduce ozone-precursors through mitigation programs that reduce driving and emissions from power plants (ozone).
</td></tr>
</table>

	• Strengthen long-term air quality planning and implement short-term measures such as discouraging engine idling and incentives to reduce emissions from mobile sources during heat waves *(all categories of air quality impacts)*. • Reduce the region's carbon footprint. Undertake strategies such as *(all categories of air quality impacts)*: o Building energy efficiency programs and retrofits to reduce energy consumption, energy expenditures, and reduce greenhouse gas emissions; o Revise building codes and design guidelines to consider and mitigate air quality impacts; o Expand the portfolio of energy sources for power to include alternative source (wind, solar) and move towards carbon neutrality; and o Low-carbon transportation options.
Education	• Educate the public on the need to reduce greenhouse gas emissions through things such as smart transportation planning, energy efficiency projects, renewable energy installations, and others *(all categories of air quality impacts)*. • Make sure that heat alerts are very clearly advertised to the public through venues such as websites, social media, and potentially an air quality flag system (e.g., EPA has a similar program) *(all categories of air quality impacts)*. • Continue and expand educational campaigns relative to air pollution exposure due to poor indoor air quality, wildfires, local, and regional air pollutants *(all categories of air quality impacts)*. • Educate the public about the potential risk of wildfire, including the release of particulates and how they can impact public health, and what protective measures to take. As part of this campaign, highlight the value of activities such as the use of fire resistant building materials and keeping vegetation and trees a minimum distance from houses *(all categories of air quality impacts)*. • Develop early warning systems for extreme heat events. This includes building a system to identify and alert the public when projected heat conditions pose a health risk *(extreme heat)*. • Educate at-risk groups and their caregivers to detect signs and symptoms and prevent heat-related illness. Emphasize the importance of immediate medical assistance for heat-related illness *(extreme heat)*.
Monitoring and Assessment	• Continue to monitor heat and humidity (*extreme heat*). • To the extent possible, monitor trends in forest condition and climate to proactively identify areas with high susceptibility to wildfire and conduct studies of specific implications of climate change scenarios on frequency and magnitude of fire. If not possible, work to stay abreast of efforts other agencies or departments are doing in this area (*all categories of air quality impacts*). • Continue monitoring surface ozone, mercury, and particulate matter *(all categories of air quality impacts)*.

4.4 Aquatic and Terrestrial Plants

Many species of both aquatic and terrestrial plants play a significant and substantial role in the lives and culture of band members.

		Sensitivity: Low → High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity: High ↓ Low	**AC4**		• Berries (non-bog species)			
	AC3					
	AC2			• **Culturally Significant Plants (not Labrador Tea)**	• **Wild rice** • Berries (bog species) • **Labrador Tea**	
	AC1					
	AC0					

Traditional knowledge and uses of these plants extend back countless generations, prior to written accounts of history, and are incorporated into every aspect of tribal culture in some respect.[46] Many of these plants provide sustenance or medicinal value, but also have important cultural connections through storytelling, ceremonies, harvesting, processing, and sharing.[47] Many plants also provide a resource for sheltering wildlife and provide building materials for humans.[48]

Aquatic and terrestrial plants is a broad term; for the purpose of this vulnerability assessment the following groups and sub groups of plant species have been identified for assessment due to their importance to the bands in the 1854 Ceded Territory and across reservations: ***wild rice*** (manoomin), ***berries*** (blueberry, raspberry, strawberry, chokecherry, pin cherry, cranberry, juneberry, thimbleberry, and bearberry), and ***culturally significant plants*** (Labrador Tea, sweet flag, wild ginger, and sweet grass). The plant species identified are adapted to thrive primarily in aquatic, wetland/bog, or forest environments. Each of these environments is susceptible to climate change and variability, though some more than others and in different ways.

Non-climate factors also affect the presence, quality, and quantity of aquatic and terrestrial plants. Proper management of forest, wetland, and aquatic environments is important to ensure the sustainability and presence of these important species for tribal members into the future. This section focuses on the specific vulnerabilities and potential adaptation strategies for wild rice, berries, and other culturally significant plants. Detailed adaptation strategies are provided for wild rice and culturally significant plants, and general strategies are provided for berries.

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[46] Portman, T.A. and M. Garrett (2006). Native American Healing Traditions. International Journal of Disability, Development, and Education. **53**, 453-469.

[47] Lynn, K., J. Daigle, J. Hoffman, F. Lake., N. Michelle, D. Ranco, C. Viles, G. Voggesser, P. Williams (2013). The impacts of climate change on tribal traditional foods. *Climatic Change*, **120**, 545-556.

[48] USDA (2010). Culturally Significant Plants: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/plantmaterials/technical/publications/?cid=stelprdb1043052

4.4.1 Wild Rice (Manoomin) – Focus Species

The Ojibwe people have a special cultural and spiritual tie to natural wild rice. It is an important plant species and food source across Minnesota and the Great Lakes region. For thousands of years, wild rice has been harvested for food, played a significant role in Ojibwe cultural practices, and served as an economic resource. Wild rice is also a source of food and shelter for a variety of fish and wildlife species. For example, it is one of the most important sources of food for some waterfowl.[49]

Figure 19: Wild rice stand in the 1854 Ceded Territory. Image courtesy of the 1854 Treaty Authority.

Natural wild rice grows best in shallow waters (ideal 1-3 feet deep) with soft sediments. It generally requires some moving water for growth, so inlets/outlets of lakes, lakes with water flow, and rivers are prime areas for growth and maturation. Wild rice is an annual plant; naturally it germinates in the spring from seeds that fell into the water during previous years. A cool period (water temperature less than 35°F) of 3 to 4 months for dormancy is required prior to germination. The growing season is typically 110 to 130 days and depends on temperature and other environmental factors.[50] Seeds have the ability to remain dormant until favorable conditions trigger germination. Viable seed may be present over long periods of time in a water body, and wild rice may re-establish after poor production years or reappear after long absences if environmental conditions change.

There are several non-climatic stressors that are known to affect wild rice, including: water quality, seasonal water levels, lakebed conditions, aquatic vegetation, and pressure/competition from invasive and native species.[51] Species that commonly impact wild rice include: rice worms, geese, swans, carp, migratory waterfowl, and songbirds; thus an increase in these populations could put pressure on wild rice populations. Pressure from industrial activities can also negatively affect wild rice through direct discharges or nonpoint source releases that impact water flows, levels, and quality (sulfate, nutrients, etc.). Increased recreational disturbance and shoreline development are also threats to rice beds. As shallow lakes become more developed and utilized, pressure can be applied to change the characteristics of these lakes to less aquatic vegetation and deeper water. An additional concern is competition from native and non-native aquatic vegetation, especially purple loosestrife, non-native phragmites, cattails (multiple varieties), and pickerelweed. These plants can outcompete wild rice. Lastly, pressure from invasive species has been shown to negatively impact wild rice through competition and impediments to water movement. With climate change, many of these impacts, especially pressure from invasive species and water quality concerns, will likely increase.

[49] Minnesota Department of Natural Resources. 2008. Natural Wild Rice in Minnesota: A Report submitted to the Minnesota Legislature. 116 pgs.

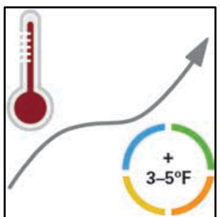
[50] Minnesota Department of Natural Resources, Division of Fish and Wildlife, Management Section of Wildlife. 2007. Minnesota Natural Wild Rice Harvester Survey: A Study of Harvesters' Activities and Opinions. 149 pgs.

[51] ibid

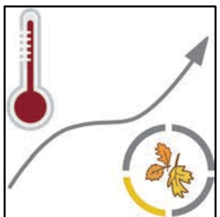
4.4.1.1 Climate Threats to Wild Rice

Existing Conditions: Wild rice is susceptible to changes in temperature and precipitation. Cool waters, less than 35°F, are required for a period of dormancy that is a prerequisite to wild rice germination. High heat is thought to negatively impact pollination and seed development. Additionally, since wild rice is a shallow water plant, it is particularly sensitive to changes in local hydrology.[52] Heavy precipitation events, which have increased in the 1854 Ceded Territory and across the reservations over the last few decades, have been shown to uproot wild rice plants. Wild rice is particularly vulnerable during early summer when it is in the floating-leaf stage of germination.[49] This rapid influx of water during heavy precipitation events leads to a "bounce" in which water rises rapidly and then falls rapidly. Such a drastic change in water levels can uproot the wild rice plants and cause them to wash away. If water levels remain high for extended periods, wild rice plants may also be drowned out and killed during the floating-leaf stage. Low or high water levels can also be damaging to wild rice by preventing seed germination. Control structures downstream (e.g., man-made dams or beaver activity) and upstream modifications (i.e., drain tile that increase stream flow) can exacerbate the effects of heavy and flash precipitation events by artificially increasing stream flow from upstream sources and causing raised water levels, all of which can be detrimental to wild rice.

Projected Climate Related Impacts: Projections of future climate for the 1854 Ceded Territory and across the reservations indicate substantial warming from what has historically been experienced. Since wild rice is at the southern edge of its range, there is a concern that increases in temperature could lead to a shifting of wild rice outside of the Great Lakes region and the 1854 Ceded Territory in particular. Increased temperatures in the cool season could lead to decreased germination of wild rice due to the temperatures being too warm in lakes and streams for the dormant hardening-off period that some wild rice require. Whether or not lakes within the 1854 Ceded Territory will warm enough to disrupt germination on a large scale, however, is unknown. Air temperatures and light cycles also have a relationship to wild rice germination, though this has not been studied in depth and is a source of uncertainty.



The average annual temperature is projected to increase by 3–5°F

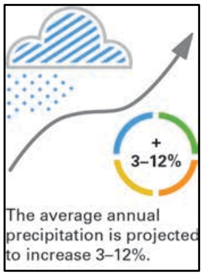

The maximum fall temperature is projected to increase by 3–6.5°F.

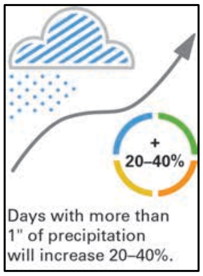
What is more certain is that warming temperatures will very likely give invasive and some native plant species a competitive advantage over wild rice, which could lead to a further reduction of wild rice in the region.[53] Recent observational evidence has shown an increase in dew-point temperatures in Minnesota.[54] This trend is expected to continue in the future, leading to more warm and humid conditions that are favorable for diseases that affect wild rice, such as brown spot, ergot, leaf sheath, and stem rot.[55] Specifics about the threat posed by individual diseases or pests in a warming climate have not been extensively studied, though it is generally agreed upon that the threats posed by pests and diseases

> *In the late 90s, Fond du Lac installed 4 water control structures on various wild rice lakes to manage the rapid rise and then decline in water levels that is often associated with extreme precipitation events.*

[52] Engel, S. and S.A. Nichols. 1994. Aquatic marcrophyte growth in a turbid windswept lake. Journal of Freshwater Ecology 9(2): 97-109.
[53] Ad Hoc Working Group on Invasive Species and Climate Change. 2014. Bioinvasions in a Changing World: A Resource on Invasive Species-Climate Change Interactions for Conservation and Natural Resource Management. 52 pgs.
[54] Minnesota Department of Natural Resources, Division of Fish and Wildlife, Management Section of Wildlife. 2007. Minnesota Natural Wild Rice Harvester Survey: A Study of Harvesters' Activities and Opinions. 149 pgs.
[55] Aiken, S.G., P.F. Lee, D. Punter, and J.M. Stewart. 1988. Wild Rice in Canada. NC Press Limited Toronto. 176 pgs.

will increase as the climate warms. There is also substantial evidence that days with very high maximum temperatures and high humidity can negatively impact the pollination and fertility of both domesticated and wild rice species.[56]





Precipitation projections for the region are less certain than for temperature, with most showing a range from little change to slightly wetter by the mid-21st century. Although there is a lot of uncertainty, precipitation is projected to increase between 3%-12% and in every season. In addition, the severity of storms in a warmer climate is projected to increase, which is likely to cause increases in heavy precipitation events. Days with more than one inch of precipitation are projected to increase 20-40%, which could lead to greater and more frequent fluctuations in water levels, potentially damaging wild rice plants. In addition, more extreme weather events (e.g., heavy rains, wind, hail) can significantly disrupt and damage wild rice plants, with potentially significant impacts on wild rice harvest. Changes in precipitation patterns already impact wild rice and these changes are likely to continue and potentially become more severe in a climate-altered future. If changes in precipitation and/or extreme temperatures happen more frequently (as projected), they have the potential to lead to multiple years of reduced wild rice production.

In addition, any climate related changes that are beneficial to beaver and/or muskrat have the potential to impact wild rice, albeit in different ways. Climate change is likely to generally benefit beaver, but potentially at a cost to wild rice since beaver can disrupt wild rice habitat and alter water levels on wild rice waters.[57] Climate change is also projected to benefit muskrat, which are habitat generalists (see furbearer section). It is unknown, however, how climate change impacts on muskrats will in turn affect wild rice. Muskrats are thought to help maintain healthy wild rice waters by controlling competing vegetation and have been referred to as cleaners or gardeners of lakes. Although muskrat also utilize wild rice, they have generally been viewed as favorable to wild rice. As such, changing climate conditions and the associated impacts on beaver and muskrat will likely lead to both positive and negative indirect impacts on wild rice. Other vertebrates that have been identified as threats to wild rice include: carp, geese, and swans. Carp are primarily a threat to wild rice in shallow waters, due to their violent thrashing movements during spawning and feeding, which can uproot wild rice plants. Geese and swans both eat the stems, leaves, and the grain of mature plants. Red-winged blackbirds also eat kernels of rice in the "milk" stage and knock off ripe kernels that haven't shattered.[58] Many of these species will likely thrive in a warming environment.

A number of invertebrate species can also have substantial impacts on wild rice populations. One of the insects that impact wild rice, both natural stands and cultivated, is the rice worm.[59] Adult moths emerge and reproduce at the same time that wild rice is undergoing fertilization. Moths lay their eggs in the plants and as their larvae develop, they consume the developing rice. This can cause a substantial decrease in rice production in infected areas. Other insect species that can impact wild rice include rice stalk borer,

[56] Julia, C. and M. Dingkuhn. 2012. Variation in the time of day of anthesis in rice in different climatic environments. European Journal of Agronomy 43: 166-174.
[57] Vennum, T. Jr. 1988. Wild Rice and the Ojibway People. Minnesota Historical Society Press, St. Paul. 368 pgs.
[58] Aiken, S.G., P.F. Lee, D. Punter, and J.M. Stewart. 1988. Wild Rice in Canada. NC Press Limited Toronto. 176 pgs.
[59] Vennum, T. Jr. 1988. Wild Rice and the Ojibway People. Minnesota Historical Society Press, St. Paul. 368 pgs.

leafminer, aphids, pyralid moth, and leaf beetles.[60] The effects of climate change on these specific insect species is unknown and represents an uncertainty when assessing the vulnerability of wild rice.

4.4.1.2 Wild Rice Vulnerability Assessment Results

Based on these factors, it was determined that wild rice has a high sensitivity (S3) to changes in climate and a moderate adaptive capacity (AC2) to respond. This means that ***wild rice has a medium vulnerability to existing as well as projected future changes in climate***.

4.4.1.3 Customized Adaptation Strategies for Wild Rice

The following series of detailed wild rice adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of the 1854 Ceded Territory and reservations

Adaptation Strategies to Address Climate Change Impacts to Wild Rice	
Collaboration	• Review and comment on aquatic plant permits provided by Minnesota Department of Natural Resources (MNDNR). • Review and comment on lake management plans provided by MNDNR. • Continue to advocate or work with EPA to promulgate regional water quality standards to protect wild rice (as opposed to focusing only on state standards). • Consult with federal and state agencies on the development and enforcement of water quality standards. • Coordinate management and restoration efforts among tribal, federal, state, county, and non-governmental entities. • Investigate and understand differences in tribal traditional management approaches versus other management techniques.
Conservation, Preservation, and Maintenance	• Protect remaining populations of wild rice, regardless of density. • Conduct water level management for the long-term benefit of wild rice. • Prevent the introduction of invasive species. This includes the creation of invasive species prevention plans, physical practices to help remove invasive species when they do appear, and education and early detection programs (monitoring programs) to quickly identify the presence of invasive species. • Manage species that directly compete with wild rice (i.e. cattails, pickerelweed, etc.). • Protect wild rice habitats (e.g. further restrictions on shoreline development, prevention of plant removal using aquatic plant management permits, protection from motorized watercraft, etc.). • Update and enforce state and tribal regulations on wild rice harvesting. • Manage beaver populations in relationship with wild rice. • Promote muskrat populations in wild rice areas, as they are generally thought to be beneficial to wild rice. • Manage and prevent industrial runoff and discharge into waters where wild rice is present or has been present historically. • Manage common carp, rusty crayfish, geese, and other species that may negatively impact wild rice. • Investigate feasibility of seed banking of wild rice from within the 1854 Ceded Territory and

[60] ibid

<table>
<tr><td></td><td>across the reservations.</td></tr>
<tr><td>Education</td><td>Install outreach materials (e.g., educational kiosks, signage with boot brushes) near access points of wild rice waters (especially priority and/or at high risk areas) to educate about the need to not spread invasive species.
Promote the recruitment and retention of wild rice harvesters (need to use the resource to protect the resource).
Complete education and outreach about the importance of wild rice and the need for resource preservation.
Conduct education about proper wild rice harvesting techniques and practices.</td></tr>
<tr><td>Monitoring and Assessment</td><td>Develop and update an inventory of wild rice waters within the 1854 Ceded Territory and on reservations if they do no already exist.
Complete surveys of wild rice waters to determine wild rice presence, suitable habitats, and other general characteristics.
Continue and expand monitoring of wild rice lakes utilizing established standard protocol for density and biomass.
Record and monitor water depths in wild rice lakes.
Monitor air temperature and humidity and study potential impacts on wild rice lakes and wild rice plants.
Monitor prevalence of fungal diseases (e.g. brown-spot, ergot) and learn more about impacts to wild rice and the relation to climate change.
Monitor prevalence and impacts of pests (e.g. rice worms).
Track ice-out dates on wild rice waters and determine if there are impacts to wild rice (changes in growing season, changes to competing vegetation, etc.).
Monitor water temperatures in wild rice lakes.
Record and monitor weather and storm events.
Monitor wild rice phenology.
Invest in additional research into the ecology of wild rice, which may help the development of more adaptation strategies.</td></tr>
<tr><td>Restoration</td><td>Manage water levels to allow for natural restoration and for the long-term benefit of wild rice.
Manage and remove barriers to water movement, to the extent they are impeding flow to wild rice waters and/or altering water levels. Care needs to be taken to ensure culverts and road/trail crossing are properly designed to accommodate changing climate conditions.
Seed wild rice in supportive aquatic environments using seed rice from within that watershed when possible.
Model which lakes may be viable in the future for wild rice production and create management plans to begin preparing those lakes for wild rice.</td></tr>
</table>

4.4.2 Culturally Significant Plants – Focus Species

Many plants throughout the 1854 Ceded Territory and across the reservations serve important roles in sustenance, medicine, and have important cultural connections through storytelling, ceremonies, harvesting, processing, and sharing.[61] Plant species included in the category of *culturally significant plants* within the 1854 Ceded Territory and reservations are those that are primarily used for medicinal and cultural practices.[62]

Figure 20: Picture of Labrador Tea. Courtesy of the 1854 Treaty Authority.

Climate and other environmental and land use changes will likely affect the range and availability of plants that have historically been present in the 1854 Ceded Territory and across the reservations; there is potential for these changes to occur rapidly in some cases.[63] Culturally significant plants identified by subject matter experts for inclusion in this analysis include: Labrador Tea, sweet flag, wild ginger, and sweet grass. Many of these species have similar characteristics in terms of favorable growing locations, preferred soils, and suitable climate. A common characteristic among all of these species is that they are typically found in areas with moist soils.

Wild ginger prefers moist soils and serves as a dominant (within favorable sites), deciduous cover species in shaded or partially shaded areas. This makes it particularly well suited to forested areas and, as a result, is vulnerable to logging pressure. Wild ginger has uses as both a spice for foods and in medicinal practices, particularly as an antibiotic.[64]

Labrador tea, sweet flag, and sweet grass are found in boggy/wetland areas. Labrador tea prefers peaty soils and thrives in a cooler boreal environment. It has historically been used as a hot drink and a medicine (for a wide array of ailments) by many indigenous peoples throughout northern North America.[65] Sweet flag is a fragrant monocot that is found in wetland areas throughout much of North America north of 38°N latitude.[66] It is usually found directly on mucky shorelines and in shallows with up to a foot of water. It has a ceremonial and medicinal role due to its anti-inflammatory, antioxidant, and antimicrobial properties.[67] Sweet grass is an aromatic herb found throughout much of North America and Eurasia[68] typically found in wetland areas with full sun or partial shade and is not drought tolerant. It is an important ceremonial plant and medicine and is a good material for making baskets.

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[61] Lynn, K., J. Daigle, J. Hoffman, F. Lake., N. Michelle, D. Ranco, C. Viles, G. Voggesser, P. Williams (2013). The impacts of climate change on tribal traditional foods. *Climatic Change*, **120**, 545-556.

[62] Portman, T.A. and M. Garrett (2006). Native American Healing Traditions. International Journal of Disability, Development, and Education. **53**, 453-469.

[63] Kelly, A.E. and M.L. Goulden (2008). Rapid Shifts in Plant Distribution with Recent Climate Change. *Proceedings of the National Academy of Sciences*. **105**, 11823-11826.

[64] Cavallito, C.J. and J.H. Bailey (1946). Antibacterial Substances from Asarum canadense. *Journal of the American Chemical Society*. **68**, 489-492.

[65] USDA. (2012) Plant Fact Sheet: Bog Labrador Tea. http://plants.usda.gov/plantguide/pdf/cs_legr.pdf

[66] USDA. (2016) Plant of the Week: Sweet Flag (Acorus americanus). http://www.fs.fed.us/wildflowers/plant-of-the-week/acorus_americanus.shtml

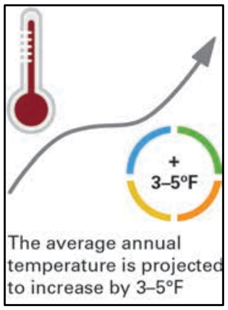
[67] ibid

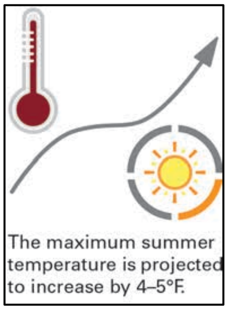
[68] USDA (2010). Plant Fact Sheet: Sweetgrass. http://plants.usda.gov/factsheet/pdf/fs_hiod.pdf

4.4.2.1 Climate Threats to Culturally Significant Plants

***Existing Conditions*:** Warming temperatures and changing seasonality of temperature patterns (particularly in winter) have been observed in the 1854 Ceded Territory and on reservations in recent decades. Precipitation has been decreasing in most seasons, with the most marked declines in winter and summer. Opposite of other seasonal patterns and trends, there have been substantial increases observed in fall precipitation within the 1854 Ceded Territory and across the reservations.

Projected Climate Related Impacts: As temperatures across the region warm (annual temperature is projected to increase 3-5°F by the middle of the century) species that are currently at the southern edge of their range within the 1854 Ceded Territory and on the reservations may not be present in the future. This is particularly notable for Labrador tea, which prefers a boreal climate. Conversly, species that are currently at the northern edge of their range may thrive in a warming climate. Summer temperatures are projected to increase by 4-5°F by the middle of the century. This will increase evaporation and species that reside in bogs and consistently moist areas may experience more stress. This is likely the key vulnerability for culturally important plants in this assessment, as they all prefer moist soils, and many are found only in wetland/bog areas.





Forests in the 1854 Ceded Territory are projected to shift towards what has historically been a more southern forest composition (maple, beech, birch, elm, ash, oak, hickory vs. spruce, fir, aspen, birch) by the end of the 21st century.[69] Shifting forest composition, logging pressure, and the invasion of noxious weeds (garlic mustard, common and glossy buckthorn, and Japanese barberry) will likely have a negative effect on wild ginger.

Species that thrive in boggy areas may experience more water stress in the future. Species that thrive in forested areas may be more impacted by shifting forest ecosystems and logging pressure.

4.4.2.2 Culturally Significant Plants Vulnerability Assessment Results

Generally speaking, plants in this category are moist-soil/wetland plants, and were assigned a sensitivity score of S2, meaning that they have a medium sensitivity to changing climate conditions. Labrador tea may be somewhat higher, due to its preference for cooler climates (S3). All species were assigned an adaptive capacity of AC2, meaning they are somewhat adaptable to changing environments. This was given due to their wide distribution throughout North America. Their adaptive capacity, however, is somewhat limited due to their preferred habitat and low resistance to drought. Combined, this means that ***culturally significant plants referenced here have a medium vulnerability to climate change.***

[69] Prasad, A. M., L. R. Iverson, S. Matthews, and M. Peters, cited 2007: A Climate Change Atlas for 134 Forest Tree Species of the Eastern United States [Database]. U.S. Department of Agriculture, Forest Service, Northern Research Station.

4.4.2.3 *Customized Adaptation Strategies*

The following series of adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of culturally significant plants within the 1854 Ceded Territory and reservations.

Adaptation Strategies to Address Climate Impacts to Culturally Significant Plants	
Collaboration	• Engage in commenting, consulting, and reviewing land management decisions made at other scales of governance. • Hire plant specialists within each of the bands to identify/inventory areas with these species and areas with suitable habitat. • Enhance collaboration with local, county, state, and federal wetland management organizations to identify, monitor, and track wetlands throughout the region.
Conservation, Preservation, and Maintenance	• Use traditional practices such as fire to encourage culturally significant plants on the landscape and clear undergrowth. • Utilize best practices for managing invasive species. • At a minimum, within 50 feet of the wetland maintain 50 percent crown cover to help maintain the water and soil temperatures • At a minimum, within 150 feet of the wetland 1) avoid clear cutting and be more selective about harvest, 2) avoid making skid trails, 3) minimize use of heavy equipment, and 4) limit ruts deeper than 6 inches below ground level. • Work across property boundaries to respond to and limit the spread of invasive species that have the potential to outcompete native vegetation. • Utilize funding opportunities to protect habitat for culturally significant species.
Education	• Educate the public on the threats of overharvesting culturally significant plants and devise management strategies to help reduce the risk of overharvesting. • Explore the installation of signage in areas where the restoration or protection of culturally significant plants is underway and state the message in English and Ojibwe. Strike a balance between providing too much detail about what species exist in the area and educating the public about the importance of the species.
Monitoring and Assessment	• Create an inventory of the top culturally significant plants as determined by band members. • Conduct additional surveys to monitor the location of key culturally significant plant species and potential impacts on those species from climate change. This includes building trust relationships with tribal members and elders. • Investigate the need for building water control structures to maintain historic water levels in wetlands (especially for sweet grass).
Restoration	• Maintain and restore wetland ecosystems, which are important locations for culturally significant plants. • Develop plans for forest management that promotes a diversity of tree and plant species.

4.4.3 Berries

Berries are an important food for the bands in the 1854 Ceded Territory and provide not only sustenance but also cultural and medicinal value. Studies show that declines in the general health of indigenous populations are often linked to declines in access and use of traditional foods.[70] In fact, modern medicine is only now starting to understand and uncover many of the potential medicinal values of berries.[71]

Figure 21: Blueberries. Source: messagemedia.co.

Climate and other environmental changes are already affecting the range, quality, and quantity of berry resources in some regions.[72,73] The native berry resources identified as important for use by band members in the 1854 Ceded Territory[74] and on reservations include: blueberry, raspberry, strawberry, bearberry, chokecherry, pin cherry, cranberry, juneberry, thimbleberry, and bearberry. Many of these species have similar characteristics in terms of favorable growing locations, preferred soils, and suitable climate. For this vulnerability assessment, berries were grouped into categories: 1) disturbance species that thrive on well-drained soils; and 2) wetland/bog species (Figure 22). These categories are not mutually exclusive since some species share attributes between the two groups, but provide a tool for grouping species so that a vulnerability assessment can be conducted.

Disturbance species share the characteristics of thriving in well-drained soils and in areas that have previously been disturbed (i.e. past clear cuts, areas that have burned or been logged in recent years, or along the edges of roads, trails, or campsites). There is variation within this group as to how much moisture in the soils the plants are able to tolerate. For example, thimbleberry does well in a variety of soil types, though they prefer moist soils with good drainage. Many of these species have variable preferences for shade, from moderately shaded areas to full sun. Upland species of blueberries also do well in rocky areas, with well drained/acidic soils.

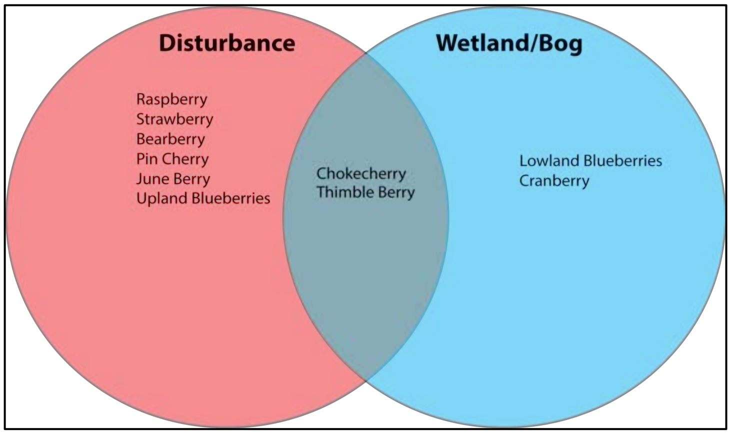


Figure 22: Classification of key berry species by the type of soil in which they grow (disturbance = well drained soil, wetland/bog = wet soils)

[70] Kuhnlein, H.V., B. Erasmus, D. Spigelski (2009). Indigenous peoples' food systems: the many dimensions of culture, diversity, and environment for nutrition and health. United Nations Food and Agricultural Organization, Rome.

[71] Burn Kraft, T.F., M. Dey, R.B. Rogers, D.M. Ribnicky, D.M. Gipp, W.T. Cefalu, U. Raskin, M.A. Lila (2008). Photochemical composition and metabolic performance-enhancing activity of dietary berries traditionally used by Native North Americans. *Journal of Agricultural and Food Chemistry*, **56**, 654-660.

[72] Kellogg, J., J. Wang, C. Flint, D. Ribnicky, P. Kuhn, E. Gonzalez de Mejia, I. Raskin, M.A. Lila (2010). Alaska wild berry resources and human health under the cloud of climate change. *Journal of Agricultural and Food Chemistry*, **58**, 3884-3900.

[73] Michelle, N. (2012). Uses of plant food-medicines in the Wabanaki bioregions of the Northeast; a cultural assessment of berry harvesting practices and customs. University of Maine, Orono.

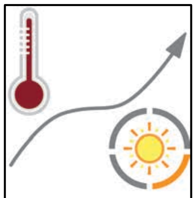
[74] Vogt, D. 2004. Fish, Wild Game, and Plant Consumption Survey Results. 1854 Authority. 30 pgs. Note: Bearberry was not identified in the survey of band members, but was included by expert recommendation.

Species that do well in wetland/bog environments are found in areas with soils that consist of sand, peat, gravel, and clay that were originally created by glacial deposits. Blueberries are typically found in the areas that are in the transition zone into bogs, while cranberry are typically found in the bog area. Chokecherry will grow in a variety of areas, but prefers wet-moist soils and are often found near streams/rivers.

4.4.3.1 Climate Threats to Berries

Existing Conditions**:** Warming temperatures and changing seasonality of temperature patterns (particularly in winter) have already been observed in the 1854 Ceded Territory and across the reservations in recent decades. There have been marked declines in winter and summer precipitation while spring precipitation has increased slightly in East Central Minnesota (ECM) and decreased in the Minnesota Northeast (NEM) climate divisions. There has been a substantial increase in fall precipitation within the ceded territory and across the reservations.

Projected Climate Related Impacts: The trends in temperature change and precipitation shifts experienced to-date are projected to continue into the future. This means that species currently at the southern edge of their range may not be present in the future as the climate warms in the 1854 Ceded Territory and across the reservations. Conversely, species that are currently at the northern edge of their range may thrive in a warming climate. Summer temperatures are projected to increase by 4-5°F by the middle of the century. This will increase evaporation and species that reside in bogs and consistently moist areas may experience more stress and decline than disturbance species.


The maximum summer temperature is projected to increase by 4–5°F.

Species that thrive in boggy areas (i.e. cranberries and some varieties of blueberries) may experience more water stress in the future. Species that depend on disturbance may be more sensitive to human impacts and forest management, but not as sensitive to projected changes in climate.

While changes in temperature and precipitation will affect berries, it is perhaps the shifting composition of the forest ecosystem that will have the greatest impact on the presence, quality, and quantity of berry species present in the region. Under a changing climate, forests in the 1854 Ceded Territory are projected to shift towards what has historically been a more southern forest composition (maple, beech, birch, elm, ash, oak, hickory vs. spruce, fir, aspen, birch) by the end of the 21st century.[75] This change in forest composition, combined with warmer temperatures and changes in the timing and amount of precipitation may alter the fire regime of the region. As a result, berry species (and other species) that thrive in areas disturbed by periodic fires may be affected; this could be a positive or negative depending on how the fire regime is altered. Another threat for species that have traditionally done well in disturbed/cleared areas are invasive species (ex. garlic mustard, common and glossy buckthorn, and Japanese Barberry), both of which will likely move into woodlands and outcompete berries.

[75] Prasad, A. M., L. R. Iverson, S. Matthews, and M. Peters, cited 2007: A Climate Change Atlas for 134 Forest Tree Species of the Eastern United States [Database]. U.S. Department of Agriculture, Forest Service, Northern Research Station.

Table 5: Berry species in the region grouped by how they are likely to be affected by changing climate conditions.

Winners	Neutral	Losers
Raspberries Strawberries Thimbleberry Pin Cherry	Juneberry Bearberry Upland Blueberries	Lowland Blueberries Cranberries Chokecherry

Finally, human impacts on the forest system, rates of land disturbance, and fire occurrences/management will greatly affect berries in the 1854 Ceded Territory and across the reservations. These impacts will likely be more immediate than changes in temperature and precipitation alone, but combined with projected changes in climate, these changes could cause significant impacts to the region's berry species.

Based upon the reviewed literature, feedback, and information from experts, Table 6 suggests species that will do well, species that are neutral or for which not enough is known, and potential losers in a changing climate.

4.4.3.2 Berry Vulnerability Assessment Results

Generally speaking, berries were assigned a sensitivity score of S1, meaning they have a very low sensitivity to changing climate conditions. They were assigned an adaptive capacity of AC4, meaning they are highly adaptable to changing environments. Combined, this results in a ***low vulnerability to climate change***.

Bog species are the exception. Bog species (cranberry, chokecherry, and some species of blueberries) have a higher sensitivity (S3) and lower adaptive capacity (AC2) than disturbance species. This makes them much more vulnerable (***medium vulnerability***) to changes in climate.

4.4.3.3 Adaptation Strategies

Detailed adaptation strategies were not developed for berries. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of berries to climate change.

1) Complete proper forest management within reservations and in cooperation with other land managers in the 1854 Ceded Territory, specifically including consideration of berry species.
2) Conduct prescribed burns within reservations and in cooperation with other land managers in the 1854 Ceded Territory.
3) Collaborate with other land managers (federal, state, county) on forest and wetland management, and consult on specific projects.
4) Conduct invasive species management (monitoring, prevention, control, education/outreach)
5) Encourage and complete proper wetland management practices, including conservation and strategic management (more guidance can be found in Wetlands chapter of this document).
6) Promote sustainable harvesting of berries.
7) Provide public education about the importance of berries and the need to maintain a sustainable population.
8) Comment, consult, and review land management decisions made at other scales of governance.
9) Hire plant specialists within each of the Bands to identify/inventory areas with berries and proper habitat.

10) Use traditional practices such as fire to encourage disturbance species of berries on the landscape and clear undergrowth.
11) Utilize best practices for managing invasive species.
12) At a minimum, within 50 feet of the wetland 1) maintain 50 percent crown cover to help maintain the water and soil temperatures, and 2) leave 5-15 dead standing trees for insect and bird habitat and avoid removing rotting stumps.
13) At a minimum, within 150 feet of the wetland 1) avoid clear cutting and be more selective about harvest, 2) avoid making skid trails, 3) minimize use of heavy equipment, and 4) limit ruts deeper than 6 inches below ground level.
14) Work across property boundaries to respond to and limit the spread of invasive species that have the potential to outcompete native vegetation.
15) Utilize funding opportunities to protect habitat for berry species.
16) Explore the installation of signage in areas where the restoration or protection of berry species is underway and state the message in English and Ojibwe. A balance must be struck between providing too much detail about what species exist in the area and educating the public about the importance of the species.
17) Educate the public on the threats of overharvesting culturally significant plants and devise management strategies to help reduce the risk of overharvesting.
18) Create an inventory of the top culturally significant berry species as determined by Band members.
19) Conduct additional surveys to monitor the location of key culturally significant berry species and potential impacts on those species from climate change. This includes building trust relationships with tribal members and elders.
20) Investigate the need for building water control structures to maintain historic water levels in wetlands to protect bog species (e.g. lowland blueberry, cranberry, chokecherry).
21) Maintain and restore wetland ecosystems, which are important locations for lowland blueberry, cranberry, chokecherry.
22) Develop plans for forest management that promotes diversity of tree and plant species.

4.5 Culturally Significant Places

		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
Adaptive Capacity: High ↓ Low	AC4					
	AC3					
	AC2					
	AC1			• Culturally Significant Places		
	AC0					

From ancestral burial sites to trails and archeological sites, culturally significant places abound within the 1854 Ceded Territory and on reservations. Climate change, along with land use change, however, threatens the viability of many of these important locations.[76] For example, extreme weather and more extreme precipitation events could cause significant erosion to sacred places and ancestral land.[77] Changes to annual temperature and precipitation regimes could cause ecosystem shifts that lead to traditional hunting grounds and fishing areas no longer being viable for species such as moose and brook trout.[78] Disruptions such as these and others discussed throughout this report can deteriorate or destroy centuries of cultural history and identity.[79, 80] This includes a mismatch between traditional ecological knowledge, especially knowledge related to historic environmental conditions, traditional hunting and gathering techniques, and traditional resource management approaches and what may be needed in changing climate conditions.[81]

Climate change also threatens the viability of negotiated treaty rights, specifically those aimed at sustaining lifeways within the 1854 Ceded Territory and on the reservations. This is a particularly acute threat since the physical location of the reservations in the 1854 Ceded Territory ties the bands to their ancestral lands, affording them an essential connection to their ancestors and traditional subsistence practices.[82] Changes in climate, however, threaten to disrupt these established treaty rights, specifically those related to the right to hunt, fish, and gather traditional resources, because these rights were reserved in locations where access to culturally significant resources has historically existed. However, since these resources are not fixed, there is a high likelihood that some will shift outside of existing treaty lands as the climate of the region changes. This could create a situation in which band members no longer have the same legal right to traditionally harvest significant plants, animals, or aquatic species.[83] Drawing upon work from Dr. Seth Moore in Grand Portage, Dr. Kyle Whyte from the Michigan State University explicitly identifies this disconnect between tribal land and resource use:

> *"For the Grand Portage Band of Lake Superior Chippewa in Minnesota, for example, moose are a culturally significant species for the community. When moose populations on the reservation drop below a certain number, the natural resources/environmental staff engage in more intensive moose stewardship. But climate change is altering moose habitat, which has concerned the staff; for the moose population may reach a point where there is nothing that can be done to keep moose within the reservation area… In this example, the fixed limit of the reservation area is disoriented because it is out of sync with climate change. This case shows that indigenous peoples may not be able to engage in needed stewardship of culturally significant species because the species are moving off reservation."*[84]

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[76] US Global Change Research Program. 2014. U.S. National Climate Assessment.
[77] Ford, J.K, and E. Giles. 2015. Climate Change Adaptation in Indian Country; Tribal Regulation of Reservation Lands and Natural Resources. William Mitchell Law Review: 41(2): 519-551
[78] Moore, Seth. ND. Grand Portage Band of Lake Superior Chippewa: Creative Solutions for a Changing Environment. Northern Arizona University. http://www7.nau.edu/itep/main/tcc/Tribes/gl_gpchippewa
[79] Ford, J.K, and E. Giles. 2015. Climate Change Adaptation in Indian Country; Tribal Regulation of Reservation Lands and Natural Resources. William Mitchell Law Review: 41(2): 519-551
[80] McNutt, D. (2010) Northwest Tribes: Meeting the Challenge of Climate Change, Northwest Indian Applied Research Institute, Olympia, WA, USA
[81] US Global Change Research Program. 2014. U.S. National Climate Assessment.
[82] Whyte, K. Powys. 2011. The recognition dimensions of environmental justice in Indian Country. Environmental Justice, 4, 185-186.
[83] McNutt, D. (2010) Northwest Tribes: Meeting the Challenge of Climate Change, Northwest Indian Applied Research Institute, Olympia, WA, USA
[84] Whyte, K.P. 2014. A concern about shifting interactions between indigenous and non-indigenous parties in US climate adaptation contexts. Interdisciplinary Environmental Review. 20 pgs.

For the purposes of this vulnerability assessment, culturally significant places are defined as physical places within the 1854 Ceded Territory or on reservations that have important cultural resonance to band members. Nearly all locations, be it streams, rivers, wetlands, lakes, bogs, fields, or trails have cultural value, but this assessment focuses exclusively on: burial and archeological sites, significant landscape features, and trails. It is important to recognize that sharing information on locations of cultural and spiritual significance to tribes is not appropriate in this report. This is partly, as Latady and Isham (2013) note, because *"history has shown the information may be misused and exploited at the expense of the individual, tribe or resource."*[85] As such, this section does not provide specific place-based assessments of vulnerability, but instead looks at climate-related impacts to larger groupings of culturally significant places (e.g., trails or archeological sites).

4.5.1 Climate Change and Culturally Significant Places

4.5.1.1 Archeological Sites – Existing Conditions

There are many archeological sites within the region containing human remains, pottery, projectile points, tools, and other artifacts left by ancestral tribal members. Some of these artifacts are considered sacred and, according to custom, should remain where they are buried. Human factors such as land use change and increasing development pressure, as well as climate-related changes such as extreme precipitation, are simultaneously unearthing a number of buried artifacts and bringing more people into contact with them, leading to deterioration of the sites and the artifacts buried there.[86] This threatens the integrity of the artifacts and could potentially lead to the artifacts being destroyed.[87]

4.5.1.2 Landscape Features – Existing Conditions

Landscape features have–played and continue to play an extremely important role in the lives of band members by providing spiritual inspiration and cultural value. Within the 1854 Ceded Territory and across the reservations, some of the most prominent landscape features include Misaabe wajiw (the continental divide), lakeshores, forests, springs, wetlands, and rivers. Changing climate conditions already are, and will likely continue, to cause changes and shifts to many of these landscape features, especially forests, wetlands, and rivers.[88]

Figure 23: Iron Ore Mine Pit on Mesabi Range

4.5.1.3 Trails – Existing Conditions

Historic trails, which traditionally provided both economic connections between bands in the region and a means for social interaction, are vulnerable to changes in climate, especially changes in extreme precipitation events which have been occurring more frequently in the last several years.[89] Historically, trails were the means by which families stayed in touch, exchanged goods and services, and traveled

[85] Whyte, K.P. 2014. A concern about shifting interactions between indigenous and non-indigenous parties in US climate adaptation contexts. Interdisciplinary Environmental Review. 20 pgs.

[86] Latady, W.R., and M. Isham. 2013. Identification of Historic Properties of Traditional Religious and Cultural Significance to The Bois Forte Band of the Minntac Progression Project Area of Potential Effect. Bois Forte Tribal Historic Preservation Office. Tower, MN. 19 pgs.

[87] ibid

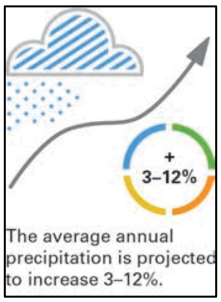
[88] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, national Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington. D.C.

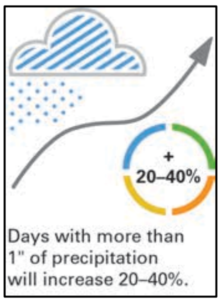
[89] U.S. Global Change Research Program. 2014. *Midwest,* in 2014 U.S. National Climate Assessment: http://nca2014.globalchange.gov/report/regions/Midwest

between villages. Trails also provide access to other culturally significant places such as landscape features where spiritual and cultural practices take place.

In addition to previously identified impacts, weather and human-related erosion is also negatively impacting all three groups of culturally significant places. This impact is twofold: 1) important physical sites are being damaged by both use and weather; and 2) the artifacts found around these sites are deteriorating due to exposure to the elements. Extreme precipitation events have caused natural erosion rates to increase at these sites. In addition, the increasing numbers of tourists and hobbyists visiting archeological sites is also contributing to greater erosion of these sites.

4.5.1.4 Projected Climate Related Impacts:





Climate change is projected to alter the timing and severity of future precipitation patterns with an annual projected increase in precipitation within the 1854 Ceded Territory of 3-12% by mid-century. While all seasons are projected to see an increase in precipitation, fall and winter are projected to have the largest increase (10-20% increase in each season). In addition, the region is projected to see a 20-40% increase in the number of days with more than 1" of precipitation. For culturally significant places, especially archeological sites and historic trails, heavy precipitation events threaten to unearth cultural artifacts, which could be eroded by the elements or illegally collected, and cause significant erosion. Extreme weather can also cause significant disruption to natural landscape features such as forests and wetlands, and cause rapid vegetation growth, including the expansion of invasive species. Rapid growth of vegetation could obscure or block culturally significant places such as trails.

Freeze-thaw cycles can also affect culturally significant places, especially archeological sites. For organic items found in these locations, exposure to natural elements will likely lead to more rapid decay and deterioration. This could mean a complete loss of certain cultural artifacts. Additionally, any changes to lake water levels will also threaten many culturally significant places by either further exposing them during periods of low precipitation or flooding them during periods of greater precipitation. Since lakes, rivers, and streams have always been important to band members, it is very likely that a large number of the culturally significant places within the 1854 Ceded Territory are located in close proximity to water, making them especially vulnerable to water-level fluctuations.

4.5.2 Culturally Significant Places Vulnerability Assessment Results

Based on these results, it was determined that, as a group, culturally significant places within the 1854 Ceded Territory and on the reservations have a moderate sensitivity to changing climate conditions (S2). There are, of course, different sensitivities for culturally significant places depending on their location within the 1854 Ceded Territory or within a reservation. For those that are in close proximity to water bodies, the sensitivity and potential climate-related impacts may be more severe. Areas that are further from water will likely face less severe impacts. In aggregate, however, culturally significant places demonstrate a moderate sensitivity to changing climate conditions and have a low to moderate level of adaptive capacity (AC1) to cope with changing climate conditions. Therefore, ***culturally significant places have a medium vulnerability to changing climate conditions***.

4.5.3 Adaptation Strategies

Detailed adaptation strategies were not developed for culturally significant places. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of culturally significant places to climate change.

1) Continue protection of culturally significant places within reservation boundaries through tribal ordinances and policies.
2) Educate the public about proper use of culturally significant places to minimize the human footprint on these locations.
3) Educate tribal resource managers about the importance of keeping buried cultural resources in the ground.
4) Contact the appropriate Tribal Historic Preservation Office for guidance if cultural resources/artifacts are unearthed.
5) Work to minimize erosion at known culturally significant sites.
6) Build a trust relationship with tribal elders and community so they may be comfortable disclosing the locations of spiritual or sacred family heirlooms, recorded stories, or significant places. This confidential information can be used to ensure that these sites are protected and preserved.
7) Manage future development to avoid culturally significant places.
8) Work with other federal and state agencies on cultural resource management, including consultation on specific projects.
9) Develop and maintain agreements with other government agencies on cultural resource consultation.
10) Complete cultural resource survey work as appropriate to avoid or reduce impact from land management or development activities.
11) Develop and maintain inventory of cultural resource sites within reservations and within the 1854 Ceded Territory (respecting the sensitivity and confidentiality of the information).
12) Monitor impacts (climate/weather and human use) at known cultural resource sites, and mitigate when necessary.

4.6 Fisheries

		Sensitivity: Low → High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity: High ↓ Low	**AC4**	• Black Crappie	• Other Fish Species			
	AC3			• **Walleye** • Northern Pike	• **Sturgeon**	
	AC2					
	AC1				• Cisco • Lake Trout • Whitefish	• Brook Trout
	AC0					

The Ojibwe people have a strong subsistence, cultural, and spiritual relationship with fish going back centuries. Band members accessed the innumerable lakes and rivers of the 1854 Ceded Territory and beyond for sustenance and as an exercise of their culture. Ojibwe people developed innovative technologies such as spearing and netting to assist in the capturing, harvesting, processing, and storage of fish resources. The increasing presence of European settlers in the region severely diminished these fisheries and altered the landscape and habitats that support these lake and river ecosystems. Fortunately, many fish species are still available for harvest by band members. Tribal organizations continue to conduct assessments, stock native species, regulate harvest, and monitor the environment to sustain fisheries resources for future generations.

Climate change brings a new set of impacts to fisheries in the 1854 Ceded Territory and within reservations. Tribal fishermen and managers have noticed some shifting climate variables over their careers, generally including: shorter winter seasons, reduced ice cover on Lake Superior contributing to rising water temperatures, earlier 'ice-out' dates on inland lakes, warmer water temperature particularly in more southerly lakes in the 1854 Ceded Territory, shifting species composition in lakes due to a combination of warm water temperatures and invasive species, and an alteration in timing and intensity of precipitation patterns.[90]

Throughout this assessment, core team members and tribal experts identified fish species for assessment: walleye, brook trout, northern pike, lake sturgeon, cisco, lake trout, whitefish, black crappie, and other fish species (perch, bluegill, smallmouth bass, largemouth bass, burbot). The remainder of this section profiles each of these species and presents detailed adaptation strategies for walleye and sturgeon, and general strategies for the other seven species or groups.

[90] From fisheries experts within the 1854 Ceded Territory and reservations

4.6.1 Walleye (Ogaa) – Focus Species

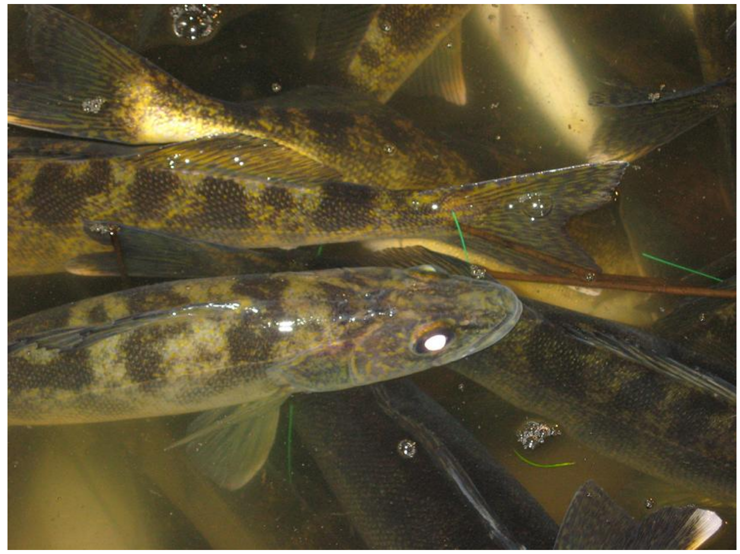


Figure 24: Walleye, courtesy of the 1854 Treaty Authority.

Walleye, or *Ogaa* in Ojibwe, are a sought after and celebrated fish species in the 1854 Ceded Territory and across the reservations. Walleye populations in the area have shown stability through much of modern time, but are now augmented in some locations with stocking efforts to protect against recruitment failure and overharvest. Recent well-publicized walleye declines in the 1837 Ceded Territory (Mille Lacs Lake) have been attributed to an intersecting web of climate change impacts to the food chain, management practices, and invasive species like zebra mussels and spiny water flea.[91] Walleye are a priority for fisheries research and management for the Bois Forte, Fond du Lac, and Grand Portage bands and 1854 Treaty Authority. The 1854 Treaty Authority and Fond du Lac Band conduct annual assessments in the spring and fall on priority lakes in the 1854 Ceded Territory to: estimate adult populations, investigate year class production, and monitor important spawning and nursery habitat.

The walleye is considered a 'cool water' fish but also thrives in a temperature range that is warmer than most of its current habitat in northern Minnesota. Walleye spawn in early spring in water temperatures between 42-50°F by laying adhesive eggs on clean rock, rubble, or gravel. Eggs hatch in 2-3 weeks.[92] Walleye reside in inland lakes and rivers, and Lake Superior and some of its tributaries.

4.6.1.1 *Climate Threats to Walleye*

Existing Conditions: Walleye are susceptible to a range of existing environmental conditions that could be further altered by changing climate conditions, including: water temperature, nutrient levels, invasive species, low dissolved oxygen, overall water quality, and lake level fluctuations. Within Lake Superior, one estimate of walleye habitat has reported an increase of 223 square miles over the past 40 years. Previously, walleye on the lake were restricted to warmer near-shore waters, bays, and estuaries but, with overall warming of deeper, colder waters, suitable thermal habitat has expanded. As an interesting caveat to this habitat expansion, there have been reports of lower walleye growth rates on Lake Superior due to higher densities and increased competition.[93] Lake Superior has also seen rapid warming since 1981 at a rate of 9°F per century. This warming is faster than the surrounding inland air temperatures and the associated increase in evaporation led to record low water levels on the lake in the fall of 2007.[94]

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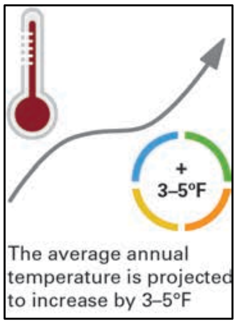
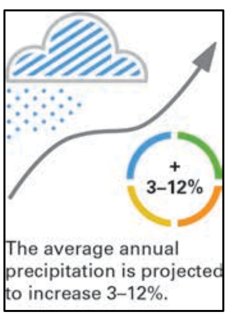
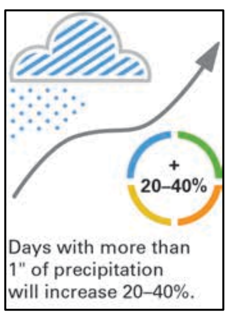
[91] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[92] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
[93] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[94] Minnesota Department of Natural Resources, 2011. Climate change and renewable energy: management foundations. Version 1.03. Available: http://files.dnr.state.mn.us/aboutdnr/reports/conservationagenda/crest-ccref.pdf

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°- 5°F. Current modeling by the State of Minnesota suggests that under near term climate change projections walleye may experience extended growing seasons and increased primary productivity in northern Minnesota lakes. However, heat stress and exceedingly warm temperatures in southern and shallow Minnesota lakes will likely impact walleye throughout Minnesota, including in the 1854 Ceded Territory.[95] By the end of this century, this category of lake will likely be too warm for ideal walleye habitat, and will create strong competition by warmer water fish species (such as smallmouth bass) that are already expanding populations in the region. The warmer water temperatures will likely increase algal growth and decrease dissolved oxygen in lakes, which could lead to more widespread low to anoxic conditions, directly affecting walleye's important deep water prey species such as cisco.

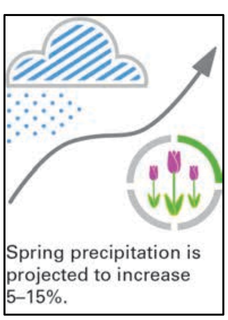


The occurrence of continued *later* freeze-up and *earlier* ice-out is likely assured by the 2050s. Currently, early ice out doesn't substantially affect recruitment of that year class, but very late ice-out often correlates with poor or failed year classes. It is not known to what extent photoperiods interact with ice-out conditions and water temperature to influence the timing of spawning. These complexities point to walleye potentially having some limited ability to adjust to earlier ice out conditions, but if ice out conditions change significantly, this could lead to major disruptions to walleye. Moreover, shifted spawning times may create a mismatch in timing with prey, in particular the availability of prey for walleye fry such as zooplankton.





The interaction between climate change and lake levels is not certain: while the overall warming of air and water will likely increase evaporation on the lakes and decrease lake levels, these decreases may be offset by increases in precipitation.[96] By the 2050s, average annual precipitation is expected to increase by 3-12% in the region. Moving past the projections of a general increase to annual precipitation, confounding factors for overall lake levels include the high variability of cycles of precipitation and dry periods. Extreme precipitation event days (days with more than 1" of precipitation) for the region are projected to increase 20-40% by the 2050s. Since walleye utilize rock and gravel shorelines and reefs in lakes for spawning, fluctuations in lake level could restrict access to these sites and reduce the quality of these sites through siltation and erosion.



Walleye utilize rivers in both inland settings and along Lake Superior (St. Louis River and Pigeon River) for spawning in the spring. The projected alteration in timing and amounts of precipitation will induce a greater flux in river flows during this season. Spring precipitation is projected to increase 5-15% in the region by the 2050s. High velocity stream flow can prevent fish passage to spawning grounds, increase organic matter which can smother eggs, and sweep eggs downstream into unsuitable rearing habitats. Low stream flows can restrict access to spawning areas and leave rearing habitat too warm and shallow. Both of these situations may compromise walleye spawning success and decrease survival rates.

[95] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[96] ibid

Overall, walleye may see some short-term population gains as northern inland lakes and Lake Superior waters warm. However, these gains may come at the cost of increased native species (such as bass), increased invasive species populations, and disruption of the food chain, including impacts to walleye prey species like cisco, which are not as capable of adapting to warmer waters. Conversely, prey species such as yellow perch may do well under climate change conditions and increase food availability for walleye. These complexities defy easy projections of future walleye predator/prey interactions. Larger seasonal changes in temperature and changes to freeze-up and ice-out dates on lakes could impact the timing and success of walleye spawning, though the implications of those changes are not yet well understood.

4.6.1.2 Walleye Vulnerability Assessment Results

Based on these factors, it was determined that walleye are somewhat sensitive (S2) to changes in climate and are mostly able to adjust and adapt to projected impacts (AC3). These results indicate that ***walleye have a medium-low vulnerability to changing climate conditions***.

4.6.1.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of walleye within the 1854 Ceded Territory and within reservations.

Adaptation Strategies to Address Climate Impacts to Walleye	
Collaboration	• Comment and consult on Minnesota Department of Natural Resources (MNDNR) lake plans and regulations (management plans and harvest regulations). • Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on walleye. • Improve communication between water resource managers and fisheries managers. • Legally secure water rights/agreements for in-stream flow.
Conservation, Preservation, and Maintenance	• Improve enforcement of fishery regulations. • If summer water temperatures in a lake remain < 28°C (82°F) in the hypolimnion for consecutive years, consider the lake to be habitable for walleye and maintain the current fish community. If summer temperatures are greater than a certain threshold (e.g., > 28°C (82°F)) in the hypolimnion for consecutive years, consider altering the fish community to a warmer water assemblage. • If surface water temperatures in a river remain below a certain threshold (e.g., < 30°C (86°F)), continue with walleye management. If surface water temperatures reach above a certain threshold (e.g., > 30°C (86°F)), re-evaluate walleye management practices, examine thermal refuges, and consider management of warmer water species like northern pike or smallmouth bass. • Consider limiting the number of anglers or the harvest size, on lakes near the thermal thresholds for walleye, or other lake-by-lake management strategies utilizing climate change variables. • Limit or prevent invasive fish species that compete with walleye. Remove or control invasive fish species. • Reduce non-climate stressors like pollution and fishing pressure on walleye: expand the restoration or enhancement of riparian buffer zones around key lakes and streams to limit

	agricultural run-off or other non-point source pollution that would degrade water quality. • Enhance or restore riparian vegetation in degraded areas to protect water quality and temperature. • Explore landscape water retention projects to protect habitat against extreme runoff events and low flow/high temperature events (e.g. increase and/or reconnect floodplain habitat to streams and rivers). • On regulated streams, pulse flows during critical times (e.g. lower flows coupled with high temperatures), sourcing from lower in the thermocline.
Education	• Emphasize angling for subsistence as opposed to sport. This includes promoting the harvesting of fish caught by anglers as opposed to trophy fishing. • Provide information on the harvesting of alternative fish species for subsistence.
Monitoring and Assessment	• Complete/continue walleye fisheries assessments (which are regularly conducted in the spring and fall). This includes continuing or expanding intensive monitoring of populations health and habitat. • Complete fishery assessments for other species (ex. smallmouth bass) to determine changes in fish assemblage. • Conduct water temperature monitoring (especially in the smaller or more southerly lakes in the 1854 Ceded Territory). • Monitor ice-out dates and length of ice cover season. • Monitor the prey base of walleye in key lakes (e.g., cisco, and others). • Identify refuge lakes that have cool water and the appropriate habitat conditions to support walleye. • Start tracking phenology of prey species that are beneficial for walleye growth and survival.
Restoration	• Evaluate future stocking plans and their use of deep and more thermally stable lakes. • Reduce barriers to movement between lakes and streams - where appropriate, identify, prioritize, and remove barriers. • Enhance lakes or streams by creating off-channel or wetland fed streams that provide higher water flows and lower temperatures during the summer. • Develop propagation capacity for restoration activities.

4.6.2 Lake Sturgeon – Focus Species


Figure 25: Lake sturgeon, image courtesy of the 1854 Treaty Authority.

Lake sturgeon are an important cultural and spiritual species within the 1854 Ceded Territory and across reservations, serving as one of the original head clans. Lake sturgeon currently exist in Lake Superior, Pigeon River, St. Louis River, the Kettle River system, and US/Canada border waters running along the 1854 Ceded Territory boundary. Historically, sturgeon had strong populations in the 1854 Ceded Territory and across most reservations, but these populations were diminished over the last half-century through a combination of pollution (especially in the St. Louis River before the Clean Water Act), overharvesting, and alterations to hydrology from logging and dams. Water quality improvements, spawning habitat restoration, and stocking have led to a recovering lake sturgeon population in the St. Louis River. Evidence of this recovering population has been observed in the form of documented spawning activity and captures of naturally produced larval and juvenile lake sturgeon. Adult sturgeon have been observed spawning below the Fond du Lac dam and larval sturgeon were observed in 2011 and 2013 through drift net surveys conducted by Fond du Lac and 1854 Treaty Authority fisheries staff. A naturally produced 1 year old sturgeon was also captured with trawling gear by 1854 staff in 2015.

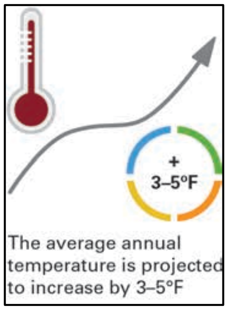
Lake sturgeon are considered a 'cool-water' fish but also thrive in water temperature (low 50°F-mid 60°F) higher than most of its current habitat. Female sturgeons often do not reach sexual maturity until 24-26 years, while males often reach sexual maturity between 8-12 years. Spawning occurs on clean gravel shoals and stream rapids from April to June. Females can live to be between 80-150 years while males typically live to 55 years.[97] These unique qualities make sturgeon even more vulnerable to environmental impacts as they take longer to recover from failed year-classes.

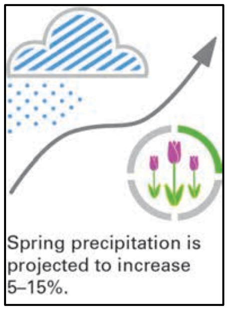
4.6.2.1 Climate Threats to Sturgeon

Existing Conditions: The recent focus on restoring sturgeon populations has been on the reduction of non-climate stressors including: water quality improvements, spawning habitat restoration, and stocking. There are indications that sturgeon could benefit from warmer water temperatures, but this has not been linked to any recent gains in sturgeon populations. Compared to their historical presence, many populations of lake sturgeon have been extirpated or represent remnant populations; therefore, on the whole, their populations are quite compromised.

[97] U.S. Fish and Wildlife Service, 2016. Lake sturgeon biology and population history in the great lakes. Accessed: http://www.fws.gov/midwest/sturgeon/biology.htm

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. Lake Sturgeon can thrive in a water temperature range that is warmer than most of its current habitat. Therefore with the exception of the shallowest inland lakes and rivers, the projected near-term warming may extend the growing season and increase productivity for sturgeon, although indirect impacts in timing of reproduction (e.g. if sturgeon spawned earlier in the spring) and overall ecosystem health could slow these gains.[98] In addition, the projected alteration in timing and amounts of precipitation could induce a greater flux in river flows. By the 2050s, spring precipitation is expected to increase by 5-15%, while summer precipitation is expected to increase 0-5% for the region. If these changes instigate more flooding in spring or summer, it could impact fry survival or dislodge eggs, pushing both downstream. If precipitation changes lead to lower river levels, rock bars for spawning could become 'perched' and inaccessible to spawning fish, along with reducing overall habitat. Similar to walleye, sturgeon eggs would also be smothered/buried with increased sedimentation from extreme events.





4.6.2.2 Sturgeon Vulnerability Assessment Results

Based on these factors, sturgeons have a relatively high sensitivity (S3) to climate change but will be mostly able to adapt (AC3) to these changes. This means that ***sturgeon have a medium vulnerability to climate change***.

4.6.2.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of sturgeon within the 1854 Ceded Territory and within reservations.

Adaptation Strategies to Address Climate Impacts to Sturgeon	
Collaboration	• Improve communication between water resource managers and fisheries managers. • Communicate and consult on Minnesota Department of Natural Resources (MNDNR) fishery plan as it relates to sturgeon.
Conservation, Preservation, and Maintenance	• Continue efforts to sustainably manage harvest, including developing and enforcing harvest regulations. • Continue sea lamprey control and monitoring efforts. • Target invasive species control efforts (especially for round goby) in those areas with sturgeon spawning beds. • Explore landscape water retention projects to protect habitat against extreme runoff events and low flow/high temperature events (e.g. increase and/or reconnect floodplain habitat to streams and rivers). • On regulated streams, pulse flows during critical times (e.g. lower flows coupled with high temperatures), sourcing from below the thermocline.
Education	• Conduct education on the history and the overall importance of sturgeon.

[98] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.

Monitoring and Assessment	• Work collaboratively with other partners to actively monitor lake sturgeon (Lake Superior sturgeon assessment, trawling surveys, larval drift netting, radio tagging, etc.). This includes expanding existing monitoring for indicators of populations' health. • Continue to monitor environmental conditions (e.g. water level, flow rate, water quality, temperature) especially in the smaller or more southerly rivers in the region.
Restoration	• Explore and implement restoration opportunities (ex. Fond du Lac restoration work). • Reduce non-climate stressors like pollution: expand the restoration or enhancement of riparian buffer zones around key lakes and streams to limit agricultural run-off or other non-point source pollution that would degrade water quality, ensure water quality standards are met and enforced. • Reduce barriers and/or modify barriers to movement between lakes and streams - where appropriate, identify, prioritize and remove barriers. • Enhance lakes or streams by creating off-channel or wetland fed streams that provide higher water flows and lower temperatures during the summer. • Participate in or implement habitat improvement projects such as spawning locations.

4.6.3 Brook Trout


Figure 26: Brook trout. Source: nrri.umn.edu

Brook trout are one of two trout species (the other being lake trout) that are native to the Great Lakes Basin. They were once prevalent but are no longer abundant within the 1854 Ceded Territory or on reservations. Brook trout are a "cold-water" species, needing water temperature less than 68°F to survive. They do, however, have the ability to tolerate warmer waters for brief periods of time.[99] Because of this temperature preference, they are generally restricted to habitats of cold, fast flowing streams and tributaries to Lake Superior. In many of the Lake Superior north shore tributaries where brook trout reside, the steep streams lack consistent groundwater inputs and are therefore more "flashy" as they rise and fall with surface water run-off. Since the mid-late 1800s, brook trout populations have been impacted by habitat alterations (e.g. culverts and riparian development, beaver dam construction, logging, and forestry management practices), competition from non-native fish species (e.g. rainbow trout), and overfishing. In more recent years, it has been reported that some lakes that used to support brook trout have warmed to the point that they create thermal stress for the fish.[100]

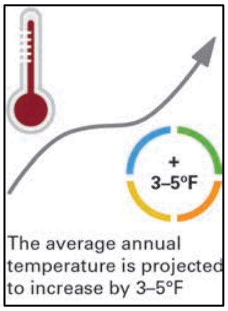
Brook trout are a fall-spawning fish (September-October) whose eggs are deposited in clean, well-oxygenated gravels,[101] which benefit from the protection of winter ice cover and its mediating effects on temperature, turbulence, wave action, and storms.[102] Their preference for cooler water temperatures makes them more sensitive to a warming climate, especially when that warming occurs in conjunction with altered precipitation patterns that affect the timing and flow of streams.

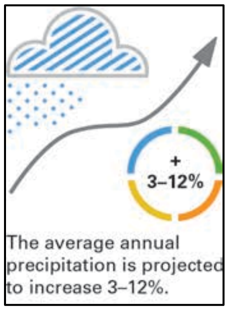
4.6.3.1 *Climate Threats to Brook Trout*

Existing Conditions: Brook trout continue to experience impacts from habitat loss and competition from stocked non-native fish species, with no expected change in those trends in the near term. Their low population numbers and thermal and habitat preference suggests an overall weakness in their ability to adapt to future changes in climate. Warming is being noticed in streams and tributaries that flow into Lake Superior along the north shore, a trend expected to continue under climate change. Current low flows during the fall in brook trout streams are leading to more sporadic recruitment, and have been identified as one of the biggest current threats to brook trout rehabilitation.[103]

[99] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
[100] Grand Portage Band of the Lake Superior Chippewa. 2015. Climate Change Vulnerability Assessment.
[101] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
[102] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[103] Per fisheries subject matter experts within the 1854 Ceded Territory and Reservations

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. The warming temperatures and associated likely reduction in ice cover will affect the overall vitality of brook trout and the survival of their eggs and young trout. However, the actual amount of warming in streams depends on the interaction of air temperature and stream flow, the extent of groundwater inputs, the influence of evaporation, and changing precipitation timing and intensity. By the 2050s average annual precipitation is expected to increase by 3-12% in the region. Extreme precipitation event days (days with more than 1" of precipitation) for the region are also projected to increase 20-40% by the 2050s, which can impact streambed habitat by increasing sediment transport and scouring of spawning grounds during high flows, inhibiting fish passage, and heightening water temperatures during low flow periods.





4.6.3.2 Brook Trout Vulnerability Assessment Results

Based on these factors, it was determined that brook trout have a high sensitivity (S4) to climate change, and a very low ability to adapt (AC1). This means that ***brook trout are highly vulnerable to changing climate conditions***.

4.6.3.3 Adaptation Strategies

Detailed adaptation strategies were not developed for brook trout. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of brook trout to climate change.

1) Improve identification and modeling of brook trout habitat that would most benefit from restoration.
2) Improve identification and modeling of brook trout habitat that would provide the highest conservation benefit and could be used as refugia under the stresses of a changing climate.
3) Work with the Minnesota Department of Natural Resources and other entities to reduce stocking efforts of non-native fish species that compete with brook trout for food and habitat.
4) Protect a source pool of genetics (e.g. Isle Royale) for potential future enhancement efforts.
5) Improved management and restoration for healthy riverine forests to ensure slow spring snowmelt and gradual runoff during summer and fall rains, as well as shade cover to maintain cool water temperatures.[104]
6) Improved groundwater management and aquifer recharge around brook trout streams.[105]
7) Maintain conservative harvest regulations to protect brook trout populations from angling.
8) Enhance brook trout populations through stocking of genetically relevant strains to assist in recovery/maintenance goals.
9) In the event there are indications of a collapse of a cold-water species (e.g. brook trout) from a system reaching/surpassing their critical temperature threshold, consider shifting management of the system to cool water species (e.g. walleye and yellow perch).
10) Monitor environmental conditions (e.g. water level, flow rate, water quality, temperature).
11) Understand and map where groundwater inputs are providing cold water habitat.

[104] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[105] ibid

4.6.4 Northern Pike

Figure 27: Northern Pike. Source: Michigan Sea Grant

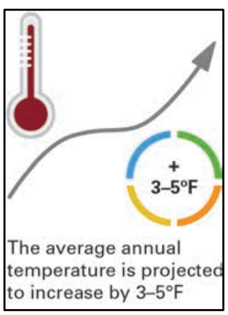
Northern pike are a fish native to the 1854 Ceded Territory and reservations, and perhaps second only to walleye in consumption by band members. Northern pike spawn in seasonally flooded shallow, marshy bays in lakes or rivers, subject to influence by spring snowmelt. Northern pike have high reproductive potential (fecundity). They lay adhesive eggs on vegetation in early spring, just after ice-out in water temperatures 39-52°F, the eggs hatch in two weeks and if not already within bays in lakes, the fry move downstream to lakes.[106]

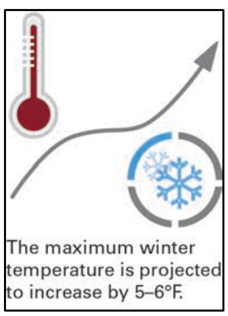
Northern pike have a preference for cool water but also thrive in a temperature range that is warmer than most of its current habitat. Pike populations benefit from a broad and opportunistic diet and reside in both inland lakes and river systems.

4.6.4.1 Climate Threats to Northern Pike

Existing Conditions: Northern pike are currently affected by management strategies and trophy regulations (high density populations are often stunted in size and can reduce angler buy-in for size restrictions). Current climate and habitat conditions are favorable for northern pike.

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3^{o}-5^{o}F. Northern pike have a preference for cool-water but are able to survive in a temperature range that is warmer than most of its current habitat (e.g. the species is currently experiencing rapid growth in waters around 71^{o}F). This indicates that, in the near term, warming temperatures could extend the growing season for northern pike. However, climate-related impacts to northern pike food sources such as cisco (which thrive at a temperature threshold lower than 62^{o}F) could offset these gains.[107] A reduction in spring snowpack or earlier spring snowmelt could lead to a spring drought in the shallow, marshy bays where the northern pike spawn. Spawning grounds could also become too shallow or inaccessible during spring drought or the water could become too warm and anoxic. Additionally, invasive species like rusty crawfish can further reduce vegetation needed for habitat. By the 2050s, average winter temperatures in the region are expected to increase by 5^{o}-6^{o}F. Decreased ice duration in the winters would reduce the protection it offers and the moderating effect it has on temperature. Timing and amounts of seasonal precipitation could disrupt the predator/prey interactions for survival of pike in larval and fry stages.





4.6.4.2 Northern Pike Vulnerability Assessment Results

Based on these factors, it was determined that northern pike are moderately sensitive (S2) to climate change and will mostly be able to adapt (AC3) to climate-related impacts. This gives ***northern pike a medium-low vulnerability to climate change***.

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[106] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf

[107] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.

4.6.4.3 Adaptation Strategies

Detailed adaptation strategies were not developed for northern pike. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of northern pike to climate change.

1) Monitor the health of northern pike population and implement more aggressive adaptation strategies if the population begins to decline.
2) Evaluate and enforce harvest regulations (size and limits) in relation to subsistence needs and the exercise of treaty rights.
3) Communicate and consult on Minnesota Department of Natural Resources (MNDNR) fishery plans and management as it relates to northern pike.
4) Comment on MNDNR lake plans and regulations (management plans and harvest regulations).
5) Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on northern pike.
6) Improve communication between water resource managers and fisheries managers.
7) Legally secure water rights/agreements for in-stream flow.
8) Improved management and conservation of spawning areas in seasonally flooded marshes and lake shore areas.
9) Improve enforcement of fishery regulations.
10) Limit or prevent invasive fish species that compete with northern pike.
11) Reduce non-climate stressors like pollution and fishing pressure on northern pike: expand the restoration or enhancement of riparian buffer zones around key lakes and streams to limit agricultural run-off or other non-point source pollution that would degrade water quality.
12) Enhance or restore riparian vegetation in degraded areas to protect water quality and temperature.
13) Explore landscape water retention projects to protect habitat against extreme runoff events and low flow/high temperature events (e.g. increase and/or reconnect floodplain habitat to streams and rivers).
14) On regulated streams, pulse flows during critical times (e.g. lower flows coupled with high temperatures), sourcing from lower in the thermocline.
15) Emphasize angling for subsistence as opposed to sport. This includes promoting the harvesting of fish caught by anglers as opposed to trophy fishing.
16) Educate the public about the importance of sustainable fishing techniques and the importance of northern pike to lake ecosystems.
17) Encourage the harvesting of alternative fish species for subsistence.
18) Monitor northern pike populations to see if there is a need for some type of special regulation.
19) Monitor the prey base of northern pike in key lakes (e.g., tullibee and others).
20) Identify refuge lakes that have cool water and the appropriate habitat conditions to support northern pike.
21) Monitor lakes for shifting stratification.
22) Start tracking phenology of prey species that are beneficial for northern pike growth and survival.
23) Evaluate future stocking plans and their use of deep and more thermally stable lakes.
24) Reduce barriers to movement between lakes and streams - where appropriate, identify, prioritize, and remove barriers.
25) Enhance lakes or streams by creating off-channel or wetland fed streams that provide higher water flows and lower temperatures during the summer.

4.6.5 Cisco

Cisco are a ‘cold water’ pelagic (i.e. suspended in the water column) fish species. Cisco require adequate dissolved oxygen and begin to experience oxythermal stress when oxygen levels drop to below 3.0 mg/L.[108] Cisco are broadcast spawners over shallow gravel bars and reefs in depths of 3-9 feet, such as the nearshore area of Lake Superior, usually spawning in November when water temperatures are in the low 40^{o}F range. Cisco feed on invertebrates, plankton, and small fish.[109] Juvenile cisco benefit from the protection of ice cover on lakes and its protection and moderation of temperature and turbulence during the winter.


Figure 28: Cisco. Source: files.dnr.state.mn.us

Cisco were a heavily harvested commercial species during the early 20th century in Lake Superior with harvest peaking in the 1930-1940s and becoming greatly reduced by the 1970s.[110] Overharvesting was a significant driver of adult population dynamics. In the 1960s and 1970s, rainbow smelt populations increased in Lake Superior and further reduced cisco populations. Recent reductions of rainbow smelt have been beneficial to cisco recruitment, with cisco populations appearing to be increasing.[111] As such, cisco continue to be a species of commercial interest in Lake Superior, with some management agencies pushing for sustainable harvest of adults.

4.6.5.1 Climate Threats to Cisco

<u>Existing Conditions in Inland Lakes</u>: Research shows that cisco are sensitive to warm surface water temperatures and low levels of dissolved oxygen. For example, in a Minnesota lake outside of the 1854 Ceded Territory (Mille Lacs Lake), their decline has been linked to warmer waters with extended periods of low dissolved oxygen levels.[112] Die offs of cisco have been noted at the height of summer due to a combination of high productivity, high temps, and low dissolved oxygen. The summer of 2006 saw large cisco mortality events in 18 lakes across Minnesota, one of which was in the 1854 Ceded Territory.[113] In general, recent climate conditions have led to earlier ice-off dates and warmer temperatures for inland lakes. Some estimates project that cisco could be lost in 30 to 40 percent of inland lakes in Minnesota, with shallow lakes in central and south-central Minnesota appearing to be the most vulnerable.[114]

<u>Existing Conditions in Lake Superior</u>: Recruitment of cisco in Lake Superior is dependent on factors such as ice cover, temperature, wind, and timing of food resources. Recruitment of cisco has been very unstable in Lake Superior over recent decades, with the current fishery being supported by a few strong year classes. In the short-term, some experts think Lake Superior may not be as vulnerable to changes in water temperatures and dissolved oxygen owing to its deep, cold waters. However, Lake Superior has

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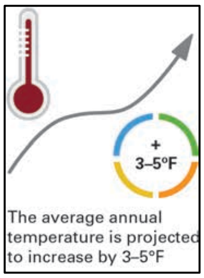
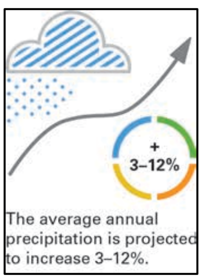
[108] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[109] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
[110] ibid
[111] Minnesota Department of Natural Resources, Division of Fish and Wildlife, Fisheries Management Section, 2006. Fisheries management plan for the Minnesota waters of Lake Superior. Special publication 163. Available: http://files.dnr.state.mn.us/areas/fisheries/lakesuperior/lsmpfinalplan2006.pdf
[112] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[113] University of Minnesota, St Anthony Falls Laboratory. “Will lake warming in Minnesota drive cold-water fish to extinction?” Available: http://www.safl.umn.edu/featured-story/will-lake-warming-minnesota-drive-cold-water-fish-extinction
[114] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.

seen rapid warming since 1981 at a rate of 9°F per century. This warming is faster than the surrounding inland air temperatures and the associated increase in evaporation, combined with low precipitation, led to record low water levels on the lake in the fall of 2007.[115] The lake also experiences high wind speeds, which can drive complex changes in variables contributing to water warming. Current research is tracking the less frequent strong year classes in the lake and assessing their occurrence and potential correlation with changes in temperature and ice cover.

<u>Projected Climate-Related Impacts on Inland Lakes</u>: By the 2050s, average annual temperatures in the 1854 Ceded Territory and on the reservations are expected to increase by 3°-5°F. Increases in water temperature will alter the thermocline depth, limiting the suitable habitat in the water column and decreasing cold water refugia. Any warming that drives increases in primary productivity in lakes will likely also decrease water quality. Similar environmental changes that create eutrophication or algae blooms would also impact cisco by decreasing the dissolved oxygen in the water column. Heightened temperature in nearshore spawning areas may alter the timing and survivability of the larval hatch. The projected alteration to precipitation timing and amounts could also alter run-off to lakes.



By the 2050s, average annual precipitation in the region is expected to increase by 3-12%. Increased run-off would increase nutrient loading in lakes and decrease dissolved oxygen leading to more widespread anoxic conditions. Any climate-driven increase in invasive species, or population gain by more warm water species, could increase competition and/or predation on cisco. Any continued disruption by invasive zooplankton (such as spiny water flea) may continue to impact cisco populations. Current research suggests that with continued climate warming, by 2100, 460 of the existing 620 designated cisco lakes in Minnesota would no longer support cisco habitat, leaving 131 lakes with 'good' cisco habitat and only 29 lakes with excellent habitat that could be considered a cisco refuge.[116]



<u>Projected Climate-Related Impacts on Lake Superior</u>**:** Under general warming conditions, the timing of cisco's larval hatch is likely to be variable. This could lead to inconsistencies between when cisco hatch and when prey species are available. Cisco diet in Lake Superior is comprised of a significant amount of invasive species such as spiny water flea, and they are likely acting as the only significant predator for this invasive.[117] Other cisco prey includes native zooplankton, which are sensitive to changes in productivity and nutrient levels in the lake. Changes to the timing and amount of ice cover will affect survivorship of larval fish, leading to increased variability in year-class strength.

4.6.5.2 Cisco Vulnerability Assessment Results

Based on these factors, cisco are highly sensitivity (S3) to climate change and have a minimal ability to adapt (AC1). This means that ***cisco are highly vulnerable to changing climate conditions***.

[115] Minnesota Department of Natural Resources, 2011. Climate change and renewable energy: management foundations. Version 1.03. Available: http://files.dnr.state.mn.us/aboutdnr/reports/conservationagenda/crest-ccref.pdf
[116] University of Minnesota, St Anthony Falls Laboratory. "Will lake warming in Minnesota drive cold-water fish to extinction?" Available: http://www.safl.umn.edu/featured-story/will-lake-warming-minnesota-drive-cold-water-fish-extinction
[117] Fisheries and subject matter expert within the 1854 Ceded Territory and Reservations

4.6.5.3 Adaptation Strategies:

Detailed adaptation strategies were not developed for cisco. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of cisco to climate change.

1) Comment on Minnesota Department of Natural Resources (MNDNR) lake plans and regulations (management plans and harvest regulations).
2) Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on cisco.
3) Improve communication between water resource managers and fisheries managers.
4) Improved protective management of harvest on inland lakes and pursuit of sustainable harvest regulations across all jurisdictions in Lake Superior.
5) Control and limit the spread of invasive species (e.g., spiny water flea) in cisco lakes.
6) Investigate development of strategies to support greater propagation capabilities.
7) Improved management of cisco predators (at each life cycle stage), such as more liberal harvest of non-native salmon in Lake Superior.
8) Complete surveys and population monitoring.
9) Improve identification and modeling of cisco habitat that would most benefit from restoration.
10) Improve identification and modeling of cisco habitat that would provide the highest conservation benefit and could be used as refugia under the stresses of a changing climate.
11) Work with the MNDNR and other entities to reduce stocking efforts of non-native salmon species in Lake Superior.
12) Improved groundwater management and aquifer recharge around cisco lakes.
13) In the event there are indications of cisco collapse in a system reaching/surpassing their critical temperature threshold, consider shifting/bolstering management of the system to support cool water prey species.
14) Understand and map where groundwater inputs are providing cold water habitat in cisco lakes.
15) Continue to evaluate the importance of environmental factors in cisco recruitment.

4.6.6 Lake Trout

Lake trout are an important species for band members, and results from an 1854 Treaty Authority survey indicated the third most eaten fish species (after walleye, and just behind northern pike). Lake trout are a valued 'cold water' fish species, requiring well-oxygenated waters (at least 5 ppm or more). Minnesota is the southern extent of the lake trout range. Water temperatures and dissolved oxygen are known to vary together, an important consideration for assessing the impacts of climate change. Most trout lakes are self-sustaining, but some stocking is undertaken to introduce or reintroduce trout and supplement natural production.[118] Trout spawn over clean rocks or boulders at depths of 3 to 260 ft. This spawning takes place in October in 40-50°F water, with eggs hatching in 16 to 20 weeks.[119] As fall spawners, trout eggs benefit from the protection of winter ice cover and its mediating effects on turbulence, wave action, and storm events. In Lake Superior, trout populations were nearly eliminated by the invasive sea lamprey.[120] However, through natural reproduction, improved management strategies, and continued sea lamprey control, the wild lake trout population in Lake Superior is recovering.[121] Lake trout populations are generally stable but harvest has increased in some areas of Lake Superior, including potential overharvest in some near shore waters.

Figure 29: Lake Trout. Source: NPR.

Lake trout rely on sustainable prey populations (such as cisco) for their population vitality. Therefore, alteration to harvest rates and health of the cisco populations will affect lake trout. Trout continue to be preyed on by sea lamprey and compete for prey with non-native salmonids in Lake Superior. Sea lamprey productivity and therefore their parasitism on trout will increase with warming. A control program exists for sea lamprey, which needs to continue in order to help mitigate natural mortality.

Trout of interest to this assessment come in two forms: lean lake trout (residing in inland lakes and nearshore Lake Superior), and siscowet lake trout (endemic to deep offshore regions of Lake Superior). Generally, Lake Superior allows trout more expansive areas for vertical migration in and out of thermal habitats compared to inland lakes.

4.6.6.1 *Climate Threats to Trout*

***Existing Conditions for Lean Lake Trout*:** Water temperature changes and decreasing ice cover duration are already affecting lean lake trout populations in both inland and Lake Superior habitats. In the east-central region of the 1854 Ceded Territory, there have been some notable die-offs of trout during very warm summers.[122] It has been noted that two of the lean lake trout's prey species, cisco and rainbow smelt, have been declining in Lake Superior and inland lakes.

Existing Conditions for Siscowet Lake Trout: This trout has a very high fat content and is only found offshore in Lake Superior in very deep waters (more than 200 feet), which suggests much greater

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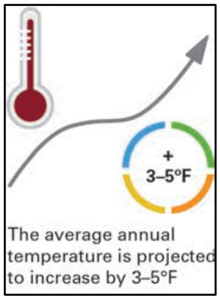
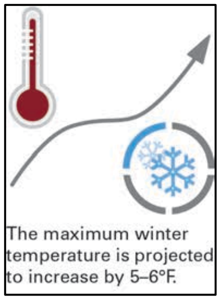
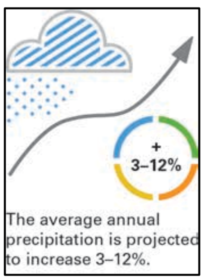
[118] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
[119] ibid
[120] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[121] Minnesota Department of Natural Resources, Division of Fish and Wildlife, Fisheries Management Section, 2006. Fisheries management plan for the Minnesota waters of Lake Superior. Special publication 163. Available: http://files.dnr.state.mn.us/areas/fisheries/lakesuperior/lsmpfinalplan2006.pdf
[122] Per fisheries subject matter experts within the 1854 Ceded Territory and Reservations.

protection from surface water and nearshore warming effects projected under climate change. Siscowet have increased in abundance in recent times and compete with, and even prey on, lean lake trout.[123]

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. Researchers have projected that warmer water temperatures will lead to worsening conditions for lake trout as there is an early onset of lake stratification. In these conditions, trout fry have fewer days to feed on prey species in rapidly warming surface waters.[124] The continued decline of trout prey species like cisco and rainbow smelt is likely with warming waters. Lake ice cover amount, duration, and timing of 'freeze-up' and 'ice-out' dates are projected to continue to decrease and will likely affect trout survivability. By the 2050s, average winter temperatures in the region are expected to increase by 5°-6°F, assuring continued *later* freeze-up and *earlier* ice-out by mid-century. Without protective ice cover, winter storms could lead to high egg mortality and failed year classes.







The projected alteration to precipitation timing and amounts could alter run-off to lakes. By the 2050s, average annual precipitation is expected to increase by 3-12% in the region. Higher amounts of run-off could increase siltation on trout spawning grounds and impact reproduction. Increased run-off would increase nutrient loading in lakes and diminish dissolved oxygen leading to more widespread anoxic conditions. Within inland lakes, there are some estimates that trout could be lost in 30 to 40 percent of inland lakes in Minnesota, with shallow lakes in central and south-central Minnesota appearing to be the most vulnerable.[125]

Lake Superior could offer cold water refugia under increasing temperatures, though ultimately those refugia might not sustain trout if secondary impacts to prey species, lower dissolved oxygen levels, and increased numbers of sea lamprey or other invasive species, occur. Increased water temperatures increase the metabolic rates of sea lamprey, which increases their overall consumption of other fish. Where temperatures do warm on the lake, lean lake trout may be able to expand their habitat, though the larger changes to prey species and competitors (like non-native salmonids who may be better suited to utilize these habitats), could offset these gains.

4.6.6.2 Lake Trout Vulnerability Assessment Results

Based on these factors, it was determined that lake trout are extremely sensitive to climate change (S3) and are minimally able to adapt to projected impacts (AC1). This means that ***lake trout have a high vulnerability to climate change***.

[123] Hansen, M. J. [ED.]. 1996. A lake trout restoration plan for Lake Superior. Great Lakes Fish. Comm. 34 p. Available: http://www.glfc.org/pubs/SpecialPubs/LakeTroutRepSup.pdf
[124] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[125] ibid

4.6.6.3 Adaptation Strategies

Detailed adaptation strategies were not developed for lake trout. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of lake trout to climate change.

1) Improved management of lake trout competitors, such as more liberal harvest of non-native salmon in Lake Superior.
2) Work with the Minnesota Department of Natural Resources (MNDNR) and other entities to reduce stocking efforts of non-native salmon species in Lake Superior.
3) Improved protective management of harvest for inland lakes and pursuit of sustainable harvest regulations across jurisdictions in Lake Superior.
4) Work with state and federal regulators to continue control efforts for sea lamprey in Lake Superior, taking into account changing climate conditions.
5) Explore opportunities for increased collaborative stocking and enhancement programs outside of Lake Superior.
6) Complete or participate in population assessments and monitoring.
7) Communicate and consult on MNDNR fishery plans and management as it relates to lake trout.
8) Consider and implement management activities that benefit prey species (e.g. cisco, rainbow smelt).
9) Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on lake trout.
10) Improve communication between water resource managers and fisheries managers.
11) Control and limit the spread of invasive species in lake trout lakes.
12) Improve identification and modeling of lake trout habitat that would most benefit from restoration.
13) Improve identification and modeling of lake trout habitat that would provide the highest conservation benefit and could be used as refugia under the stresses of a changing climate.
14) Improved groundwater management and aquifer recharge around lake trout lakes.
15) In the event there are indications of a lake trout collapse in a system reaching/surpassing their critical temperature threshold, consider shifting/bolstering management of the system to support cool water species (e.g. walleye and yellow perch).
16) Understand and map where groundwater inputs are providing cold water habitat in lake trout lakes.

4.6.7 Lake Whitefish

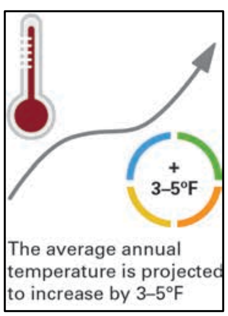
Lake whitefish are a highly valued species, the most harvested fish in Lake Superior, and are likely to face increasing fishing pressure if populations of trout or cisco decline. Whitefish are a benthic (i.e. lake bottom) species that prefer cold waters. Whitefish feed on zooplankton and other fish's eggs. Over the winter whitefish feed on cisco eggs, so their vitality is directly tied to the health of the cisco population.[126] As fall spawners, whitefish eggs benefit from the protection of winter ice cover and its mediating effects on turbulence, wave action, and storm events.[127]

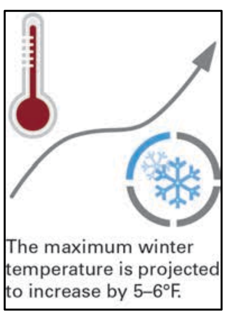
Figure 30: Whitefish. Source: archive.epa.gov

4.6.7.1 Climate Threats to Whitefish

Existing Conditions: Few connections between current changes in climate and whitefish have been identified. What is known is that the invasive sea lamprey parasitizes whitefish in Lake Superior and consistent recruitment failures of whitefish in southern areas of the 1854 Ceded Territory have occurred.[128]

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F, which will likely also lead to increasing water temperatures. This increase will lead to changes to lake temperatures, which will make whitefish recruitment more variable. Altered temperature and precipitation cycles may throw off important timing of relationships between larval whitefish and availability of their prey. Lake ice cover amount, duration, and timing of 'freeze-up' and 'ice-out' dates will surely be altered and these changes will affect whitefish. By the 2050s, average winter temperatures in the region are expected to increase by 5°-6°F (fall and spring temperatures are also projected to increase), assuring continued *later* freeze-up and *earlier* ice-out by mid-century. Without protective ice cover, winter storms could lead to high egg mortality and failed year classes.[129]





In addition, any conditions that increase invasive species population, such as sea lamprey, will likely cause reductions in whitefish populations. Higher water temperatures increase the metabolic rates of sea lamprey, which increases their overall consumption of other fish, which will negatively affect whitefish populations. If climate change reduces commercially harvested species like cisco and lake trout, the demand for lake whitefish will continue to grow.

[126] Fisheries expert with the 1854 Ceded Territory
[127] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
[128] Fisheries expert with the 1854 Ceded Territory
[129] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.

4.6.7.2 Whitefish Vulnerability Assessment Results

Based on these factors, whitefish are highly sensitivity to climate change (S3) and have minimal ability to adapt to projected impacts (AC1). This means that ***whitefish have a high vulnerability to climate change.***

4.6.7.3 Adaptation Strategies

Detailed adaptation strategies were not developed for whitefish. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of whitefish to climate change.

1) Monitor, maintain, and support the invertebrate prey base.
2) Comment on Minnesota Department of Natural Resources (MNDNR) lake plans and regulations.
3) Work with state and federal regulators to continue control efforts for sea lamprey in Lake Superior, taking into account changing climate conditions.
4) Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on whitefish.
5) Improve communication between water resource managers and fisheries managers.
6) Improved protective management of harvest on inland lakes and pursuit of sustainable harvest regulations across all jurisdictions in Lake Superior.
7) Control and limit the spread of invasive species in whitefish lakes.
8) Investigate development of propagation capabilities.
9) Improved management of whitefish predators (at each life cycle stage), such as more liberal harvest of non-native salmon in Lake Superior.
10) Improve identification and modeling of whitefish habitat that would most benefit from restoration.
11) Improve identification and modeling of whitefish habitat that would provide the highest conservation benefit and could be used as refugia under the stresses of a changing climate.
12) Work with the MNDNR and other entities to reduce stocking efforts of non-native salmon species in Lake Superior.
13) Improved groundwater management and aquifer recharge around whitefish lakes.
14) In the event there are indications of a whitefish collapse in a system reaching/surpassing their critical temperature threshold, consider shifting/bolstering management of the system to support cool water or other prey species.
15) Understand and map where groundwater inputs are providing cold water habitat in whitefish lakes.
16) Complete or participate in population assessments and monitoring.
17) Communicate and consult on MNDNR fishery plans and management as it relates to whitefish.

4.6.8 Black Crappie

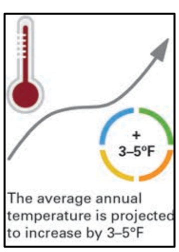
Figure 31: Black crappie. Source: www.infisherman.com.

Black crappie live in lakes across the 1854 Ceded Territory and within reservations. Crappie are utilized by band members, and results from an 1854 Treaty Authority survey indicated that they are the fourth most eaten fish species (after walleye, and just behind northern pike and lake trout). They prefer deep, cool, clear water, though they can also live in stained shallow bogs and low flow systems. Spawning occurs May through June at depths of 1-6 feet as water temps approach the mid-60s Fahrenheit. Males build and guard nests in colonies. Their reproduction is quite prolific and it can lead to stunting among different year classes. Crappie may compete with walleye for food since their diet and feeding behaviors are similar.[130]

4.6.8.1 *Climate Threats to Black Crappie*

Existing Conditions: With little detailed information found on black crappie across the 1854 Ceded Territory, it is helpful to consider the existing conditions in Lake Ontario. Black crappie populations are expanding in Lake Ontario, owing to potentially more favorable environmental conditions and illegal introduction by motivated anglers. The fish have seen rapid gains during El Niño years (i.e. warmer and wetter conditions), which contribute to successful recruitment and strong year classes. In addition, El Niño years add 'space' between the next favorable environmental conditions to help contribute to less competition from other fish species and an overall healthier population of black crappie in Lake Ontario.[131] Although El Niño response provides some insights for black crappie adaptation to warmer and wetter than average climate conditions, it is not immediately translatable to the effects of longer term climate warming.

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. University of Minnesota climate modeling suggests black crappie will see increased abundance in inland lakes under these conditions.[132] In Wisconsin, climate modeling for three different scenarios suggested black crappie would increase its range northwards[133] even with an average temperature increase of 7 to 8°F to air and water temperatures.[134]



[130] Minnesota Department of Natural Resources, 2016. "Crappie biology and identification". Available: http://www.dnr.state.mn.us/fish/crappie/biology.html
[131] Intermedia Outdoors Blog, 2011. "Giant crappies north". Available: http://imomags.com/blog/2011/05/25/giant-crappies-north/
[132] Star Tribune, 2015. "Climate change is a culprit in decline of Minnesota Walleye". Available: http://www.startribune.com/climate-change-is-a-culprit-in-walleye-s-decline/302314741/
[133] Pomplun, S., Lathrop, R., Katt-Reinders, E., 2011. "Managing our future: Getting ahead of a changing climate". Wisconsin Natural Resources Magazine. Available: http://dnr.wi.gov/wnrmag/2011/02/climate.htm
[134] Lyons, J. Predicted effects of water temperatures increases on the distribution of warmwater fishes in Wisconsin streams and rivers [Presentation]. Wisconsin Department of Natural Resources. Available: http://www.umesc.usgs.gov/climate_change/symposium/presentations/lyons_ws-05b_2007_midwest.pdf

4.6.8.2 Black Crappie Vulnerability Assessment Results

Based on this assessment of vulnerability, black crappie are not sensitive to climate change (S0) and will be able to adapt in a beneficial way (AC4). This means ***black crappie have a very low vulnerability to climate change***.

4.6.8.3 Adaptation Strategies

Detailed adaptation strategies were not developed for black crappie. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can utilize to take advantage of black crappie to offset potential losses to other species.

1) Continue sustainable management including harvest.
2) Maintain and support invertebrate prey base. An example of one relevant action is to support terrestrial inputs into lakes with large shoreline buffers.
3) Manage and control invasive species.
4) Complete or participate in population assessments and monitoring.
5) Communicate and consult on Minnesota Department of Natural Resource (MNDNR) fishery plans and management as it relates to crappie.
6) Comment on Minnesota Department of Natural Resource lake plans and regulations.
7) Improve communication between water resource managers and fisheries managers.

4.6.9 Other Fish Species (perch, bluegill, smallmouth bass, largemouth bass, burbot)

Smallmouth bass are a cool-water fish species targeted by anglers. Smallmouth bass build nests in 2-6ft deep areas of sand, firm mud, or gravel, often near cover of wood or boulders. Smallmouth bass spawn in late spring in waters over 60°F, but avoid waters over 85°F and have a lethal threshold of 90°F. Smallmouth bass are well adapted to rivers and, in larger systems, may migrate up to 50 miles or more to congregate in winter resting areas.[135] Anglers typically catch and release bass. This species was introduced to the 1854 Ceded Territory in the late 1800s and early 1900s and has been rapidly expanding its range.[136]

Figure 32: Largemouth Bass. Source: exploreminnesota.com.

Largemouth bass are a warm-water fish species that nests in shallow areas near shore and is typically not targeted directly by Band members. It builds nests in depths of 2-6ft in areas with sand, firm mud, or gravel. It spawns in late spring in waters exceeding 60°F; it thrives in 80°F water and can tolerate water temperatures into the mid 90°F range. It is native to some parts of the 1854 Ceded Territory, though it has been rapidly expanding its range.

Bluegill is a warm water species spawning in early summer in 67-80°F waters. Bluegill build nests in shallow water areas with firm bottoms, often in groups or colonies. Young bluegill rely on heavy vegetation to avoid predators, while larger fish use deeper, more open waters.[137] The bluegill's relatively widespread abundance and size make them a common target of anglers.[138]

Yellow perch occur in lakes, rivers, and streams throughout the 1854 Ceded Territory and within reservations. Perch spawning takes place in the spring (April through early May), when water temperatures reach 45-52°F. Perch are one of the most important food species for walleye and are a target species for some band members.

Burbot are a cold water fish from the cod family found in many northern Minnesota lakes and rivers, including Lake Superior. The burbot spawns in mid-winter into early spring, before the ice is off the water. Spawning occurs in pairs, groups of dozens, or even hundreds, in shallow water over sand or gravel bottoms. There is no nest building or care for the young.[139]

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135 Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
136 Fisheries expert with the 1854 Ceded Territory
137 Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf
138 Moeller, S., 2011. "Species profile: Close-up on the bluegill". Available: http://www.dnr.state.mn.us/minnaqua/speciesprofile/bluegill.html
139 Kurre, M. "Species profile: Close-up on the burbot". Available: http://www.dnr.state.mn.us/minnaqua/speciesprofile/burbot.html

4.6.9.1 Climate Threats to Other Fish Species

Existing Conditions:

Smallmouth bass: In recent years, specifically in northern portions of the 1854 Ceded Territory, the proportion of smallmouth bass in lakes has increased.

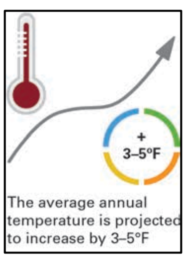
Largemouth bass: Largemouth bass populations have been increasing in distribution and abundance over time in Minnesota lakes. Before 1980, largemouth bass appeared in less than 31% of lakes surveyed by the Minnesota Department of Natural Resources (MNDNR); by 2008 they were persisting in more than 50% of lakes.[140] Some populations have experienced stunted growth due to population densities being too high, and anglers favoring catch and release.

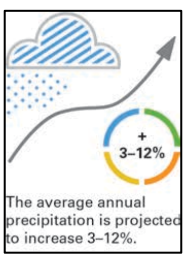
Bluegill: Bluegill abundance has significantly increased over time in Minnesota. They were found in 58% of surveyed lakes throughout the first 3 decades of MNDNR sampling and are now found in 85% of surveyed lakes. These increases have been positively associated with rising air temperatures.[141] Bluegill are now present in all major watersheds of the 1854 Ceded Territory and within reservations.

Yellow perch: Perch are seeing some declines in certain parts of Minnesota, including Cook County.[142] However researchers have found that in years with warmer air temperatures and early on-set of warm surface waters, yellow perch grow bigger and faster than normal.[143]

Burbot: Coldwater fish species (such as burbot) have experienced die offs in Minnesota lakes in the warm summers of 2006 and 2012.[144]

Projected Climate-Related Impacts:





By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. Also by the 2050s, average annual precipitation is expected to increase by 3-12% in the region. These changes will translate into a number of likely impacts for fish species considered in this assessment.

Smallmouth bass: As a cool-water species, smallmouth bass could benefit from increases in productivity under climate change, though productivity can come at a cost to water quality with reduced dissolved oxygen levels in the water column. It is highly unlikely that water temperatures will rise to a threshold detrimental to smallmouth bass by the 2050s.

Largemouth bass: As a warm-water species, largemouth bass could benefit from increases in productivity, though productivity can come at a cost to water quality with reduced dissolved oxygen levels in the water column. It is highly unlikely that water temperatures will rise to a threshold detrimental

[140] Schneider, K.N., 2010. Biological indicators of climate change: Trends in fish communities and timing of walleye spawning runs in Minnesota. A thesis submitted to the faculty of the graduate school of the University of Minnesota. Raymond M. Newman, Advisor. Available: http://www.lccmr.leg.mn/projects/2007/finals/2007_05k_appx_i.pdf

[141] ibid

[142] Persons, S. Fisheries Resource and Issues [Presentation]. Minnesota Department of Natural Resources. Grand Marais. Available: http-//mn.gov/frc/docs/MFRC_NE_Mtg4_Persons_FisheriesResources_2012-05-17.pdf

[143] Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.

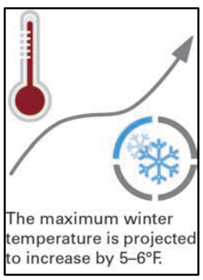
[144] University of Minnesota, St Anthony Falls Laboratory. "Will lake warming in Minnesota drive cold-water fish to extinction?" Available: http://www.safl.umn.edu/featured-story/will-lake-warming-minnesota-drive-cold-water-fish-extinction

to largemouth bass by the 2050s. The projected alteration to precipitation timing and amounts could alter run-off to lakes. Increased run-off would increase nutrient loading and turbidity in lakes, which could impact reproductive success and growth. Conversely, if future climate promotes drought conditions in the spring, it could reduce largemouth bass spawning habitat in shallow nearshore areas.

Bluegill: Under warming air and water temperatures, bluegill will likely expand in northern lakes. In some cases this may be to the detriment of walleye and pike due to increased competition.[145]

Yellow Perch: Under warming air and water temperatures, perch will likely expand in abundance and distribution in northern lakes. This would likely benefit predators such as pike and walleye.[146] Some models suggest this cool-water species could see declines under climate change.[147] These nuanced projections often point to warming effects on different habitats: when warming occurs on a cold northern lake it could increase viable habitat, while in lakes that are shallow and already warm, further warming may reduce perch habitat.[148] Perch habitat on Lake Superior is expected to increase as temperatures warm.[149]

Burbot: Some models suggest this cold water species could see declines under climate change.[150] These declines would most likely be seen in shallow to moderately deep lakes across Minnesota where warming could have a greater impact on water temperature.[151] Burbot spawn under the protective cover of ice, so any reduction in ice cover could be detrimental to spawning success. By the 2050s average winter temperatures in the region are expected to increase by 5^{o}-6^{o}F (fall and spring temperatures are also projected to increase), assuring continued later freeze-up and earlier ice-out by mid-century.



4.6.9.2 Other Fish Species' Vulnerability Assessment Results

Table 6: Fish species categorized as climate winners or climate losers/neutral.

Climate Winners	Climate Losers/ Neutral
• Smallmouth bass • Largemouth bass • Bluegill	• Yellow Perch • Burbot

These fish species were included in this assessment as a group since they are important species, but significant information about their climate-related vulnerability does not exist. As such, they were not assessed through a formal vulnerability exercise. Instead, based on current knowledge, these species are grouped by "Climate Winners" and "Climate Losers/Neutral" designations (Table 6).

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145 Fond du Lac. 2008. Draft Integrated Resource Management Plan Fisheries Climate Change. Provided as input to this project.
146 ibid
147 Star Tribune, 2015. "Climate change is a culprit in decline of Minnesota Walleye". Available: http://www.startribune.com/climate-change-is-a-culprit-in-walleye-s-decline/302314741/
148 Minnesota Department of Natural Resources, 2011. Climate change and renewable energy: management foundations. Version 1.03. Available: http://files.dnr.state.mn.us/aboutdnr/reports/conservationagenda/crest-ccref.pdf
149 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: http://www.michigan.gov/documents/deq/Lake_Superior_Climate_Change_Impacts_and_Adaptation_445176_7.pdf
150 Star Tribune, 2015. "Climate change is a culprit in decline of Minnesota Walleye". Available: http://www.startribune.com/climate-change-is-a-culprit-in-walleye-s-decline/302314741/
151 Minnesota Department of Natural Resources, 2011. Climate change and renewable energy: management foundations. Version 1.03. Available: http://files.dnr.state.mn.us/aboutdnr/reports/conservationagenda/crest-ccref.pdf

4.6.9.3 Adaptation Strategies

Detailed adaptation strategies were not developed for other fish species. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of other fish species to climate change.

1) Improve landscape management and control of runoff and nutrient loads in certain systems.
2) Improved harvest management to better control population density of these species.
3) Outreach programs to anglers to consume more of these species (e.g. 8+ inch bass).
4) Manage and control invasive species.
5) Complete or participate in population assessments and monitoring.
6) Communicate and consult on Minnesota Department of Natural Resources (MNDNR) fishery plans and management.
7) Comment on MNDNR lake plans and regulations (management plans and harvest regulations).
8) Strengthen partnerships with the MNDNR and universities to continue to evaluate and monitor climate change impacts on these species.
9) Improve communication between water resource managers and fisheries managers.
10) In systems where climate change directly or indirectly leads to poor success in maintaining traditionally preferred fisheries (i.e., walleye/trout), pursue management options utilizing alternative fish species that will do well under new climate regimes.

4.7 Forestry

		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
Adaptive Capacity: High ↓ Low	AC4					
	AC3				• Northern Red Oak, Basswood, and Chokecherry • Eastern White Pine	
	AC2			• Black Ash • **Sugar Maple**		• Quaking Aspen
	AC1					
	AC0					• **Paper Birch** • Northern White Cedar

The bands exercising treaty rights within the 1854 Ceded Territory have a cultural and spiritual relationship with forests going back centuries. The bands influenced and managed forests and, over time, experienced various small-scale, natural shifts in the region's forests. From the bands' initial presence in the region, forest resources were (and remain) fundamental to traditional building techniques and technologies, cultural and spiritual practices, and subsistence. The Ojibwe have utilized forest resources for making baskets, canoes, shelter, and for cooking, while the forest ecosystems continue to support plants and animals of central cultural importance to the bands.

In the 19th century, 50-66% of Minnesota was forested. Generally speaking, this forest cover was either deciduous or coniferous: deciduous forests are found in areas of more productive soils and coniferous forests in less favorable locations with poorer soil.[152] According to the US Forest Service, forest species across Minnesota at this time included:

> *On the uplands, jack pine dominated the droughty, fire-prone outwash plains, beach ridges, and thin soils on bedrock. White pine and red pine dominated pitted outwash and sandy moraines that burned less frequently and less intensely than the outwash plains. Aspen-birch forests occurred intermittently throughout upland areas. The glacial lake plains all supported extensive areas of swamp and peatland dominated by black spruce and tamarack, along with some northern white-cedar, balsam poplar, paper birch, and aspen (pg. 13).*[153]

Today, forests cover approximately one third of Minnesota. This decline in forest cover occurred during the late 1800s and early 1900s when half of the state's forests were lost to lumbering and conversion to agriculture. The logging in this period removed most of the white pine and white cedar, with the returning regenerating forest being dominated by paper birch and quaking aspen. However, over the last 40 years, the extent of Minnesota forests has been basically stable, with the northern half of the state losing 200,000 acres and the southern half gaining 600,000 acres over the period 1977-2008.[154]

Throughout the process of this project tribal staff foresters prioritized seven tree species for a review of projected climate change impacts and adaptation strategy selection: paper birch, black ash, northern white cedar, quaking aspen, northern red oak and American basswood, eastern white pine, and sugar maple. Detailed adaptation strategies were developed for sugar maple and paper birch and general strategies for the remaining species.

[152] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[153] ibid

[154] ibid

4.7.1 Paper birch – Focus Species

Figure 33: Birch tree, courtesy of 1854 Treaty Authority.

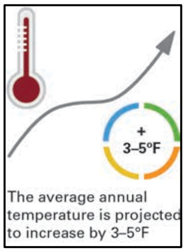
Paper birch are considered an important cultural resource, representing a central material for basketry, canoes, shelter, and a preferred firewood. Paper birch also provides important habitat and browse for valued subsistence species such as moose. Unfortunately, its overall health across the 1854 Ceded Territory and within reservations has been declining in modern times. This decline has been attributed to the age of the trees in combination with fluctuations in climate and pests, including impacts from things such as warming temperatures, drought, fire, and the bronze birch borer. Past forest management practices have also affected paper birch stands as typical logging would often include the harvesting of paper birch and their neighboring aspens together. As the forest grew back post-harvest, aspen would generally outcompete paper birch. Other non-commercial paper birch stands considered for management have aged significantly, impeding easy regeneration.

4.7.1.1 *Climate Threats to Birch*

Existing Conditions: Paper birch trees across the 1854 Ceded Territory and within reservations have experienced declines, much of which is attributed to climate variability over the last 10-15 years. Changes such as: extended periods of dryness, changing fire seasons, warmer summers, limited snow cover (which can affect seed distribution), and increased opportunity for insect infestation (mainly bronze birch borer), have all occurred in recent years. These impacts are occurring alongside the described impacts associated with land use change and forest management.

Along the north shore of Lake Superior over 80% of paper birch forests are old and dying and little regeneration is occurring. Regeneration has been impeded by: the lack of older pine and cedar to provide seeds, heavy competition from native grasses, and browsing pressure from deer. In response to this situation, a group of federal, state, county, and non-governmental representatives, private landowners, and the Grand Portage Band, have partnered together as the "North Shore Forest Collaborative" to begin restoration efforts. The current plan for this restoration includes efforts to assist paper birch (and other tree species) in adapting to climate change through the identification of north facing slopes (i.e. "cold pockets") that could act as refuge for birch and healthy birch stands which could offer stock for regeneration.[155]

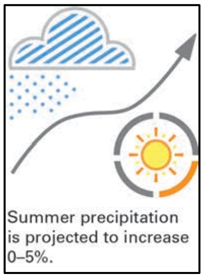
Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded



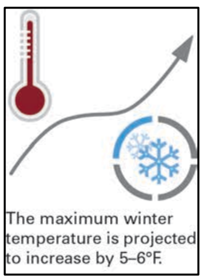
Territory and across the reservations are expected to increase by 3°-5°F. Many species of birch, such as paper birch, are boreal species with preference for colder temperatures. It is expected that boreal tree species, already at the southern limit of their range, will have difficulty with the overall warming that is expected in the region. The USFS has found in their modeling that by 2100 yellow birch could experience a large increase in population under more mild climate change, while both paper birch and yellow birch would see

[155] http://northshoreforest.org/

decreases under more severe climate change.[156] In the 1854 Ceded Territory, modeling for Grand Portage National Monument by the National Park Service (NPS) suggests a broad decrease in suitable habitat for both paper birch and yellow birch due to a changing climate.[157]



By the 2050s, summer precipitation is expected to increase 0-5% for the region, and annually, days above 95°F are projected to increase 0-10 days on average by the same decade. These conditions will likely shorten the summer fire return interval, which would negatively impact paper birch since they succeed best with longer return fire intervals that allow the forest to be shaped by small scale disturbances such as wind, insects, and disease.[158] Since paper birch relies on fire to scarify the forest floor and destroy overstory, an reduction in fire potential could negatively impact birch growth and regeneration.



By the 2050s, average winter temperatures in the region are expected to increase by 5°-6°F, pointing to a continued reduction in winter snowpack, which will affect paper birch seed distribution. The lack of insulating snow could allow paper birch roots to be damaged by freeze and thaw cycles.[159] Increased presence of herbivores, such as deer, expanding northwards into paper birch stands may increase browsing pressure on vulnerable birch saplings. A changing climate may also bring additional pest pressures, such as the gypsy moth, which may contribute to birch defoliation. Paper birch are a preferred species for gypsy moth, which are now present throughout most of the 1854 Ceded Territory. Lake and Cook counties have been under a gypsy moth quarantine since 2014.

4.7.1.2 Birch Vulnerability Assessment Results

Based on these factors, paper birch have a high sensitivity to changing climate conditions (S4) and a low ability to adapt to climate-related impacts (AC0). This finding suggests that ***birch are highly vulnerable to climate change***.

4.7.1.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of birch within the 1854 Ceded Territory and reservations.

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[156] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[157] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf

[158] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[159] ibid

Adaptation Strategies to Address Climate Impacts to Paper Birch	
Collaboration	• Review/consult on timber management with federal, state, county and tribal agencies.
Conservation, Preservation, and Maintenance	• When harvesting a paper birch stand, be sure to leave scattered seed trees or to assure living, healthy, seed producing paper birch in less than a quarter mile from the timber harvest. • Harvest all ages of trees. • Paper birch do well in scarified soils so look to change regulations that allow for this practice to happen (right now it's hard to do this harvesting in summer months in particular because of existing regulations). • Use fire to create disturbance needed for regrowth. • Assess commercial aspen/birch stands that were previously or plan to be harvested and thin aspen to reduce competitive pressure on birch. • Identify and protect high quality paper birch sites (such as north facing slopes, deep and fertile soils, low drought stress) to create refuges until new long-term sites can be identified and populated. • Increase stand diversity by under planting of low densities of other tree species. • Remove gypsy moth preferred species that are small and poor quality or girdle these trees to create wildlife snags. • Incorporate more mixed aspen-conifer management by increasing regeneration emphasis on mixed conifer species within stands including white pine and white spruce. Mixed-species management is a climate change resilience strategy aimed at increasing within-stand biodiversity to reduce the effects of a changing climate on the stand as a whole. • Manage herbivory (e.g. deer grazing) using barriers to promote regeneration. • Assess and control pests and invasive species (ex. gypsy moth). • Promote landscape water retention to protect against soil drying and overall drought stress. • Reconsider existing fuels management strategies under warming conditions and potentially elevated fire risk.
Education	• Educate about the proper harvesting of birch bark.
Monitoring and Research	• Inventory soil moisture and nutrient content to identify high-value forest lands most resistant to climate disturbance. • Undertake more research around temperature thresholds for paper birch bark harvesting. This includes studies to understand how the timing for the optimal harvesting may change with climate change. Make sure that any future regulations reflect that change in climate conditions.
Restoration	• As needed, use seeds, germplasm, and other genetic material from across a greater geographic range. This includes planting seeds or seedlings originating from seed zones that resemble the expected future conditions of the planting site. • If birch regeneration fails, transition forest through under planting of species that may fare better under climate change (e.g. white pine). • Avoid planting species of trees that are highly susceptible to bronze birch borer. European and Asian species and cultivars of birch are very susceptible to bronze birch borer, even if trees are healthy and vigorous. However, native species, such as paper, gray, yellow and sweet birch are more resistant to borer attack as long as they are not stressed by drought, over mature, or have some other health issue. River birch appears to be immune to this borer.

4.7.2 Sugar Maple – Focus Species

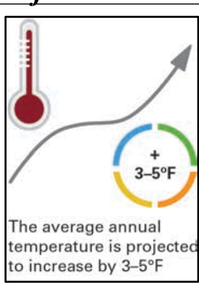
Sugar maples provide sap that has been harvested by the Ojibwe for centuries. From February to April, the warm days and frosty nights in Minnesota allow the sap within the sugar maple to run. Sugar maples prefer cool, nutrient rich soil locations. They are very shade tolerant but slow growing.

Figure 34: Sugar maple. Source: gb.123rf.com

4.7.2.1 Climate Threats to Sugar Maple

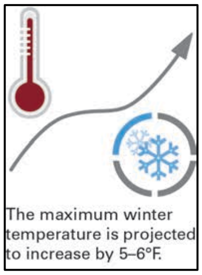
Existing Conditions: Sugar maple are on the decline across the 1854 Ceded Territory and on reservations.[160] The Fond du Lac Reservation has seen dieback in their sugar maple crowns likely due to drought stress and earthworm-influenced reproduction failure (seedlings are more vulnerable to drought when there is no duff layer and the soil is compacted). Student research at Menominee Tribal College has shown sugar maple growth rate declines of 30%, even in large mature overstory trees, when earthworms were introduced.[161] Gypsy moths have also been captured in sugar maples, including at the Grand Portage Reservation, even though they are not a preferred target species of the insect.[162] It is not currently known if climate has played any role in the presence of gypsy moth. Invasion of Norway maple and amur maple could outcompete sugar maple, as they have been known to reduce species diversity in other areas of the country, and are frequently planted in residential landscapes throughout the 1854 Ceded Territory. However, overall warming (perhaps without consideration of these indirect stressors) has been suggested as being very beneficial to maple species, both theoretically and experimentally.[163]

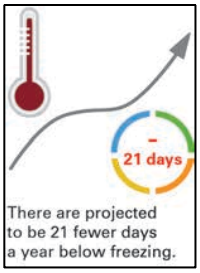
Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and within reservations are expected to increase by 3°-5°F. The US Forest Service (USFS) has found in their modeling that by 2100 sugar maple could experience large increases under more mild climate change scenarios, with greater increases under more severe climate change scenarios.[164] The sugar maple is projected to gain substantial areas of suitable habitat along the north shore of Lake Superior, however more severe climate change may bring drought conditions that could negatively impact the species. These findings contradict modeling done for the Grand Portage National Monument by the National Park Service that showed no change to sugar maple for



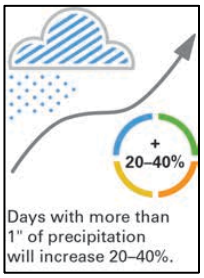
[160] Forestry expert within the 1854 Ceded Territory
[161] Forestry expert within the 1854 Ceded Territory
[162] Forestry expert within the 1854 Ceded Territory
[163] Reich, P.B., Sendall, K.M., Rice, K., Rich, R.L., Stefanski, A., Hobbie, S.E., Montgomery, R.A., 2015. Geographic range predicts photosynthetic and growth response to warming in co-occurring tree species. Nature Climate Change 5: 148-152.
[164] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

more moderate climate change and a small decrease for more severe climate change.[165] Combined, these results suggest that the full extent of climate impacts upon sugar maple in the 1854 Ceded Territory and on reservations is not fully known.





By the 2050s, average winter temperatures in the region are expected to increase by 5°-6°F, and there will be approximately 21 fewer days below freezing annually. Overall, warmer winters will likely reduce the snowpack, which diminishes insulating cover for root systems, allowing for deeper penetrations of freezing temperatures into the soil. This freezing exposure to root systems could damage (and may already be damaging) the sugar maple.[166]



Extreme precipitation event days (days with more than 1" of precipitation) for the region are projected to increase 20-40% by the 2050s. This increase in extreme variation in precipitation amounts and timing could also affect nutrient cycling. Current research has shown that cycling drought and flood conditions amplifies nutrient imbalances for sugar maples.[167] Increased presence of herbivores such as deer, whose range is expanding northwards into sugar maple stands, may increase browsing pressure, which could hamper sugar maple's ability to adapt to climate change.[168]

4.7.2.2 Sugar Maple Vulnerability Assessment Results

Based on these factors, sugar maple are somewhat sensitive (S2) to climate change and have a modest ability to adapt (AC2) to climate-related impacts. ***This gives sugar maple a medium vulnerability to projected changes in climate.***

4.7.2.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of sugar maple within the 1854 Ceded Territory and reservations.

Adaptation Strategies to Address Climate Impacts to Sugar Maple	
Collaboration	• Use landscape-scale planning and partnerships to reduce fragmentation and enhance connectivity across the landscape. • Work with other agencies to review, comment, and consult on management activities that could impact sugar maple. • Monitor the development of the intertribal maple syrup cooperative. Over time, look for partnership opportunities.

[165] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf

[166] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[167] Ibid

[168] Ibid

Conservation, Preservation, and Maintenance	• Manage for fuel wood as sugar maple can be an important heating source in certain areas of the 1854 Ceded Territory and reservations. • Manage sugar maple crown spacing to ensure they have adequate sunlight to grow. • Harvests and intermediate thinning can be applied to reduce food quality and shelter for gypsy moth larvae and pupae. Intermediate thinning, such as crop tree release, improve crown condition and vigor of the residual trees in the stand. • Remove gypsy moth preferred species that are small and poor quality or girdle these trees to create wildlife snags. If girdling is used, make sure the crown and bole are not touching surrounding live trees. • Prevent the spread of invasive species (e.g. Norway maple and amur maple) and increase efforts for early detection and control in priority areas. • Promote diversity through forest management: increase structural and age diversity using even and uneven-aged management techniques. • Manage herbivory (e.g., deer grazing) using fences and other barriers to promote regeneration.
Education	• Conduct education and outreach on proper tapping techniques, including more traditional methods for tapping, and the timing of tapping. As part of this, make sure to educate on the importance of rotating tapping so as not to stress particular trees. Consider holding classes to teach people proper tapping techniques. • Increase public outreach on invasive earthworms: Don't transplant plants and trees into remote wooded areas where there are not any earthworms at this time. Dump your extra fishing bait in the trash. Remember, anything that moves dirt can move worms.
Monitoring and Assessment	• Conduct more research on climate change and maple sugar production. This includes inventorying soil moisture and nutrient content to identify high-value forest lands most resistant to climate disturbance. • Inventory important sugar maple stands for climate protective site characteristics (e.g. north facing, deep, fertile soils, low drought stress) and work with partners to enhance and protect these areas. • Monitor phenology of sugar maple (ex. timing of maple sap run).
Restoration	• Plant seeds or seedlings originating from seed zones that resemble the expected future conditions of the planting site. • Promote reforestation and afforestation of marginal lands to increase soil moisture retention, provide shade, and increase habitat for species under stress. • Explore the planting of "super-sweet" sugar maple seedlings, as a potential adaptive response.

4.7.3 Black Ash

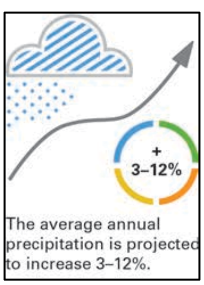
Figure 35: Black ash tree. Source: nrri.umn.edu

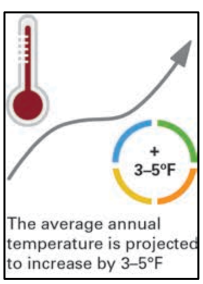
While it has many uses, black ash trees are best known for their use in traditional basket-making, an important part of tribal culture. Historical disturbance to black ash stands has been predominantly driven by human activities that have disturbed hydrology. These disturbances include: roadway and irrigation/pipeline constructions, logging, and sub surface mining that alters the water table. Black ash is known to tolerate climate variability to certain thresholds, but forest managers point to a potential tipping point for ash survivability. The Minnesota Department of Natural Resources has detected a loss of over 25,000 acres of black ash in central and northeast Minnesota, a decline that will likely continue with climate change.[169]

4.7.3.1 Climate Threats to Black Ash

Existing Conditions: In the last 10-15 years, increased instances of drought and an extended fire season have diminished the success of 'wet-footed' tree species such as black ash when they are located in upland areas. In addition, invasive species such as reed canary grass and glossy buckthorn are existing threats to the wet forests preferred by black ash. Emerald ash borer (EAB), an extremely destructive invasive insect species from Asia, was detected in 2015 in the 1854 Ceded Territory for the first time (Park Point in Duluth) among a small group of ash trees. EAB's larvae are an aggressive consumer of the inner bark of ash trees, which disrupts transportation of water and nutrients within the tree. It is not known to what extent recent climate changes have supported the establishment of EAB in the 1854 Ceded Territory.

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. The U.S. Forest Service (USFS) has found in their modeling that by 2100 black ash could experience little change under more mild climate change, with a slight decrease under a more severe climate change scenario.[170] However this modeling does not take into account the indirect influence of climate change and insect pests such as the EAB. Modeling done for the Grand Portage region by the National Park Service (NPS) similarly shows no change to black ash under two

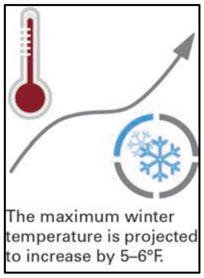


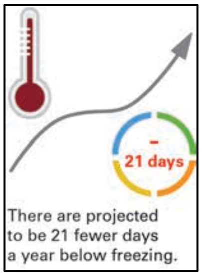


[169] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

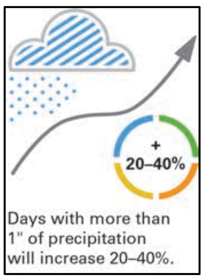
[170] ibid

climate change scenarios. This modeling, however, does not include consideration of invasive species.[171] These assessments point to the fact that a slightly warmer and wetter growing season (under more mild climate change) could help increase biomass of black ash populations.





By the 2050s, average winter temperatures in the region are expected to increase by 5°-6°F, and there will be approximately 21 fewer days below freezing annually. These milder winters, which are a predominant feature of climate change, will diminish the freezing temperatures that help knock back invasive insect populations. Results from research performed by the USFS and MN Department of Agriculture suggest that EAB larvae experience freezing death in amounts of 5% of the total population at -10°F and 98% at -30°F[172], temperatures that are less likely to occur in a climate-altered future.



Extreme precipitation event days (days with more than 1" of precipitation) for the region are projected to increase 20-40% by the 2050s, while days above 90°F are projected to increase 0-10 days on average by the same time period. This increase in extremes for both heavy rain and extreme heat events will not be beneficial to the preferred slow and steady access to water required by black ash. These broad impacts to black ash populations could also lead to wholesale ecological change in the forest structure.

4.7.3.2 Black Ash Vulnerability Assessment Results

Based on these factors, black ash are moderately sensitive (S2) to changing climate conditions and have a moderate capacity to adapt (AC2). This means that ***black ash have a medium vulnerability to changing climate conditions in the region***.

4.7.3.3 Adaptation Strategies

Detailed adaptation strategies were not developed for black ash. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of black ash to climate change.

1) Increase monitoring of black ash stands to improve management.
2) Complete and cooperate in Emerald Ash Borer surveys and monitoring.
3) Investigate Emerald Ash Borer control programs and the feasibility of implementation.
4) Undertake seed banking with appropriate genetic diversity for potential regeneration in new locations.
5) Anticipate species decline; in black ash stands create gaps and plant elm, bur oak, yellow birch, red maple, balsam poplar, hackberry, and swamp white oak.[173]

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[171] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf

[172] Venette, R.C.; Abrahamson, M. 2010. Cold hardiness of emerald ash borer, Agrilus planipennis: a new perspective. In: Black ash symposium: proceedings of the meeting; May 25-27, 2010. Bemidji, MN. US Department of Agriculture, Forest Service, Chippewa National Forest.

[173] Climate change response framework, 2015. Superior National Forest-Mesabi Project. Available: http://www.forestadaptation.org/node/538

6) Work with other agencies to review, comment, and consult on management activities that could impact black ash.
7) Prevent the spread of invasive species (e.g. reed canary grass and glossy buckthorn) and increase efforts for early detection and control in priority areas.
8) Use landscape-scale planning and partnerships to reduce fragmentation and enhance connectivity across the landscape.
9) Work with other agencies to review, comment, and consult on management activities that could impact black ash.
10) Inventory important black ash stands for climate protective site characteristics and work with partners to enhance and protect these areas.

4.7.4 Northern White Cedar

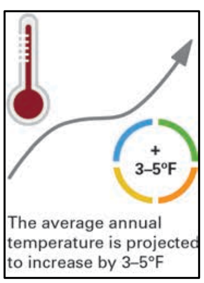
Figure 36: White cedar tree. Source: ci.blaine.mn.us

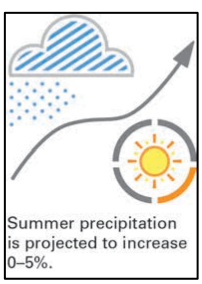
Native to Minnesota, northern white cedar are a long-lived species of tree (80-100+ year life span) that provide important ecological, cultural, and economic value. White cedar remains a sacred plant to the Ojibwe people, providing material for a number of uses. The versatility and strength of white cedar, alongside white pine, led to it being targeted during the logging efforts of the late 1800s and early 1900s. The forest regeneration following this intensive logging effort in the region allowed for heavy browsing by white tail deer, which further reduced the size of the cedar forests. Compounding these impacts is the difficulty in acquiring cedar nursery stock. Northern white cedar has particular seedbed requirements that are strongly linked to specific hydrologic conditions.[174]

4.7.4.1 Climate Threats to Northern White Cedar

Existing Conditions: As mentioned, cedar stands provide an important food source for deer, along with shelter during winter. However, local increases in deer populations (some of which are related to changes to-date in weather and climate patterns) are leading to heavy browsing of cedar (and other trees) that reduce the trees' regeneration and recruitment potential.[175]

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across reservations are expected to increase by 3°-5°F. The US Forest Service found in their modeling that by 2100 northern white cedar could experience slight decreases under more mild climate change scenarios and large decreases under a severe climate change scenario.[176]





By the 2050s, summer precipitation is expected to increase 0-5% for the region, and annually days above 95°F are projected to increase 0-10 days. These conditions will likely shorten the summer fire return interval. White cedar succeeds best with longer return fire intervals that allow the forest to be shaped by small-scale disturbances such as wind, insects, and disease.[177] Modeling done for the Grand Portage National Monument by the National Park Service similarly shows a projected decrease of northern white cedar populations, with the decrease running from small to large dependent on the severity of climate change.[178] These assessments point to some small short-term gains in white cedar biomass under more mild climate change scenarios, followed by a long-term decline if warming and dry conditions persist.

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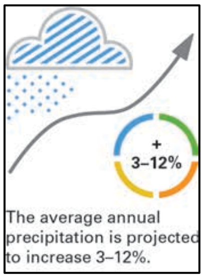
[174] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

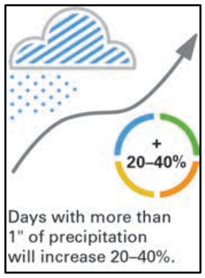
[175] Kenefic, L.S., Ruel, J.C., Tremblay, J.P., 2015. Sustainable management of white-tailed deer and white cedar- from the wildlife professional. The Wildlife Society. Available: http://wildlife.org/sustainable-management-of-white-tailed-deer-and-white-cedar/

[176] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[177] ibid

[178] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf





The warmer weather is also expected to support increases in deer populations and expansion northwards. This could increase deer browsing on white cedar, which is currently more common in the southern portion of the state. This could significantly impact cedar forests, as deer are already affecting the health and regeneration ability of white cedar. With regards to extreme weather, white cedar displays some resiliency in the face of strong wind events when compared to other species.[179]

By the 2050s, average annual precipitation is expected to increase by 3-12% in the region. Extreme precipitation event days (days with more than 1" of precipitation) are projected to increase 20-40% in the region by the 2050s. Changes in the timing and intensity of precipitation, potentially cycling between flooding and drought, could have an adverse effect on the sensitive requirements of cedar seedbeds.

4.7.4.2 Northern White Cedar Vulnerability Assessment Results

Based on these factors, northern white cedar are highly sensitive (S4) to climate change and have a very low ability to adapt to climate-related impacts (AC0). ***This makes white cedar extremely vulnerable to climate change.***

4.7.4.3 Adaptation Strategies

Detailed adaptation strategies were not developed for northern white cedar. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of northern white cedar to climate change.

1) Explore opportunities to cage cedar seedlings for protection from deer, although the amount of effort involved would likely only allow up to 1/3 of seedlings to be protected.
2) Set 'adaptive forest composition objectives': for example, the Manitou forest strives by 2095 to see 10-15% white cedar (currently 5%) in their northern hardwood-conifer stands. The Sand Lake Seven Beavers forest in their aspen-pine stands aim to restore white cedar to 7-10% of total stems by 2095, twice as many as would be accomplished under current management.[180]
3) Manage the deer population to reduce browsing on northern white cedar.
4) Work with other agencies to review, comment, and consult on management activities that could impact northern white cedar.
5) Use landscape-scale planning and partnerships to reduce fragmentation and enhance connectivity across the landscape.
6) Work with other agencies to review, comment, and consult on management activities that could impact white cedar.
7) Inventory important white cedar stands for climate protective site characteristics and work with partners to enhance and protect these areas.
8) Investigate replacements for tree species.
9) Prevent the spread of invasive species and increase efforts for early detection and control in priority areas.

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[179] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[180] Kahl, K., Hall, K., Doran, P., 2011. Climate Change Adaptation Case Study. Planning for the Forests of the Future: Updating Northeast Minnesota's Forest Management Strategy. The Nature Conservancy. Available: http://www.nature.org/ourinitiatives/regions/northamerica/areas/greatlakes/explore/climate-change-mn-case-study.pdf

4.7.5 Quaking Aspen

Figure 37: Quaking Aspen. Source: webapp8.dnr.state.mn.us

Quaking aspen are a boreal species and are the most economically important commercial timber resource in Minnesota. In addition to their economic value, quaking aspen provide habitat and food for important subsistence game species such as moose, deer, and grouse. Quaking aspen are the most abundant tree species in Minnesota, covering 30% of forest land area, and present in the northwoods (the boreal forests located in the northern portion of the U.S.) in live tree volume at triple the amount of the next abundant tree species (paper birch). Management strategies in the past have largely favored aspen regeneration, resulting in a decrease in overall forest stand diversity and structural complexity in managed forests.[181]

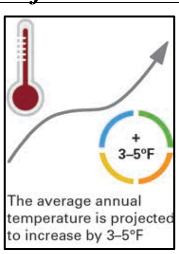
After a timber harvest, quaking aspen can often aggressively outcompete other partner species such as birch, owing to aspens reproduction by root suckers and quick succession. As birch faces the challenges of climate change and forest managers work to support this species, aspen could be more actively thinned to decrease competition.

The overall volume of quaking aspen has declined in recent years due to the harvesting of older stands and natural succession, combined with the effects of a multi-year drought and insect defoliation.[182] Quaking aspen stands in the 1854 Ceded Territory and within reservations have an average stand age of 60+ years,[183] this holds serious implications for the species regeneration potential if climate change adds additional stressors to aging stands.

4.7.5.1 *Climate Threats to Quaking Aspen*

Existing Conditions: Current stands of aspen in the 1854 Ceded Territory and on reservation are generally older and vulnerable to a range of stressors, pests, and diseases. These include: forest tent caterpillar, gypsy moths, deer herbivory, hypoxylon canker, and exotic earthworms.[184]

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. The USFS found in their modeling that by 2100 quaking aspen could experience decreases under more mild climate change scenarios and a large decrease under more severe climate change scenarios. Under the most aggressive climate scenario, aspen habitat would eventually be confined to a small northeast corner of the northwoods.[185] Modeling completed for the Grand Portage National Monument by the National Park Service similarly shows a projected decrease for quaking aspen habitat with the decrease running from small to



[181] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

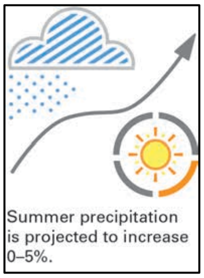
[182] ibid

[183] Forestry expert within the 1854 Ceded Territory

[184] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[185] ibid

large dependent on the severity of climate change.[186]



By the 2050s, summer precipitation is expected to increase 0-5% for the region, and days above 95°F are projected to increase 0-10 days annually, on average, by the same decade. These conditions will likely shorten the summer fire return interval, which could favor aspen reproduction in the short term as a 'pioneer' species. However, considering aspen is drought intolerant, these gains in a disturbed environment could be short-lived.[187]

A warming climate likely provides more growth opportunity for the existing pests and diseases that affect aspen including: forest tent caterpillar, gypsy moths, and hypoxylon canker. Stressors like exotic earthworms also reduce the drought tolerance of aspen, which when paired with actual drought conditions, could have an amplifying effect.[188] Increased presence of herbivores such as deer expanding northwards into aspen stands may also increase browsing pressure and reduce the overall health of the forest.

4.7.5.2 Quaking Aspen Vulnerability Assessment Results

Based on these factors, quaking aspen are highly sensitive (S4) to climate change, but will be somewhat able to adapt to these impacts (AC2). This means that ***aspen have a medium-high vulnerability to climate change***.

4.7.5.3 Adaptation Strategies

Detailed adaptation strategies were not developed for quaking aspen. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of quaking aspen to climate change.

1) Set 'adaptive forest composition objectives' to control and conserve aspen simultaneously. The Sand Lake Seven Beavers, in their aspen-pine stands, aims to reduce aspen to 10-25% of the forest by 2095. This is in contrast to aspen growth under its own conditions that would hit 35% of the forest composition over the same timeframe.[189]
2) Identify and protect high quality aspen sites to create refuges until new long-term sites can be identified and populated.[190]
3) Continue to manage aspen stands over a wide range of site types and local conditions.[191]
4) Promote diverse age classes through selective thinning and preservation of multiple small sites over one homogenous stand.[192]

[186] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf

[187] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[188] ibid

[189] Kahl, K., Hall, K., Doran, P., 2011. Climate Change Adaptation Case Study. Planning for the Forests of the Future: Updating Northeast Minnesota's Forest Management Strategy. The Nature Conservancy. Available: http://www.nature.org/ourinitiatives/regions/northamerica/areas/greatlakes/explore/climate-change-mn-case-study.pdf

[190] Swanston, Chris; Janowiak, Maria, eds. 2012. Forest adaptation resources: Climate change tools and approaches for land managers. Gen. Tech. Rep. NRS-87. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.121 p. Available: http://www.nrs.fs.fed.us/pubs/40543

[191] ibid

[192] Climate change response framework, 2015. Superior National Forest-Kabetogama project. Available: http://www.forestadaptation.org/node/541

5) Anticipate species decline and convert aspen sites to other forest types.[193]
6) Maintain species diversity in sites: in aspen stands retain white pine, sugar maple, northern red oak, and basswood.[194]
7) Work with other agencies to review, comment, and consult on management activities that could impact quaking aspen.
8) Assess and control pests and invasive species (ex. gypsy moth).
9) Manage the deer population to reduce browsing.
10) Harvests and intermediate thinning can be applied to reduce food quality and shelter for gypsy moth larvae and pupae. Intermediate thinning, such as crop tree release, improve crown condition and vigor of the residual trees in the stand.
11) Remove gypsy moth preferred species that are small and poor quality or girdle these trees to create wildlife snags. If girdling is used, make sure the crown and bole are not touching surrounding live trees.
12) Use landscape-scale planning and partnerships to reduce fragmentation and enhance connectivity across the landscape.
13) Work with other agencies to review, comment, and consult on management activities that could impact quaking aspen.
14) Prevent the spread of invasive species and increase efforts for early detection and control in priority areas.

[193] Climate change response framework, 2015. Superior National Forest-Kabetogama project. Available: http://www.forestadaptation.org/node/541
[194] Climate change response framework, 2015. Superior National Forest-Mesabi Project. Available: http://www.forestadaptation.org/node/538

4.7.6 Northern Red Oak/ Basswood/ Chokecherry

Northern red oak, basswood, and chokecherry all provide important habitat and food for game species, as well as material for cultural use by band members. They are grouped together in this assessment because of their likely potential to benefit from or increase their abundance with climate change. The species are native to the area but have been limited in distribution due to harvesting practices and competition from boreal species. Northern red oak currently grows in isolated stands along the Lake Superior lakeshore as well as in southern and western portions of the 1854 Ceded Territory.[195] Basswood was used traditionally as rope making material. Chokecherry can offer sustenance to many important game species in the region.

Figure 38: Chokecherry. Source: examiner.com.

The Fond du Lac Band has already started supporting some of these more climate resilient species in their commercial plantings, using oak and white pine alongside important native/cultural species. Oaks will need to be protected from deer foraging, which could easily intensify under climate change. Other groups have also planted red oak and basswood seedlings in northwoods test plots in the Arrowhead region of the state (with seedlings from two distinct Minnesota seed zones) in the hope that these species will exhibit a strong resilience to climate change.[196] Results from experimental test plots of oaks under future warming conditions suggest they will likely adapt to a warmer climate, while more boreal species will likely suffer.[197]

4.7.6.1 Climate Threats to Northern Red Oak, Basswood, and Chokecherry

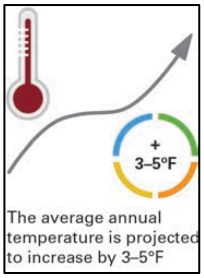
Existing Conditions: Northern red oak, basswood, and chokecherry currently are, in general, at their northernmost extent in the region but have populations that extend well to the south. Oak wilt is a devastating fungus to oaks. It can kill red oaks within 1 – 3 months and white and bur oaks within 3 years. High concentrations of oak wilt are found in SE Minnesota and the Twin Cities and the disease is spreading north, having been found in Pine County. This disease is spread long distances by sap beetles transferring spores from an infected tree to a wounded tree (pruning or wind damage) and spreads locally to surrounding trees along root grafts.

[195] Forestry expert within the 1854 Ceded Territory

[196] The Nature Conservancy. Minnesota: Planting a forest for the future. Available: http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/minnesota/explore/minnesota-climate-change-adaptation.xml

[197] Reich, P.B., Sendall, K.M., Rice, K., Rich, R.L., Stefanski, A., Hobbie, S.E., Montgomery, R.A., 2015. Geographic range predicts photosynthetic and growth response to warming in co-occurring tree species. Nature Climate Change 5: 148-152.

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. The US Forest Service (USFS) has found in their modeling that by 2100 northern red oak could experience increases under more mild climate change scenarios and no change under severe climate change scenarios.[198] The outcomes of more severe scenario are the result of oak's limited drought tolerance and likely impacts to seedling establishment under those conditions. Modeling done for the Grand Portage National Monument by the National Park Service (NPS) shows a large increase for red oak under both moderate and more severe climate change scenarios.[199]



USFS modeling suggests basswood could experience no change under more mild climate change scenarios, and an increase under more severe climate change scenarios, which could be expected as this temperate hardwood prefers a longer growing season in a slightly drier climate.[200] Modeling done for the Grand Portage National Monument by the NPS shows a small to large increase for basswood dependent on the extent of climate change scenario.[201]

USFS modeling suggests chokecherry may experience no change under both mild climate change scenarios and severe climate change scenarios.[202] Modeling done for the Grand Portage National Monument by the NPS shows a small to large increase for chokecherry dependent on the extent of climate change scenario.[203]

An increase in oaks will in turn increase mast (i.e. tree fruits such as seeds and nuts) for deer, bear, and turkeys. Turkeys have been increasing in the region over the last 10-20 years and are expected to increase in the region as conditions become more favorable. Increased presence of herbivores such as deer expanding northwards may increase browsing pressure on red oaks, basswood, and chokecherry, which may hinder their ability to adapt.

4.7.6.2 Northern Red Oak, Basswood, and Chokecherry Vulnerability Assessment Results

Based on these factors, northern red oak, basswood, and chokecherry have relatively high sensitivities to changing climate conditions (S3) and will mostly be able to adapt to these changes in a beneficial way (AC3). These factors combined translate into a ***medium-low vulnerability of northern red oak, basswood, and chokecherry to climate change***.

[198] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939
[199] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf
[200] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939
[201] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf
[202] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939
[203] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf

4.7.6.3 Adaptation Strategies

Detailed adaptation strategies were not developed for northern red oak, basswood, and chokecherry. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of northern red oak, basswood, and chokecherry to climate change.

1) Continue to use red oak as a climate resilient species in commercial plantings.
2) Use basswood as a partner species in birch regeneration as it does not aggressively outcompete birch.[204]
3) Protect red oak regeneration from deer browsing, either at the landscape or stand level (seedlings should be protected from deer 5-10 years after planting).[205]
4) Work with other agencies to review, comment, and consult on management activities that could impact northern red oak, basswood, and chokecherry.
5) Manage the deer population to reduce browsing.
6) Increase awareness of oak wilt with outreach and education and use best management practices to prevent its spread.

[204] Swanston, Chris; Janowiak, Maria, eds. 2012. Forest adaptation resources: Climate change tools and approaches for land managers. Gen. Tech. Rep. NRS-87. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.121 p. Available: http://www.nrs.fs.fed.us/pubs/40543

[205] ibid

4.7.7 Eastern White Pine

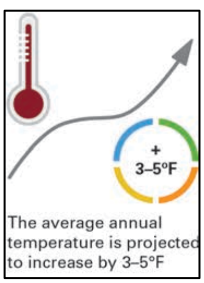
Figure 39: White pine trees. Source: nrs.fs.fed.us.

Eastern white pine provides favored browse (food) for deer, and it is expected that it may increase under changing climate conditions. White pine is vulnerable to blister rust and white pine weevil (though it is not as susceptible to weevil if under-planted). Fond du Lac has already started using oak and white pine alongside important native/cultural species in their forest management and planting activities. Other groups have also planted white pine in northwoods test plots in the Arrowhead region of the state (with seedlings from two distinct seed zones in Minnesota and one zone from lower Michigan) in the hope that these species will exhibit a strong resilience to climate change.[206]

4.7.7.1 *Climate Threats to Eastern White Pine*

Existing Conditions: In general, eastern white pine are at their northernmost extent in the 1854 Ceded Terriory and directly across the Canadian border, but have populations that extend to the south and along most of the eastern seaboard.[207]

Projected Climate-Related Impacts: By the 2050s, average annual temperatures in the 1854 Ceded Territory and across the reservations are expected to increase by 3°-5°F. The USFS has found in their modeling that by 2100 eastern white pine could experience increases under both mild climate change scenarios and more severe climate change scenarios. It is expected that this increase in white pine and red pine will come at the expense of the aspen-birch forest type.[208] Modeling done for the Grand Portage National Monument by the National Park Service (NPS) shows no change under more mild future climate change scenarios and a small increase under more severe climate change scenario.[209]



Extreme storms such as windstorms could also change in frequency and strength under climate change. Increased wind could affect the shelterwood (i.e. overstory) that protects white pine and make it more susceptible to pine weevil and other pests.[210] Increased presence of herbivores, such as deer whose range is expanding northwards, could increase browsing pressure on eastern white pine, which may hamper its ability to adapt.

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[206] The Nature Conservancy. Minnesota: Planting a forest for the future. Available: http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/minnesota/explore/minnesota-climate-change-adaptation.xml

[207] Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. Available: http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

[208] Handler, S., Duveneck, M.J., Iverson, L., Peters, E., Scheller, R.M., Wythers, K.R., … Ziel, R., 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p Available: http://www.treesearch.fs.fed.us/pubs/45939

[209] Fisichelli, N. A., S. R. Abella, M. P. Peters, and F. J. Krist Jr., 2014. Climate, trees, pests, and weeds: Change, uncertainty, and biotic stressors at Grand Portage National Monument. Forest Vulnerability Project Brief. National Park Service. Available: https://www.nps.gov/grpo/learn/education/upload/Fisichelli_et_al_2014.pdf

[210] Swanston, Chris; Janowiak, Maria, eds. 2012. Forest adaptation resources: Climate change tools and approaches for land managers. Gen. Tech. Rep. NRS-87. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.121 p. Available: http://www.nrs.fs.fed.us/pubs/40543

4.7.7.2 Eastern White Pine Vulnerability Assessment Results

Based on these factors, eastern white pine have relatively high sensitivities to changing climate conditions (S3) and will mostly be able to adapt to these changes in a beneficial way within the 1854 Ceded Territory and on reservations (AC3). These factors combine to give ***eastern white pines medium-low vulnerability to climate change.***

4.7.7.3 Adaptation Strategies

Detailed adaptation strategies were not developed for eastern white pine. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of eastern white pine to climate change.

1. Protect white pine regeneration from deer browsing, either at the landscape or stand level (seedlings should be protected from deer for 5-10 years after planting, until the trees are tall enough to avoid significant browsing).[211]
2. Underplant white pine in regenerating birch stands to help minimize competition stressors on birch.[212]
3. Expand the geographic area from which seedlings are obtained.[213]
4. Set 'adaptive forest composition objectives" for eastern white pine. The Sand Lake Seven Beavers, in their aspen-pine stands, aim to maintain white pine as a component (up to 10% of stems) through 2095. This represents a doubling of what would be achieved through current management.[214]
5. Thin mature white pine stands favoring vigorous, healthy individuals, to reduce competition for moisture, light, and nutrients.[215]
6. Prune lower branches of white pine to make them more resistant to blister rust infection.[216]
7. Promote white pine regeneration by anchoring gaps on existing white pine to take advantage of the seed sources on-site.[217]
8. Apply prescribed fire under burning in white pine stands in addition to thinning to help reduce competition and to create a suitable seed bed.[218]
9. Work with other agencies to review, comment, and consult on management activities that could impact white pine.
10. Use landscape-scale planning and partnerships to reduce fragmentation and enhance connectivity across the landscape.

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[211] Swanston, Chris; Janowiak, Maria, eds. 2012. Forest adaptation resources: Climate change tools and approaches for land managers. Gen. Tech. Rep. NRS-87. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.121 p. Available: http://www.nrs.fs.fed.us/pubs/40543

[212] ibid

[213] ibid

[214] Kahl, K., Hall, K., Doran, P., 2011. Climate Change Adaptation Case Study. Planning for the Forests of the Future: Updating Northeast Minnesota's Forest Management Strategy. The Nature Conservancy. Available: http://www.nature.org/ourinitiatives/regions/northamerica/areas/greatlakes/explore/climate-change-mn-case-study.pdf

[215] Climate change response framework, 2015. Superior National Forest-Kabetogama project. Available: http://www.forestadaptation.org/node/541

[216] Katovich, S. & Mielke, M., 1993. How to manage eastern white pine to minimize damage from blister rust and white pine weevil. USFS, Northeastern Area. Available: http://www.na.fs.fed.us/spfo/pubs/howtos/ht_white/white.htm

[217] Climate Change Response Framework. Cloquet forestry center- Stand 57. Available: http://www.forestadaptation.org/node/513

[218] Climate Change Response Framework. Superior national forest- Pearl project. Available: http://www.forestadaptation.org/node/266

4.8 Resource Access

		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
Adaptive Capacity: High ↓ Low	AC4					
	AC3					
	AC2			• Resource Access		
	AC1					
	AC0					

The 1854 Ceded Territory has an abundance of natural resources. From wild rice and moose to walleye and birch, the region has traditionally had more than enough natural resources to provide food, shelter, spiritual and cultural sustenance, and medicines to the Ojibwe people. Because of this, band member identity, health, and lifeways are intrinsically tied to natural resources within the 1854 Ceded Territory and on reservations.

Clean water and air are vital for survival. Walleye, sturgeon, lake trout, pike, and other species of fish provide nutrient rich and healthy sources of protein. Moose and deer provide meat and skins that are important in maintaining cultural practices such as drum making (moose hides). Furbearing animals have provided economically and culturally important furs and food for centuries. Birch, ash, maple, cedar, aspen and other tree species provide shelter, building materials, supplies for spiritual and cultural practices, and a home for animals throughout the 1854 Ceded Territory and within reservations. Hundreds of cultural places, where ancestors are buried, historical trails forged, and spiritual practices undertaken, are scattered across the regional landscape.

Figure 40: Wild rice harvesting. Source: mpr.news.org

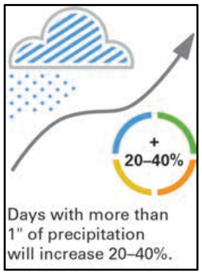
As the 2014 National Climate Assessment found: "*Tribal access to valued resources is threatened by climate change impacts,"*[219] and because band members' way of traditional life is so closely tied to the natural resources in the region, climate-related impacts will very likely have significant and far ranging consequences for the people and ecosystems within the 1854 Ceded Territory and on reservations. This section of the report focuses on how climate change already is and will likely continue to affect how band members access these resources.

4.8.1 Climate Threats to Resource Access

Existing Conditions: In recent decades, the 1854 Ceded Territory and reservations have seen an increase in the number and severity of extreme precipitation events. These events can damage roads, trails, bridges, and other transportation infrastructure and keep people from accessing resources for two reasons. First the resources themselves may be damaged or lost as a consequence of the extreme weather event. Second, access to the resources is limited due to impacts to the transportation infrastructure.

[219] US National Climate Assessments

Projected Climate Related Impacts: With changing climate conditions, the number of extreme precipitation events is projected to increase 20%-40% by the middle of the century. Increased periods of heavy precipitation can make trails and roads impassable, cause significant erosion, and flood soils. These weather events along with droughts, floods, wildfires and even more extreme snow events will continue to impede the ability of band members to access the resources they have come to depend upon.



In addition, climate change is likely to cause some significant ecological shifts within the 1854 Ceded Territory and within reservations, especially as it pertains to the composition of the region's forests. Forests in the 1854 Ceded Territory are projected to shift towards, what has historically been, a more southern forest composition (e.g. oak/maple dominated vs. spruce dominated forests) by the end of the 21st century.[220] Species that exist in the present forest environments of the 1854 Ceded Territory and on reservations may face increased pressure from invasive species, disease, and thermal or moisture stress under projected climate conditions. Because band members have traditionally been heavily dependent on the region's natural resources, ecosystem shifts have the potential to significantly limit the availability and hence the access to traditional natural resources.

Changing temperature and precipitation patterns along with the associated ecosystem shifts will also lead to species migration, the loss of certain species as they are outcompeted by other species, and the arrival of new species within the 1854 Ceded Territory and on reservations. The decline or loss of certain species, such as moose that provide a significant source of sustenance for band members, will likely mean a decline in traditional hunting. This could lead to increased economic and social problems associated with loss of cultural and traditional livelihoods and the loss of cultural identity.[221] Moreover, when band members are forced to turn from traditional food sources to more processed foods, a serious health risk lingers as foods purchased from the store are often higher in fat, salt, and chemicals than the meat and fish hunted for or caught on tribal lands.[222]

Climate change also threatens to limit access to medicinal plants, many of which provide values that are yet to be fully understood by modern medicine. All of these changes are particularly acute for band members because of their close relationship to the land and natural resources in the 1854 Ceded Territory and across reservations. As the 2014 National Climate Assessment notes, "*the large role of climate change in separating tribal people from their natural resources poses a threat to indigenous identity.*"[223]

4.8.2 Resource Access Vulnerability Assessment Results

Based on this information, it was determined that natural resource access is somewhat sensitive (S2) to climate change and that band members have some ability to adapt to those changes (AC2). ***This gives resource access a medium vulnerability to climate change.***

[220] Prasad, A. M., L. R. Iverson, S. Matthews, and M. Peters, cited 2007: A Climate Change Atlas for 134 Forest Tree Species of the Eastern United States [Database]. U.S. Department of Agriculture, Forest Service, Northern Research Station.
[221] Ford, J.K, and E. Giles. 2015. Climate Change Adaptation in Indian Country; Tribal Regulation of Reservation Lands and Natural Resources. William Mitchell Law Review: 41(2): 519-551
[222] Cultural expert within the 1854 Ceded Territory
[223] US National Climate Assessment

4.8.3 Adaptation Strategies

Detailed adaptation strategies were not developed for resource access. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of resource access to climate change.

1. Work with agencies with Federal trust responsibility to enforce tribal rights to natural and cultural resources.
2. Integrate climate change considerations into all tribal planning efforts.
3. Develop alternative access routes to critically important resources.
4. Consult with other land managers (federal, state, county, local) on access issues and needs.
5. Conduct infrastructure (roads, culverts, bridges, etc.) planning and implementation with resource access and a changing climate as considerations.

4.9 Water Quality and Quantity – Focus Area

"One thing is certain…water resources abound in the 1854 Ceded Territory. Over 2,500 lakes and nearly 5,600 miles of streams provide abundant fisheries habitat and fishing opportunities."[224]

		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
Adaptive Capacity: High ↓ Low	AC4					
	AC3					
	AC2					
	AC1				• Water Quality and Quantity	
	AC0					

Water is a vital element for the Ojibwe people, and it is intricately tied to all aspects of life—food, economy, recreation, and traditional and cultural history.[225] Clean and abundant water is also needed to support the survival of other culturally and economically important plant and animal species including, wild rice, wildlife, and the natural ecology of the forests and wetlands in the region. According to a 2011 water sustainability report:

> *Declining stands of natural wild rice have been linked to altered hydrology, such as extensive ditching that drains a rice bed, or inundation from dams or industrial discharges that overwhelms the shallow-rooted plants. The effects of global climate change are predicted to include changes to natural hydrology, and will likely aggravate existing impacts of development and land use changes on the unique and very specific hydrologic conditions that wild rice requires.*[226]

This statement makes clear that there are a number of significant climate and non-climate related impacts to water quantity and quality.

Non-Climate-Related Stressors to Water Quantity and Quality: According to interviews with water quality subject matter experts, non-climate stressors to water quantity include industrial consumption and wastewater discharge, increases in water demand, and the drying out of municipal wells. This can decrease drinking water availability and potentially contribute to drying out of important wetlands in the area.[227] In addition, other hydrological modifications such as ditching for drainage, can affect water quantity. Finally, water withdrawals to support industrial activities can reduce water supplies available for other uses.

Figure 41: Wetlands in Northeastern Minnesota. Source: Minnesota Pollution Control Agency

Non-climate water quality stressors include water contamination due to industrial activities (e.g. mining, power generation, paper mills) including discharges from existing water treatment facilities, and runoff associated with general development and subsequent creation of more impervious surfaces. With water quantity fluctuations, so too come water quality impacts. If less fresh water is available small amounts of

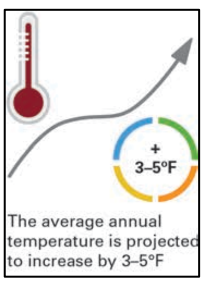
[224] 1854 Treaty Authority Fisheries, 2016. *Retrieved from:* http://www.1854treatyauthority.org/fisheries.htm
[225] Minnesota Water Sustainability Framework Recreational, Spiritual, Cultural and Technical Work Team Report January 2011.
[226] Minnesota Water Sustainability Framework Recreational, Spiritual, Cultural and Technical Work Team Report January 2011 (pg. 9).
[227] Water quality subject matter experts within the 1854 Ceded Territory

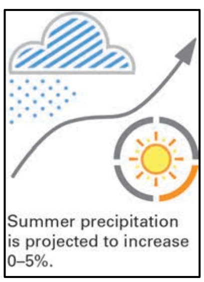
pollutants have more damaging effects (i.e. less dispersion of pollutants). Finally, due to increased human development in the area, there have been significant land use changes that affect both water quantity and quality, including headwater impacts on specific water bodies (e.g. St. Louis River watershed).

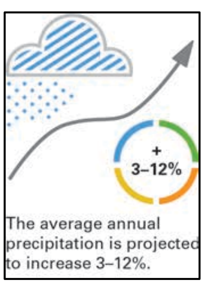
4.9.1 Climate Threats to Water Quality and Quantity

Existing Conditions: Over the past 30-40 years, throughout the United States and within the 1854 Ceded Territory and on reservations more extreme weather events have been occurring. These events have been creating both drought-like conditions and 500-year flood events, such as the recent flooding in June of 2012 in northeastern Minnesota. Flooding can lead to the destruction of the aquatic habitat central to sustaining critical plant and animal species, while drought-like conditions diminish aquifer recharge and decrease water available to sustain wetlands hydrology and base flow in streams. Additionally, according to discussions with key subject matter experts on the core team, historical observations show that shifts in temperatures and warming water may be impacting mercury methylation rates, leading to increased bioaccumulation of mercury in fish and other aquatic organisms.[228] Increasing summer temperatures may be diminishing stream flow in the late summer/early fall due to higher rates of evaporation and evapotranspiration and more frequent and/or persistent drought cycles. Finally, the presence of invasive plant species along stream banks and shorelines may also be increasing soil erosion during heavy rain and flooding events because they displace the native plant community which have fibrous roots to help hold in the soil. These flooding events also help to distribute invasive species to new locations.

Projected Climate Related Impacts: Average annual temperatures in the region are projected to increase 3° - 5° F by the 2050s. Warming is expected in every season with increases ranging from 3° to 6.5° F by the same time period. Higher temperatures coupled with little or no change in precipitation during the summer (0-5%) could diminish water quantity. Further, with increasing temperatures, human, agricultural, and energy development (i.e. power plants) will require increasing supplies of water further impacting water quantity.[229]







Precipitation projections for the region are less certain than projections for temperature, with most projections showing a range from little change to slightly wetter by the mid-21st century. Annual precipitation is predicted to change between 3 and 12%. In addition, the severity of storms in a warmer climate is projected to increase. Increased severity of storms will likely lead to increases in heavy precipitation, which could lead to greater and more frequent fluctuations in water levels.

Climate change will also alter existing aquatic habitats by creating dramatic shifts in water quantity, which have impacts on animal (e.g. fish) and plant (e.g. wild rice) species important to the economic and cultural ways of life within the 1854 Ceded Territory and across reservations. Further, this cycling of water can make other pollutants more available in the water system, as demonstrated in a recent study, which found that: "*Hydrologic fluctuations not only serve to release previously sequestered sulfate and [total mercury] from peatlands but may also increase the strength of peatlands as sources of [methylmercury] to downstream aquatic systems, particularly in regions that have experienced elevated*

[228] Water quality and Quantity expert within the 1854 Ceded Territory
[229] United States Environmental Protection Agency, 2016. Water Resources. *Retrieved from:* http://www3.epa.gov/climatechange/impacts/water.html

levels of atmospheric sulfate deposition."[230] The statement demonstrates the intricate link between water quantity and quality.

Increased frequency and intensity of heavy precipitation events can lead to erosion of soils and have a detrimental effect on water quality in aquatic environments and may allow more of the mercury already deposited to the watersheds of lakes, streambeds, and rivers to be released into the waterbodies, where it can be transformed into methylmercury and bioaccumulated throughout the ecosystem. "*When mercury reaches these surface waters, it can be processed by naturally occurring bacteria into the neuro-toxic methylmercury."*[231] Historical observations show that shifting temperatures leading to warmer waters could be increasing mercury methylation rates in certain watersheds, leading to increased bioaccumulation rates within fish species.[232] Fish consumption is an important cultural, public health, and economic resource central to the way of life in the 1854 Ceded Territory and across reservations, making mercury bioavailability in the water system a deep concern.

Increases in stormwater runoff and flooding also lead to water quality concerns related to public health in that increased runoff can carry increased loads of nutrients (nitrogen and phosphorus), toxic substances, and pathogenic microorganisms. Additionally, inundation from overloaded stormwater and sanitary sewers, or increased infiltration and inflow from old or failing infrastructure can overwhelm water treatment facilities as well as industrial facilities, negatively impacting water treatment infrastructure and sewage systems.[233] In these situations, it is likely that there will be more water-borne pathogens in the water supply system, potentially diminishing the quality of drinking water.[234]

Further, with warmer temperatures, increases in the frequency, intensity and locations of excessive algal blooms, are expected. This may lead to an increase of toxins in the water from harmful cyanobacteria (decreasing water quality) and negative effects on the health of humans, domestic animals, and wildlife, which consume or live within the water.[235] This could result in increased illness or death to people and animals, increases in costs for treating the water, and impacts to the ecosystems within these bodies of water.

Further, with increasing temperatures, lakes in particular (though this may be also true for streams and rivers) may be less protected from algal blooms as earlier ice-outs and later ice ups may shift the timing of existing nutrient loads and extend the growing season, thereby leading to increased productivity in algae (cyanobacteria in particular). These changes may also increase turbidity in surface water bodies. Higher turbidity can decrease light penetration and, in turn, decrease growth of aquatic vegetation. It can potentially be a positive feedback loop as lakes become more turbid from wind and wave action when there is a lack of vegetation to hold the bottom sediment in place. Further, aquatic vegetation is important for many fish and macroinvertebrates. Temperature-dependent watershed processes (i.e., rate of recycling of decaying plant nutrients) that currently contribute dissolved organic carbon to surface waters may

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[230] Coleman J.K., Engstrom D.R., Mitchell C.P.J., Swain E.B., Monson B.A., Balogh S.J., Jeremiason J.D., Branfireun B.A., Kolka R.K., and Almendinger J.E. The effects of hydrologic fluctuation and sulfate regeneration on mercury cycling in an experimental peatland. *Journal of Geophysical Research: Biogeosciences* 20 July, 2015. DOI: 10.1002/2015JG002993

[231] United States Geological Survey, September 27, 2013. How Global Change Will Impact Mercury around the World. *Retrieved from:* http://www.usgs.gov/newsroom/article.asp?ID=3707#.VvQLWM6zz8G

[232] Dijkstra JA, Buckman KL, Ward D, Evans DW, Dionne M, and Chen CY. March 12, 2013. Experimental and Natural Warming Elevates Mercury Concentrations in Estuarine Fish. PLoS One, 8(3).

[233] United States Environmental Protection Agency, 2016. Water Resources. *Retrieved from:* http://www3.epa.gov/climatechange/impacts/water.html

[234] United States Environmental Protection Agency, 2016. Climate Change: Human Health. *Retrieved from:* http://www3.epa.gov/climatechange/impacts/health.html#impactsreducedair

[235] United States Environmental Protection Agency, 2016. Nutrient Pollution: Climate Change and Harmful Algal Blooms. *Retrieved from:* http://www.epa.gov/nutrientpollution/climate-change-and-harmful-algal-blooms

accelerate, which could ultimately reduce dissolved oxygen levels and diminish both the rates of ultraviolet demethylation of methylmercury and the "buffering" from eutrophication that stained waters (high DOC) provides. Future climate projections indicate a potential worsening of these effects, with unknown multi-trophic level effects, which could alter the normal food web structures within a lake or stream.

Overall, climate change is expected to negatively impact water quality within the 1854 Ceded Territory and on reservations. Continued projected increases in temperatures in all seasons will only exacerbate existing impacts. Changes in water supply and distribution could also lead to major changes to forest ecosystems, including the migration of certain tree species and the animals that depend on them, further north or westward.

4.9.2 Water Quality and Quantity Vulnerability Assessment Results

Both Water Quality and Water Quantity were determined to be highly sensitive (S3) with a limited ability to adapt to the changing climate conditions (AC1). ***This means that water quantity and quality have a medium-high vulnerability to climate change.***

4.9.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of water quality within the 1854 Ceded Territory and within reservations.

Adaptation Strategies to Address Climate Impacts to Water Quality	
Collaboration	• Work with federal and state partners to take action through existing authorities to ensure that there is better enforcement of water quality standards. • Consult and cooperate with federal, state, and local water resource managers on policy and permitting issues within or affecting the 1854 Ceded Territory and reservations. • Cooperate with state, federal, Canadian, and local water resource managers on Lake Superior and Great Lakes issues (e.g. Lake Superior Partnership, Great Lakes Executive Committee). • Review, comment, and consult on projects within or affecting the 1854 Ceded Territory or reservations (e.g., industrial, land-use). • Advocate for no more wet-tailings storage at hard rock mines, and investigation of better storage and treatment technologies.
Conservation, Preservation, and Maintenance	• Encourage more mitigation projects for impacted surface waters, other than wetlands. Ensure that mitigation remains within the 1854 Ceded Territory and within the affected watershed. • Create solid waste management plans that integrate climate change. This will help ensure that in the case of flooding or other natural disasters, solid waste is properly stored so as not to contaminate water quality. • Work with federal and state partners, conservation groups, private landowners, and others to preserve or restore wetlands ecosystems in buffer zones along rivers, lakes and reservoirs for flood control and water quality management. Watershed management includes a range of policy and technical measures. These generally focus on preserving or restoring vegetated land cover in a watershed and managing stormwater runoff. These changes help mimic natural watershed hydrology, increase groundwater recharge, reduce runoff, and improve the quality of runoff. • Work with the utility companies, industry, and wastewater treatment facilities to reduce

	discharges of sediment and nutrient to water bodies, control runoff and maintain streamflow, buffer against flooding, and reduce storm surge impacts and inundation on shorelines. • Restore degraded (from ditching/hydrological modifications) peatlands functions and values by reestablishing natural hydrology, reforestation and subsequent conservation and/or paludiculture (wet cultivation of marshland). This includes both conserving all reasonably intact peat swamps and preventing further degradation of already degraded peatlands. • Develop sewer models to estimate the impact of increased wet weather flows on wastewater collection system and treatment plant capacity and operations. • Modify sewer systems to reduce impacts from increased flows including infiltration reduction measures, additional collection system capacity, offline storage, or additional peak wet weather treatment capacity. • Protect and mitigate existing impacts to the forests along the wetlands and riparian areas, and within the wetlands system. • Create runoff control buffers in fire prone areas and stormwater retention projects to aid in the prevention of contaminants into the environment. • Develop flood management systems that better utilize natural floodplain processes. Thus, flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low density lands to lessen flood peaks, reduce sedimentation, temporarily store floodwaters and recharge aquifers, and restore environmental flows. • Implement more stream bank erosion control strategies (e.g., promoting land use practices that reduce erosion, add buffer along streams, look at forest management practices along stream banks).
Education	• Integrate climate change projections into new and existing stormwater and sewer infrastructure improvements. • Include flood-resistant design requirements in local building codes. • Develop outreach program and training support for residential stormwater and shore best management practices.
Monitoring and Assessment	• Continue monitoring water quality in key areas such as wild rice areas and fisheries lakes and streams. • Begin monitoring for pharmaceuticals, micro-beads, and other toxins and pathogens in waterbodies at risk. • Develop and maintain water quality database for reservation waters and for waters within 1854 Ceded Territory. • Continue to compile the data that could inform adjusting the management of the peak and storage capacity at reservoirs to minimize mercury methylation. • Monitor fish mercury concentrations periodically to determine trends and inform consumption advisories. Long-term fish tissue data in Minnesota suggests that climate change may be contributing to increased mercury concentrations in commonly consumed fish species. • Monitor vegetation changes in watersheds through ground cover surveys, aerial photography or by relying on the research from local conservation groups and universities. • Develop models to understand potential water quality changes. For example, increasing water temperatures may cause eutrophication and excess algal growth, which could impact drinking water quality and lead to toxic or harmful algal blooms (HABs). Water quality and aquatic habitat may also be compromised by increased sediment or nutrient inputs due to extreme storm events. These impacts may be addressed with targeted watershed management plans.

Adaptation Strategies to Address Climate Impacts to Water Quantity	
Collaboration	• Consult and cooperate with federal, state, and local water resource managers on policy and permitting issues within or affecting the 1854 Ceded Territory and reservations. • Cooperate with state, federal, Canadian, and local water resource managers on Lake Superior and Great Lakes issues (ex. Lake Superior Partnership, Great Lakes Executive Committee, etc.) • Work with federal and state partners on water appropriation enforcement. • Support local land use agencies in the adoption of ordinances that protect the natural functioning of groundwater recharge areas. • Collaborate with state partners in groundwater management areas that may be established within the 1854 Ceded Territory. Ensure that tribal priorities are considered and incorporated into state-led plans. • Advocate for no more wet-tailings storage at hard rock mines, and investigation of better storage and treatment technologies. • Review, comment, and consult on projects within or affecting the 1854 Ceded Territory or reservations (e.g., industrial, land-use).
Conservation, Preservation, and Maintenance	• Continue to protect groundwater resources • Invest in and utilize green infrastructure to help control runoff, capture and infiltrate stormwater, and reduce water demand. Some common green infrastructure practices include bio-retention areas (rain gardens), low impact development methods, green roofs, swales (depressions to capture water) and the use of vegetation or pervious materials instead of impervious surfaces. • Maintain and restore stream connectivity (avoid channelization, improve road-stream crossings, culverts, dams, etc.). • Develop and/or update groundwater protection plans and groundwater management plans for Reservation resources. • Expand available water storage including both surface and groundwater storage. • Implement more stream bank erosion control strategies (e.g., promoting land use practices that reduce erosion, add buffer along streams, look at forest management practices along stream banks, prevent the spread of and control Japanese knotweed (and other invasive species) on stream banks and plant proper riparian vegetation in their place).
Education	• Organize a water conservation education and outreach program. Outreach communications typically include: basic information on household water usage, the best time of day to undertake water-intensive activities, and information on and access to water- efficient household appliances such as low-flow toilets, showerheads and front-loading washers. • Education and outreach can also be targeted to different sectors (i.e., commercial, institutional, industrial, public sectors). Effective conservation programs in the community include those that provide rebates or help install water meters, water-conserving appliances, toilets and rainwater harvesting tanks.
Monitoring and Assessment	• Monitor hydrology (e.g. lake levels, stream stage and discharge, groundwater levels). • Work with the state and USGS to undertake groundwater resource studies in the 1854 Ceded Territory and on reservations. • Continue to use hydrologic models to predict discharge and loading, determine ecological flows, and plan for future water supply.

4.10 Wetlands

		Sensitivity: Low → High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity: High ↓ Low	**AC4**					
	AC3					
	AC2			• Shrub Wetlands		
	AC1					• Vernal Pools
	AC0					• **Boreal Wetlands**

Wetlands are important to the 1854 Ceded Territory and the reservations for a variety of reasons. They provide valuable ecosystem services from treating and purifying water to providing habitat for the growth and survival of culturally important species.[236] The wetland varieties (technically any water body less than two meters in depth[237]) across the region are an important part of larger ecosystems, where they serve as everything from temporary breeding grounds for amphibians (vernal pools) to flood protection (larger boreal wetlands). Wetlands provide habitat for wild rice, fish, wildlife, waterfowl, and many medicinal plants.[238] They also provide recreation and aesthetic value and can serve as important cultural sites.

In Minnesota, over 52% of the original wetlands have been lost due to development,[239] though there are still 10.6 million acres of wetland in the state.[240] While less than 20% of the historic wetlands have been lost in the northeast portion of the state, more than half of them have had some degree of hydrological change, due primarily to ditching that could impact the functionality of the wetland.[241] While summer precipitation is likely to remain almost the same (up to 5% increase by the middle of the century), warmer summer temperatures (4° – 5° Fahrenheit warmer) will increase evaporation and evapotranspiration. This will likely further diminish wetland area throughout the region. The combination of human development and a 20-40% increase in the number of heavy rain events (greater than 1") will limit the ability of wetlands to absorb water and capture pollution during those events.[242] Degraded wetlands are more susceptible to invasive species such as non-native phragmites, invasive cattail species, and others.[243]

This section presents the vulnerability assessment results for three types of wetlands important in the 1854 Ceded Territory and on reservations: vernal pools, shrub wetlands, and boreal wetlands. Detailed adaptation strategies are presented for boreal wetlands and general strategies are presented for shrub wetlands and vernal pools.

[236] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, national Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington. D.C.

[237] Cowardin, L., Carter, V., Golet, F., LaRoe, E., 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior. Fish and Wildlife Service. Office of Biological Services. Washington, D.C. 20240. Available: https://www.fws.gov/wetlands/Documents/Classification-of-Wetlands-and-Deepwater-Habitats-of-the-United-States.pdf

[238] Office of Water Protection. 2013. *Wetland Restoration Plan: Method for Prioritizing Efforts on the Fond du Lac Reservation.* Fond du Lac Band of the Lake Superior Chippewa.

[239] http://www.dnr.state.mn.us/wetlands/benefits.html

[240] Shaw. D., & Lennon, M., 2014. *Climate Change Trends and Action Report.* Minnesota Board of water and Soil Resources. http://www.bwsr.state.mn.us/native_vegetation/BWSR_Climate_Change.pdf.

[241] Wetlands expert from one of the bands.

[242] Union of Concerned Scientists. 2003. Minnesota Impacts on Minnesota Communities and Ecosystems. – Findings from *Confronting Climate Change in the Great Lakes Region.* www.ucsusa.org/greatlakes

[243] Wetlands expert from one of the bands.

4.10.1 Boreal Wetlands – Focus Species

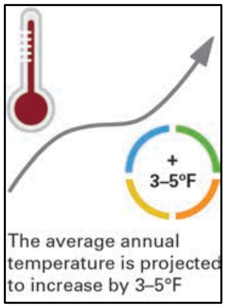
Boreal wetlands, also known as peat wetlands, play an important role in the carbon cycle due to the large accumulations of peat. The soil in the wetlands is made up of partially decomposed remains of plants and animals (peat). As an ecosystem, peatlands provide high biodiversity conservation value,[244] especially as an important breeding area for ducks and other birds.[245] Vegetation includes woody and herbaceous trees that are preferred forage for moose.[246]

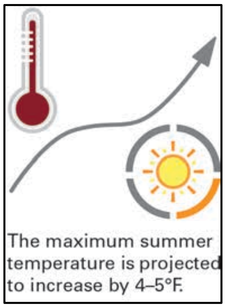
Figure 42: Boreal wetland. Source: www.na.fs.fed.us.

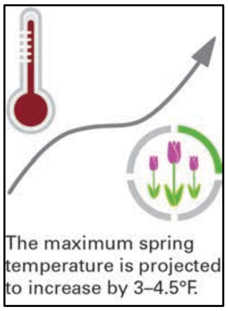
4.10.3.1 Climate Threats to Boreal Wetlands

Existing Conditions: Boreal wetlands are very sensitive to changes in water availability, especially changes that result in lower water levels.[247] In general, boreal wetlands are at the southern extent of their range in the 1854 Ceded Territory.

Projected Climate Related Impacts: Average annual temperature in the region is projected to increase by 3°-5°F by the 2050s. There is the potential for longer dry periods, particularly during the summer with only a slight potential increase in precipitation (0-5% in the region) and warmer temperatures (4° - 5°F increase) that will enhance evaporation and evapotranspiration, potentially limiting water availability and decreasing the size of the wetlands. Projected climate-related changes to the hydrological regime could reduce groundwater recharge and decrease the size of boreal wetlands.[248] According to a Union of Concerned Scientists report, "*earlier spring runoff, more intense flooding, and lower summer water levels generally translate into growing challenges for Minnesota bogs and wetlands and the species that depend on them.*"[249] These impacts will also reduce the ability of boreal wetlands (and shrub-scrub wetlands) to absorb heavy precipitation, leading to potentially significant increases in localized flooding, erosion, and water-based pollutant loads. Moreover, if temperatures increase and there is not enough water for these wetlands, they may begin to dry out and release some of the carbon stored in the peat into the atmosphere, thereby increasing the speed and magnitude of climate-related impacts.







[244] Erwin, K.L. 2008. Wetlands and global climate change: the role of wetland restoration in a changing world. Wetlands Ecology Management. 17: 71-84

[245] Division of Fish and Wildlife. 2008. *Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources.* Prepared by the Climate Change Working Group. Minnesota Department of Natural Resources. St. Paul, Minnesota.

[246] Minnesota Department of Natural Resources. Wetlands of Minnesota: . http://www.dnr.state.mn.us/wetlands/types.html

[247] Erwin, K.L. 2008. Wetlands and global climate change: the role of wetland restoration in a changing world. Wetlands Ecology Management. 17: 71-84

[248] Division of Fish and Wildlife. 2008. *Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources.* Prepared by the Climate Change Working Group. Minnesota Department of Natural Resources. St. Paul, Minnesota.

[249] Johnson, L. and S. Polasky. 2003. Minnesota: Confronting Climate Change in the Great Lakes Region. Union of Concerned Scientists. Cambridge, MA. 4 pgs.

Boreal wetland communities may also change as native and exotic species expand their range northward, potentially disrupting the existing native ecosystem complex.[250]

4.10.1.2 Boreal Wetland Vulnerability Assessment Results

Given these conditions, boreal wetlands are extremely sensitive (S4) to changing climate conditions and have extremely limited ability to accommodate or adjust to those impacts (AC0). This means that ***boreal wetlands have a very high vulnerability to changing climate conditions.***

4.10.1.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of boreal wetlands within the 1854 Ceded Territory and reservations

Adaptation Strategies to Address Climate Impacts to Boreal Wetlands	
Collaboration	• Enhance collaboration with local, county, state, and federal wetland management organizations to identify, monitor, and track wetlands throughout the region. • Work with federal and state colleagues to update the National Wetland Inventory for the 1854 Ceded Territory and reservations. • Partner with the Minnesota Board of Water and Soil Resources to implement conservation easements or soil and water conservation grants.
Conservation, Preservation, and Maintenance	• Identify financial program(s) that help create a sustainable means of conserving wetlands. • Advocate for dedicated wetland funding from the federal government. As part of this, emphasize the need for funding to implement and maintain wetland conservation programs. • Consult with US Army Corps of Engineers and/or the state on permitting decisions so as to ensure that wetlands are not negatively impacted. • Actively pursue the use of conservation easement or covenants to protect restored wetlands. As part of this, advocate for changes in laws to make conservation easements or covenants in perpetuity as opposed to 30 years. • Create a wetland banking program and require mitigated wetlands to remain within the watershed and 1854 Ceded Territory. • Explore the feasibility of creating limits on what can be gathered from the boreal wetlands: consider creating an ordinance limiting biomass harvesting. • Revisit proposed buffers as additional information about climate change and/or climate impacts become available. • Identify wetlands that can be restored to provide ecosystem services like flood protection and habitat for key species. Invest in restoring these priority ecosystems. • Restore plant communities that fit site conditions or promote vegetation sources that fit current and expected project site conditions (in some cases this may mean selecting sources from south of projects rather than north of projects). • Eliminate or slow the spread of invasive species between Lake Superior and inland waters by continuing to: ensure that equipment or waders used in Lake Superior are not used in any inland water or wetlands; washing boats and other equipment after use; educating community and visitors on procedures for eliminating spread of invasive species; and

[250] Division of Fish and Wildlife. 2008. *Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources.* Prepared by the Climate Change Working Group. Minnesota Department of Natural Resources. St. Paul, Minnesota.

	organizing community events to physically or chemically eradicate invasive species. • Enhance vegetation control in boreal wetlands. Consider manually removing invasive saplings or using prescribed fire. • At a minimum, within 50 feet of the wetland 1) maintain 50 percent crown cover to help maintain the water and soil temperatures and 2) leave 5-15 dead standing trees for insect and bird habitat and avoid removing rotting stumps. • At a minimum, within 150 feet of the wetland 1) avoid clear cutting and be more selective about harvest, 2) avoid skid trails, 3) minimize use of heavy equipment, and 4) limit ruts deeper than 6 inches below ground level. • Limit non-point source pollution by using the appropriate erosion control measures while working near wetlands.
Education	• Conduct education on the importance of boreal wetlands and the ecosystem services they provide. • Develop educational program for local community members on current invasive species issues and how to prevent the spread of invasive species.
Monitoring and Assessment	• Advocate for the creation of a national reference set of wetlands to be monitored and ensure some are located in our region. • Establish regional reference wetlands for monitoring that can serve as sentinel wetlands. • Continue monitoring wetland water quality and quantity throughout the landscape. • Develop an annual monitoring program for invasive plant and animal species and develop responses in the event that boreal wetland habitat begins to be degraded. • Combine all the historical data that exists (from monitoring and assessments) and use it to model projected changes in wetland location and conditions. This includes projections of what existing boreal wetlands could transition to in a climate-altered future. This information will be useful to help with current and future wetland management. • Model where the most vulnerable wetlands are and which might be most resilient to climate-related impacts. Based on the results, focus conservation on the most resilient wetlands.
Restoration	• Resize new and existing culverts (e.g., retrofits) to ensure they can handle projected changes in precipitation. • Undertake invasive species control best management practices. • Work to maintain species diversity within and across wetlands on the landscape. • Develop wetland restoration plans for all wetlands on the landscape, but especially for priority wetlands. • Restore wetlands, to the extent possible.

4.10.2 Vernal Pools

Figure 43: Vernal pool in northeastern Minnesota. Source: duluthfrogblog.blogspot.com.

Vernal pools are seasonal pools of water that provide essential habitat for key plant and animal species throughout the 1854 Ceded Territory and on reservations, especially tree frogs and salamanders. Vernal pools themselves are also special cultural places that are closely tied to the changing of seasons. These seasonal pools are generally found in forested areas. They fill with water in the spring from snowmelt and run-off and are frequently dry during the late summer and fall. Salamanders, wood frogs, and other amphibians use these temporary pools to lay their eggs in the spring and as habitat as they develop into juveniles and adults.

Many existing wetlands (up to 50% according to a recent study[251]) in the 1854 Ceded Territory and reservations have been degraded due to human activities such as ditching, road construction, agricultural runoff, and land-use changes.[252] In addition, timber harvest, land use change, and mining or mineral extraction continue to affect vernal pools by removing the pools' vegetation and shade, or by making the water too polluted for species to survive.

To preserve existing wetlands, including vernal pools, bands within the 1854 Ceded Territory have created Wetland Conservation Plans or water quality standards that aim to protect wetlands. While these plans are valuable, extreme weather and climate change threaten to undermine the utility of some of the conservation-based strategies identified in the plans.

4.10.2.1 Climate Threats to Vernal Pools

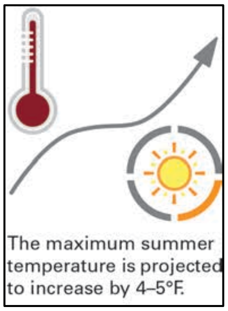
Existing Conditions: Since vernal pool formation is dependent upon snowmelt and runoff, they are particularly sensitive to extreme weather events and changing climate conditions. The wet period for vernal pools is determined by both precipitation and evapotranspiration from the surrounding forests. Heavier precipitation events may expand pools temporarily, but, if there is too much water for too long, these pools can grow into year round ponds that support fish. The fish may eat the eggs of the amphibians and make the pools un-suitable for their use, leading to a decrease in amphibian breeding locations. Longer periods of drought can increase evaporation and evapotranspiration, which will decrease the size of the pools or increase the dry period for the pools.[253] If it is dry for too long, the pools may disappear completely.

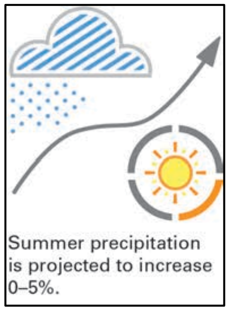
[251] Wetlands expert from one of the bands.

[252] Office of Water Protection. 2013. *Wetland Restoration Plan: Method for Prioritizing Efforts on the Fond du Lac Reservation.* Fond du Lac Band of the Lake Superior Chippewa.

[253] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, national Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington. D.C.

Projected Climate Related Impacts: Perhaps the biggest concern for vernal pools are warmer temperatures, particularly during the summer where temperatures are projected to increase 4° - 5°F by the 2050s, combined with little change in summer precipitation. Together these changes will decrease water availability by increasing evaporation and evapotranspiration, which will decrease the size of the pools or increase the dry period for the pools.[254] If it is dry for too long, the pools may disappear completely. This is particularly damaging because most of the species that use vernal pools rarely move more than 300 yards from their home pool, meaning that no viable alternative habitat for the animals may exist. Thus, shorter wet periods and shifts in the timing of those periods will likely increase reproductive failures of pool-breeding amphibians.[255] In addition, changes in the timing of rain and snow melt may shift the timing of when the pool is wet and when it is dry, affecting all the species that depend on the pool. It may also increase the susceptibility of the pool to invasive species such as glossy buckthorn.[256]





4.10.2.2 Vernal Pool Vulnerability Assessment Results

Based on vulnerability assessment results, vernal pools are extremely sensitive (S4) to changing climate conditions and have limited ability to accommodate or adjust to those impacts (AC1). This means that ***vernal pools have a high vulnerability to changing climate conditions.***

4.10.2.3 Adaptation Strategies

Detailed adaptation strategies were not developed for vernal pools. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854Treaty Authority can build upon over time to reduce the vulnerability of vernal pools to climate change.

1. Identify and map all medium and large vernal pools, especially in key timber areas prior to timber sales and removal.[257]
2. Keep treetops, slash, and heavy machinery out of pond depressions.
3. Establish a buffer (e.g., at least 132 feet) around vernal pools during timber operations.[258]
4. Work to limit siltation of the pond depression and, when used, remove silt fences as soon as practical.[259]
5. Identify key breeding habitats for salamanders and frogs and whether they could benefit from an assisted migration program between pools.
6. Develop network of larger fish-free pools that are less likely to dry up during droughts.
7. Create a program to identify and restore degraded wetlands on reservation and throughout the 1854 Ceded Territory.
8. Create a wetland mitigation bank and require mitigated wetlands to remain within the watershed and 1854 Ceded Territory.

[254] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, national Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington. D.C.
[255] Brooks. 2004. Weather-Related Effects on Woodland Vernal Pool Hydrology and HydroPeriod. *Wetlands*. **Vol 24** (1). March 2004. Pp. 104-114
[256] Tribal Staff input.
[257] http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/wetlands12_streamsides.htm#Wildlife
[258] ibid
[259] ibid

9. Work to reduce other non-climate stressors to vernal pools.[260]
10. Consult with agencies on permitting decisions to ensure that wetlands are not negatively impacted.
11. Monitor and control invasive species.
12. Conduct education on the importance of vernal pools and the ecosystem services they provide.
13. Enhance collaboration with state and federal wetland management organizations to identify, monitor, and track wetlands throughout the region.
14. Work with federal and state colleagues to update the National Wetland Inventory for the 1854 Ceded Territory and reservations.
15. Partner with the Minnesota Board of Water and Soil Resources to implement conservation easements or soil and water conservation grants.
16. Identify financial program(s) that help create a sustainable means of conserving wetlands.
17. Advocate for dedicated wetland funding from the federal government. As part of this, emphasize the need for funding to implement and maintain wetland conservation programs.
18. Consult with the US Army Corps of Engineers and/or the state on permitting decisions so as to ensure that wetlands are not negatively impacted.
19. Actively pursue the use of conservation easement or covenants to protect restored wetlands. As part of this, advocate for changes in laws to make conservation easements or covenants in perpetuity as opposed to 30 years.
20. Revisit proposed buffers as additional information about climate change and/or climate impacts become available.
21. Identify vernal pools that can be restored to provide ecosystem services and habitat for key species. Invest in restoring these priority ecosystems.
22. Restore plant communities that fit site conditions or promote vegetation sources that fit current and expected project site conditions (in some cases this may mean selecting sources from south of projects rather than north of projects).
23. Eliminate or slow the spread of invasive species between Lake Superior and inland waters by continuing to: ensure that equipment or waders used in Lake Superior are not used in any inland water or wetlands; washing boats and other equipment after use; educating community and visitors on procedures for eliminating spread of invasive species; and organizing community events to physically or chemically eradicate invasive species.
24. Enhance vegetation control near vernal pools. Consider manually removing invasive saplings or using proscribed fire.
25. At a minimum, within 50 feet of the wetland 1) maintain 50 percent crown cover to help maintain the water and soil temperatures and 2) leave 5-15 dead standing trees for insect and bird habitat and avoid removing rotting stumps.
26. At a minimum, within 150 feet of the wetland 1) avoid clear cutting and be more selective about harvest, 2) avoid skid trails, 3) minimize use of heavy equipment, and 4) limit ruts deeper than 6 inches below ground level.
27. Limit non-point source pollution by using the appropriate erosion control measures while working near wetlands.
28. Develop educational program for local community members on current invasive species issues and how to prevent the spread of invasive species.
29. Advocate for the creation of a national reference set of wetlands to be monitored and ensure some are located in our region.
30. Establish regional reference wetlands for monitoring that can serve as sentinel wetlands.

[260] Erwin, K., 2009. Wetlands and global climate change: the role of wetland restoration in a changing world. *Wetlands Ecol Manage.* **17** (71-84).

31. Continue monitoring wetland water quality and quantity throughout the landscape.
32. Develop an annual monitoring program for invasive plant and animal species and develop responses in the event that vernal pool habitat begins to be degraded.
33. Combine all the historical data that exists (from monitoring and assessments) and use it to model projected changes in wetland location and conditions. This includes projections of what existing vernal pools could be lost in a climate-altered future. This information will be useful to help with current and future wetland management.
34. Resize new and existing culverts (e.g., retrofits) to ensure they can handle projected changes in precipitation.
35. Work to maintain species diversity within and across wetlands on the landscape.
36. Develop wetland restoration plans for all wetlands on the landscape, but especially for priority wetlands.

4.10.3 Shrub Wetlands

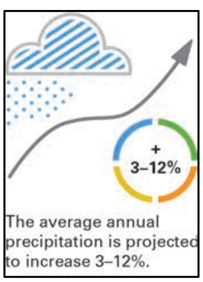
Figure 44: Shrub wetland. Source: na.fs.fed.us.

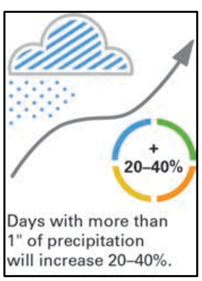
Shrub wetlands are known by a variety of names ranging from scrub-shrub, scrub swamp, or bog wetlands. They are generally dominated by woody vegetation, deciduous and evergreen shrubs, trees stunted by environmental conditions and young trees less than 20 feet tall.[261] Shrub wetlands are found along the perimeter of lakes, rivers, and streams, and are usually waterlogged during the growing season.[262] In the 1854 Ceded Territory and on reservations, willow or alder generally dominate shrub wetlands. These wetlands provide important flood retention value as well as serving as an important habitat and sustenance for a variety of plants, fish, and larger mammals such as moose. Many species rely on shrub wetlands, including birds that use the branches for nesting.

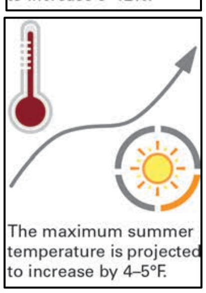
4.10.3.1 Climate Threats to Shrub Wetlands

Existing Conditions: Much like vernal pools, shrub wetlands are particularly sensitive to precipitation patterns. Wet periods can expand and elevate the water levels in the wetlands increasing water depth and affecting the plant species in the wetlands. Extended dry periods can reduce the size of the wetland, dry out soils and stress wetland plants adapted to wetter soils.

Projected Climate Related Impacts: Extreme precipitation events (rainfall exceeding one inch) are expected to increase 20%-40% by the middle of the century and can wash excess sediment into the wetland or strip vegetation from the landscape. While precipitation in the region is projected to increase (0-20% depending on the season) there will also be shifts in precipitation patterns that are more difficult to project. Longer dry periods can decrease water availability and provide an opportunity for non-native species to take hold and decrease the size and health of existing wetlands.







Warmer temperatures, particularly during the summer where temperatures are projected to increase 4° - 5° F by the 2050s, can also lead to increased rates of evaporation and evapotranspiration, leading to soil moisture deficits in ecosystems such as wetlands.[263] These "*moisture deficits would reduce groundwater recharge, wetland area, and water quality…*"[264] affecting the overall health of the wetlands. Moreover, land use changes could result in significantly degraded flood absorbing capacities of shrub-scrub

[261] Fish and Wildlife Service. Classification of Wetlands and Deepwater Habitats of the United States: Scrub-Shrub Wetland: https://www.fws.gov/wetlands/Documents/classwet/scrbshrb.htm

[262] http://www.dnr.state.mn.us/wetlands/types.html

[263] Johnson, L. B., K. Hayhoe, G. W. Kling, J. J. Magnuson, and B. J. Shuter. 2003. Confronting climate change in the Great Lakes region: technical appendix – wetland ecosystems. Union of Concerned Scientists, Cambridge, Massachusetts, and Ecological Society of America, Washington, D.C. < www.ucsusa.org/greatlakes/pdf/wetlands.pdf >

[264] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota

wetlands (as well as boreal wetlands). This could translate into more flooding, greater erosion, and heightened pollutant runoff into water bodies.[265]

4.10.3.2 Shrub Wetlands Vulnerability Assessment Results

Based on these factors, shrub wetlands are somewhat sensitive (S2) to changing climate conditions and have medium ability to accommodate or adjust to those impacts (AC2). ***This gives shrub wetlands a medium vulnerability to changing climate conditions.***

4.10.2.3 Adaptation Strategies

Detailed adaptation strategies were not developed for shrub wetlands. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of shrub wetlands to climate change.

1. Enhance collaboration with local, state, and federal wetland management organizations to identify, monitor, and track wetlands throughout the region.
2. Consider developing or partnering with the Minnesota Board of Water and Soil Resources to implement conservation easements or soil and water conservation grants.[266]
3. Buffer and decrease fragmentation of intact plant communities and create genetic corridors.[267]
4. Restore plant communities that fit site conditions or promote vegetation sources that fit current and expected project site conditions (in some cases this may mean selecting sources from south of projects rather than north of projects).[268]
5. Work across property boundaries to respond to and limit the spread of invasive species that have the potential to outcompete native vegetation.[269]
6. Work with federal colleagues to update the National Wetland Inventory for the 1854 Ceded Territory.
7. Create a program to identify and restore degraded wetlands on reservation and throughout the 1854 Ceded Territory.
8. Create a wetland mitigation bank and require mitigated wetlands to remain within the watershed and 1854 Ceded Territory.
9. Consult with agencies on permitting decisions to ensure that wetlands are not negatively impacted.
10. Conduct education on the importance of shrub wetlands and the ecosystem services they provide.
11. Resize new and existing culverts (e.g., retrofits) to ensure they can handle projected changes in precipitation.
12. Undertake invasive species control best management practices.
13. Work to maintain species diversity within and across wetlands on the landscape.
14. Develop wetland restoration plans for all wetlands on the landscape, but especially for priority wetlands.
15. Advocate for the creation of a national reference set of wetlands to be monitored and ensure some are located in our region.

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[265] Johnson, L. and S. Polasky. 2003. Minnesota: Confronting Climate Change in the Great Lakes Region. Union of Concerned Scientists. Cambridge, MA. 4 pgs.
[266] Shaw. D., & Lennon, M., 2014. *Climate Change Trends and Action Report.* Minnesota Board of water and Soil Resources. http://www.bwsr.state.mn.us/native_vegetation/BWSR_Climate_Change.pdf.
[267] ibid
[268] ibid
[269] ibid

16. Establish regional reference wetlands for monitoring that can serve as sentinel wetlands.
17. Continue monitoring wetland water quality and quantity throughout the landscape.
18. Develop an annual monitoring program for invasive plant and animal species and develop responses in the event that shrub wetland habitat begins to be degraded.
19. Combine all the historical data that exists (from monitoring and assessments) and use it to model projected changes in wetland location and conditions. This includes projections of what existing shrub wetlands could transition to in a climate-altered future. This information will be useful to help with current and future wetland management.
20. Model where the most vulnerable wetlands are and which might be most resilient to climate-related impacts. Based on the results, focus conservation on the most resilient wetlands.
21. Conduct education on the importance of shrub wetlands and the ecosystem services they provide.
22. Develop educational program for local community members on current invasive species issues and how to prevent the spread of invasive species.

4.11 Wildlife

		Sensitivity: Low → High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity: High ↓ Low	**AC4**		• White-Tailed Deer			
	AC3		• Bald Eagles • Wolves • Birds and Waterfowl (turkey, duck, pheasants, geese)		• Furbearers (beaver, black bear, bobcat, coyote, fisher, fox, mink, muskrat, river otter, snowshoe hare)	
	AC2					
	AC1				• Birds and Waterfowl (ruffed grouse, spruce grouse, loons, swans) • Furbearers (lynx, American marten, snowshoe hare)	• **Moose**
	AC0					

Wildlife and the Bois Forte, Fond du Lac, and Grand Portage bands of Chippewa are intrinsically connected. From species such as the bear, which is one of the original symbols for the Ojibwe clans, to wolves and moose, wildlife are essential to the way of life for the Ojibwe. This connectedness has existed since the beginning of the Ojibwe's time in the 1854 Ceded Territory, with wildlife providing food, clothing, tools, economic value, and cultural and spiritual lifeways.

According to research conducted for the 2014 U.S. National Climate Assessment, global climate change directly threatens the health and wellbeing of thousands of species of wildlife, as well as their habitats.[270] In the Great Lakes region, changes in both temperature and precipitation will likely cause major shifts in ecosystems. In some cases, the higher temperatures and changes to precipitation patterns will lead to the displacement or loss of species within the 1854 Ceded Territory and across reservations. Changes to seasonal patterns may alter the timing of key biological events[271] such as spring budding, migration, or synchronization that exists between the birth of young and the emergence of their food sources.[272] Shifting water levels could cause reductions in wetlands, thereby reducing viable habitat for many species of wildlife, including waterfowl and amphibians.[273] In addition, the impacts of climate change on wildlife will likely be exacerbated by land use changes, the release of pollutants into the natural system, and other interactions with humans that could reduce the amount of viable habitat or affect species numbers.[274]

Within the 1854 Ceded Territory and across the reservations, species such as white-tailed deer and wolves are projected to do well in a warmer climate. Conversely, species like moose and Canadian lynx are projected to fare poorly. Overall, climate change will lead to significant modification of the geographic range of many species as their preferred habitat shifts. For species where the 1854 Ceded Territory or the reservations are at the southern edge of their range, these shifts may mean that the climate and habitat conditions are no longer suitable.[275] For species with poor dispersal abilities (e.g., small forest vertebrates and flightless invertebrates) climate change may happen too rapidly for them to adapt[276] or move to keep pace with the shift in their preferred habitat. Even for those species able to migrate, barriers to migration and dispersal, such as human development and the Great Lakes, may significantly impede the success of

[270] U.S. Global Change Research Program. 2014. *Our Changing Climate,* in 2014 U.S. National Climate Assessment. http://nca2014.globalchange.gov/report#section-1946
[271] Parmesan, C. and H. Galbraith. 2004. Observed impacts of global climate change in the U.S. Pew Center on Global Climate Change, Arlington, Virginia
[272] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[273] Interagency Climate Adaptation Team. 2013. Adapting to Climate Change in Minnesota. 38 pgs.
[274] ibid
[275] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[276] Noss, R.F. 2001. Beyond Kyoto: forest management in a time of rapid climate change. Conservation Biology. 15:578-590.

these movements.[277] Reptiles and amphibians are particularly sensitive to changes in temperature and moisture, which can alter reproduction cycles and timing.[278]

Most of these changes are already being observed throughout Minnesota. Species such as mourning doves, northern cardinals, wild turkeys, and opossums are already being found in regions they have not historically inhabited, indicating that these species are moving northwards as the climate becomes milder.[279] Wildlife species that rely on boreal or near-boreal forests "*may be under the greatest threat of extirpation from the state due to climate change*"[280] (p. iii). In addition to shifting ecosystems, research suggests that the size of many ecosystems will also decline, thereby reducing the range available for many wildlife species in Minnesota.[281]

Climate change will also continue to affect the migration patterns of many birds as the timing of migratory cues change with the shifting seasons.[282] Invasive species, "*…including parasites and disease-causing organisms, may flourish in warmer temperatures, profoundly affecting habitat and challenging the survival of…*" birds and wildlife that depend on native vegetation.[283] Not only are some invasive species able to thrive in a greater variety of habitats under a climate-altered future, but their fecundity makes it highly likely that they will outcompete many native plants and animals.[284] Invasive species can also alter predator-prey relationships, further disrupting the long-term survivability of species within the 1854 Ceded Territory and across the reservations.[285]

The ability of a species to adapt to climate change will depend on an array of species specific and environmental characteristics. For many species, this means overcoming changes to preferred habitat and coping with environmental stresses associated with increasing temperatures, changes to the hydrological cycle, and the emergence of invasive and non-native species. Generally speaking, this research and the work of other scholars finds that generalist species (e.g., those able to survive in multiple habitats) will do better than specialist (e.g., those that reside in a single habitat) species.[286]

All species of wildlife are important and deserve protection and support adapting to changing climate conditions. However, it was impractical to complete an exhaustive climate change vulnerability assessment for all species and habitats during the course of the project. Thus, for the purposes of this assessment, the project partners decided to focus on six species or groups of species: moose, bald eagle, wolves, white-tailed deer, birds and waterfowl, and furbearers. As conditions change and specific issues arise, this assessment can serve as a foundation for evaluating the vulnerability of and developing adaptation measures for species not covered here.

The remainder of this section looks at the vulnerability assessments for these six species/groups of species and provides detailed adaptation strategies for moose, and general adaptation strategies for the other five species or groups of species.

[277] Peters and Darling (1985)
[278] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[279] ibid
[280] ibid
[281] ibid
[282] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[283] ibid
[284] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[285] Patterson et al., 2015,
[286] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota

4.11.1 Moose (Mooz) – Focus Species

Figure 45: Male moose on the 1854 Ceded Territory landscape. Image courtesy of the 1854 Treaty Authority

Moose (Mooz) have been an important subsistence and cultural resource in the 1854 Ceded Territory for as long as the Ojibwe have resided in the region. Moose are also "*central to the identity of the boreal forest*,"[287] helping to maintain the health of the forests and wetlands by consuming shrubs and trees and by serving as food for predators such as wolves. Moose meat has also been an important source of food within the 1854 Ceded Territory and across reservations, with a single moose providing about 500 lbs. of meat. Moose hides are used for cultural and spiritual purposes, such as making drums and moccasins.

Moose populations in Minnesota have declined over the last decade.[288] Land use changes, habitat shifts, the emergence of new disease vectors, pressure from predators, increasing numbers of parasites, and climate change are all factors in recent declines of the moose populations. A declining moose population has serious economic, social, and cultural ramifications within the 1854 Ceded Territory and across reservations. The loss of a moose hunt means not only the loss of a traditional food source, but also the loss of an important traditional practice that often brings generations together to hunt, harvest, and celebrate. Changing climate conditions are likely to further threaten moose population within the region.

4.11.1.1 Climate Change and Moose

Existing Conditions: Two potential reasons for the decline in the moose population are increasing annual temperatures and increasing summer humidity, both of which have physiological impacts on moose.[289] Research shows that as temperatures rise, moose are less able to regulate their internal body temperatures and can quickly overheat.[290] Overheating manifests itself in more panting, slow movement, and changes in feeding patterns, which can result in poor nutrition and heightened sensitivity to parasites such as ticks and liver fluke.[291] Increasing summer and winter temperatures are already causing increased rates of heat stress in moose populations.[292]

In addition, land use changes that result in changes in habitat, especially to coniferous and boreal forests and wetlands within the 1854 Ceded Territory and on reservations, are negatively affecting moose

[287] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[288] Lenarz, M. S. 2008. 2008 aerial moose survey. Minnesota Department of Natural Resources, St. Paul.
[289] Input from Wildlife Expert from the 1854 Treaty Authority
[290] Murray, D. L., E. W. Cox, W. B. Ballard, H. A. Whitlaw, M. S. Lenarz, T. W. Custer, T. Barnett, and T. K. Fuller. 2006. Pathogens, nutritional deficiency, and climate influences on a declining moose population. Wildlife Monographs. 166
[291] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[292] Dybas, C.L. 2009. Minnesota's Moose: Ghosts of the Northern Forest? BioScience. 59(10): 824-828

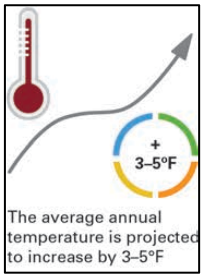
populations by reducing the amount of suitable habitat available for thermal cover and reducing the amount of viable forage.[293] These land use changes are also affecting moose by creating habitat that is more viable for white-tailed deer. More frequent interactions between moose and deer increase the spread of brainworm, a parasite that lives in the venous sinuses and subdural spaces of the brain of white-tailed deer and is spread via deer feces.[294] While white-tailed deer appear to have no negative effects from brainworm: however, when moose accidentally ingest gastropods (intermediate host) containing larval stages of the parasite, the larvae migrate to the nervous system of the moose and as they develop into adults they can cause major neurological diseases that lead to odd behavior, trouble standing and moving, and death.[295] Within the Grand Portage Reservation, the leading cause of death among collared moose was brainworm (nearly 40% of adult mortalities).[296]

Similarly, population overlap with white-tailed deer can lead to increased exposure to liver fluke. Liver fluke is a large parasitic flatworm that traditionally lives in the liver of deer, but can be transferred to moose (as well as elk, mule deer, sheep, and cattle) as they accidentally ingest infected gastropods (intermediate host) on vegetation.[297] Liver flukes do not significantly impact deer, however, in moose, liver fibrosis can occur, which can significantly reduce the moose's overall body condition making them more susceptible to infection. A 2006 study by Murray and colleagues found that liver flukes were the single greatest source of mortality in northwestern Minnesota moose.[298] While liver flukes is not be the number one killer of moose in the 1854 Ceded Territory,[299] especially given the spread of brainworm, it still represents a significant threat to moose, and will likely become more of a threat due to changing climate conditions.

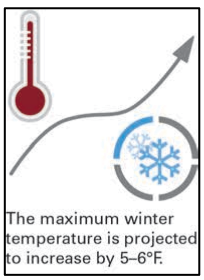
Another impact on moose populations and survival is predation from wolves. Recent and anticipated climate changes, such as less severe winters and declining snow depths, are favorable for white-tailed deer populations in the 1854 Ceded Territory. Deer are a significant food source for wolves, which may help support wolf populations. More wolves mean a greater likelihood of wolves interacting with and killing moose, especially calves.[300] Since moose are struggling with a suite of impacts associated with a changing climate (e.g., liver flukes, brainworm, habitat shifts), they are especially vulnerable to predation by wolves.[301]

[293] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[294] Michigan Department of Natural Resources. 2015. Brainworm. Accessed on March 22: https://www.michigan.gov/dnr/0,4570,7-153-10370_12150_12220-26502--,00.html
[295] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[296] Input from Wildlife Expert from Grand Portage
[297] The University of Minnesota. 2016. Moose in Minnesota: Investigating Moose Populations in Northern Minnesota: Liver Flukes. http://www.nrri.umn.edu/moose/information/LiverFluke.html
[298] Murray, D. L., E. W. Cox, W. B. Ballard, H. A. Whitlaw, M. S. Lenarz, T. W. Custer, T. Barnett, and T. K. Fuller. 2006. Pathogens, nutritional deficiency, and climate influences on a declining moose population. Wildlife Monographs 166: 1-30
[299] Input from Wildlife Expert from Grand Portage
[300] Mech, L.D. and Feinbech, J. 2014. Re-evaluation of the Northeastern Minnesota Moose Decline and the Role of Wolves . The Journal of Wildlife Management 78(7): 1143-1150
[301] ibid

Projected Climate Related Impacts: Climate change is projected to lead to a 4°-5°F increase in annual temperatures throughout the 1854 Ceded Territory and across the reservations by the 2050s. This will continue to shorten the winter season and lead to a transition in winter precipitation from snow to rain (winter temperatures are projected to increase by 5°-6°F by the 2050s). Minnesota is at the southern edge of the preferred habitat range for moose,[302] meaning temperature increases have the potential to alter the viability of the 1854 Ceded Territory and the reservations for moose, leading to further reductions in moose populations.



Moose may also "*face chronic malnutrition and parasitism*" as a consequence of climate change (p. 72).[303] This is largely due to the aspen-birch and spruce-fir forests declining and potentially disappearing from their current ranges and the increasing population of white-tailed deer in areas traditionally dominated by moose. Accompanying an increase in white-tailed deer within the 1854 Ceded Territory and across reservations is likely to be an acceleration in the spread of parasites (liver fluke and brainworm) that are relatively benign to the deer, but fatal to moose (e.g., brainworm) (see above).



In addition, warming winters, which are already being experienced in the 1854 Ceded Territory and reservations, but projected to occur more intensively in the future (projected increase of 5°-6°F by midcentury), will increase survival rates of winter ticks. Winter ticks appear to prefer moose as their host, with a study in Canada finding that the average moose hosts over 33,000 winter ticks.[304] Ticks cause damage to moose by: 1) increasing their exposure to the elements through loss of hair, 2) increasing energy expenditures because of extra time spent grooming instead of foraging, and 3) increasing stress due to substantial blood loss.[305] As springs become milder, meaning that more female ticks and eggs survive, more moose may die due to these factors[306] or through increased predation by wolves. Additionally, longer, warmer falls and earlier spring snowmelts, all of which are projected to occur in the 1854 Ceded Territory, will help to improve conditions for winter ticks.[307] Moreover, a decline in the fire potential due to projected increases in precipitation and fire suppression practices, will likely cause higher survivorship of winter ticks, snails, and slugs that can carry parasites that impact moose while also reducing the amount of browsing and foraging habitat for moose. Combined, these factors will very likely lead to increased moose mortality within the 1854 Ceded Territory and across reservations.[308]

4.11.1.2 Vulnerability Assessment Results

Based on these factors, moose are extremely sensitive (S4) to changes in climate and have very low adaptive capacity (AC1) to respond. ***This means that moose are highly vulnerable to changing climate conditions.***

[302] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[303] ibid
[304] Samuel, B. 2004. White as a Ghost: Winter Ticks and Moose. Federation of Alberta Naturalists, 1 Natural History Series. 100 pgs.
[305] The University of Minnesota. 2016. Moose in Minnesota: Investigating Moose Populations in Northern Minnesota: Winter Ticks. http://www.nrri.umn.edu/moose/information/WinterTick.html
[306] ibid
[307] ibid
[308] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center

4.11.1.3 Customized Adaptation Strategies

The following series of detailed adaptation actions were developed collaboratively and customized to the unique situation, needs, and context of moose within the 1854 Ceded Territory and reservations.

Adaptation Strategies to Address Climate Impacts to Moose	
Collaboration	• Coordinate with resource co-managers across the landscape and in neighboring regions on projects that benefit moose. • Host an annual meeting with other agencies and resource managers such as state agencies, federal agencies, local resource managers, tribal resource managers, and others to discuss and coordinate moose management. • Work with moose managers in the Northeast to understand geographic variation in moose response to climate change, which may assist wildlife managers in the 1854 Ceded Territory and on reservations with developing strategies to benefit moose. • Hire additional staff to assist in moose management and moose-related research.
Moose Abundance and Distribution	• Continue to undertake aerial surveys to determine moose abundance throughout the 1854 Ceded Territory and across reservations. • Look at alternative survey techniques that will more accurately capture the abundance of moose on the landscape, particularly in low-density areas or during different seasons. • Set specific management goals for the 1854 Ceded Territory and the individual reservations. • Use population and/or suitability models to determine the relationship between population surveys and population size. • Explore alternative techniques that are more effective for monitoring moose distribution on the landscape, particularly in low-density areas or in different seasons.
Population Demographics	• Continue to undertake aerial surveys to determine moose population dynamics throughout the 1854 Ceded Territory and across reservations. As part of those surveys, monitor: o Bull-cow ratios; and o Cow-calf ratios and twinning rates. • Continue and increase the number of collaring studies. As part of these studies, monitor physical characteristics such as pregnancy rates. • Conduct model-driven research to focus on the effect of climate and associated biotic factors (e.g., parasites and winter tick) on demographic parameters such as recruitment (number of calves per hundred cows) and twinning rate. • Conduct research on pregnancy rates. • Conduct adult and calf cause specific mortality studies. As part of these studies, investigate issues such as brainworm and liver fluke presence in deer and moose. • Conduct research to more thoroughly understand calf survival to 6-months.
Habitat Enhancement	• Assure future availability of wetlands and other habitats where moose are most secure from heat stress by undertaking wetland conservation initiatives such as conservation easements, mitigation banking, and others deemed viable. • Initiate prescribed burns and other vegetative treatment projects to improve moose habitat lost to ecological succession or human impacts. • Increase stand complexity and encourage mixed stands: Promote regeneration techniques such as fire that encourage mixed stands similar in composition, age and size to those existing under the range of natural variation and discourage the establishment of stands uniformly dominated by a single species. • Increase rotation age of aspen stands to increase understory browse component while retaining summer thermal cover.

Habitat Use	• Conduct research looking at how moose respond to their environment and use habitat to meet their thermal and foraging needs. • Identify crucial moose habitats (including calving, winter, summer, and yearlong) and work with public and private land managers to protect and enhance those areas.
Education	• Educate the public about the influences on and changing possibilities for moose populations in the face of climate change. • Install interpretive signs in moose areas for public information. • Work with news media sources to inform and educate the public about moose and moose management programs in northeastern Minnesota. • Develop a landowner's guide to moose management and disseminate through the 1854 Ceded Territory and across reservations. • Raise the public profile of moose in Minnesota by building a diverse constituency that will recognize the ecological, cultural and economic value of moose.

Monitoring and Assessment	• Research on the seasonal nutritional condition of moose.
	• Monitor habitat variables to see how they are changing and how those variables potentially affect the distribution and population dynamics of moose. Variables to measure include:
	  o Temperature and precipitation monthly
	  o Occurrence of freezing rain and extreme summer heat events
	  o Start of the growing season
	  o Changes in the distribution of mixed-wood and pure conifer forests
	  o Snow depth and crusting
	• Research and monitoring to understand the relative influence of climate-driven habitat change (e.g., proportion of mixed-wood and young forest) on moose recruitment and population growth.

Mortality-Related Efforts and Research	• Predation
	  o Monitor predator populations.
	  o Implement strategies to relieve predation pressure on adults/calves.
	• Parasites
	  o Monitor deer abundance and distribution.
	  o Monitor winter tick presence and moose coat condition.
	  o Implement strategies to reduce winter tick abundance.
	  o Implement strategies to reduce parasite transmission between deer and moose.
	  o Manage deer through strategies such as harvest and a ban on recreational feeding.
	  o Monitor intermediate hosts of parasites like brainworm, liver fluke, and others.
	  o Implement strategies to interrupt parasite cycling and impacts on moose.
	• Disease
	  o Monitor moose population for exposure to and signs of active known wildlife diseases and viruses via collaring efforts and incidental opportunities.
	  o Engage the hunting community to report incidences of potentially diseased moose.
	• Anthropogenic
	  o Aggressively address illegal harvest.
	  o Routinely review and follow adaptive harvest strategies enabling continued use of subsistence harvest.
	  o Support and enhance law enforcement efforts to reduce illegal taking of moose.
	  o Collaborate with MNDOT to implement roadside brush-clearing to improve visibility at the most dangerous moose crossings.
	  o Collaborate with MNDOT to erect warning signs at traditional moose road crossings.

4.11.2 Bald Eagle (Migizi)

Figure 46: Bald eagle. Source: www.fws.gov.

The bald eagle has long been a significant species for the Ojibwe. For hundreds of years, eagle parts, including feathers, have been used in religious and cultural practices. In pre-settlement times, the bald eagle could be found throughout present-day Minnesota.[309] However, the use of pesticides, including DDT (dichloro-diphenyl-trichloroethane), hunting, and deforestation led to a stark decline in bald eagle populations throughout the United States.[310] In light of this decline, state and federal leaders identified bald eagles as a "threatened" species on the federal (1978) and state of Minnesota Endangered Species' Lists (1984).

Through management, habitat protection, and the banning of certain pesticides, bald eagle populations have been recovering in Minnesota and throughout the U.S. Minnesota now has the third largest population of bald eagles (only Alaska and Florida have more), with an estimated 1,312 (±220) active nests identified as of 2005.[311] This recovery led to bald eagles being removed from the Endangered Species List (August 9, 2007), although bald eagles and their nests are still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.[312] Bald eagles can most commonly be found in the forested northern portions of Minnesota, including forested land in the 1854 Ceded Territory and on reservations.

Bald eagles are able to adapt to an array of habitats and are capable of surviving a fair amount of human disturbance, including development and modest land-use changes.[313] Bald eagles are also capable of migrating if food becomes difficult to find. While the bald eagle prefers fish, it is an opportunistic feeder, meaning that it will forage on fish, bird, and mammal carrion.[314] Despite its adaptability, bald eagles are still affected by human activity such as the use of pesticides, organophosphates, heavy metals, and other pollutants.[315] Lead poisoning, oil spills, and collisions with vehicles also threaten bald eagle populations.[316]

4.11.2.1 Climate Change and Bald Eagles

Existing Conditions: While little literature exists on the impacts of weather and climate on bald eagles, research shows that eagle nesting is occurring earlier every year.[317] On average, eagles nesting along Great Lakes tributaries (especially in Michigan) begin nesting 0.9 days earlier each year than they did the

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[309] Minnesota Department of Natural Resources: Bald Eagle. http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ABNKC10010

[310] ibid

[311] Baker, R. J., and Y. A. Monstad. 2005. 2005 Minnesota Bald Eagle surveys. Nongame Wildlife Program, Minnesota Department of Natural Resources Report. 4 pp.

[312] Minnesota Department of Natural Resources: Bald Eagle. http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ABNKC10010

[313] ibid

[314] Buehler, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). Number 506 *in* A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, Pennsylvania.

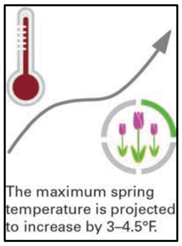
[315] Minnesota Department of Natural Resources: Bald Eagle. http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ABNKC10010

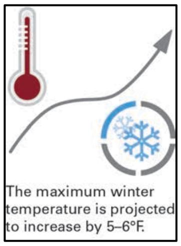
[316] Buehler, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). Number 506 *in* A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, Pennsylvania.

[317] U.S. Fish and Wildlife Service. Michigan: Nesting Behavior May Provide Clues to Climate Change Effects in Bald Eagles: http://www.fws.gov/news/blog/index.cfm/2011/6/10/Michigan-Nesting-Behavior-May-Provide-Clues-to-Climate-Change-Effects-in-Bald-Eagles

previous year.[318] Since observations began, this has translated into a nearly six-week shift in nesting initiation from mid-June to early May. One potential explanation for this change is that the "*reduced duration and extent of ice cover on the Great Lakes…has led to earlier access to foraging areas along the lakes, which has triggered earlier initiation of egg laying by nesting eagles.*"[319] Since the timing of bald eagle nesting is changing to correspond with changes in the ice-out dates (and thus the availability of food), it appears that eagles are adapting to existing changes in climate.

Projected Climate-Related Impacts: It is not entirely clear how projected changes in climate will affect bald eagles, especially bald eagles within the 1854 Ceded Territory and the reservations. What is clear is that as temperatures in the Great Lakes region warm, most lakes will be ice covered for less of the year, meaning that eagles and other birds will have easier and longer access to food sources. This will be particularly true during the winter and spring seasons where temperatures are projected to increase between 3.5°-6°F (5°-6°F during winter and 3°-4.5°F during spring).





Changes to the landscape based on increasing temperatures and shifting precipitation patterns could also affect bald eagles. Research by the National Audubon Society found that, by 2080, bald eagles across the U.S. are projected to have only 26 percent of their current summer range remaining.[320] The eagle could potentially "*recover 73% of summer range in new areas opened up by a shifting climate*,"[321] although there is no guarantee that this land will become available or that it will be viable habitat (e.g. forested, relatively undisturbed, with viable food reserves) for bald eagles. No data was specifically found on how these landscape shifts could affect bald eagles within the 1854 Ceded Territory or on reservations, but wildlife experts in the region believe that any potential negative impacts associated with shifting landscapes will be more than compensated for by longer access to the regions lakes and fish, as well as greater predation on deer carrion.[322]

One possible further impact to bald eagles within the 1854 Ceded Territory is high wind events, which have the potential to negatively impact bald eagles by felling nesting trees. Eagles prefer high trees for nesting, meaning that these trees are more susceptible to wind disturbances than smaller trees. However, the trunk width of preferred eagle nesting trees may help to reduce the impact of small and moderate wind events since eagles prefer trees with large width trunks.[323]

4.11.2.2 Vulnerability Assessment Results

Based on the above factors, bald eagles have a relatively low sensitivity (S1) to changing climate conditions and a relatively high capacity to adapt (AC3). This means that ***bald eagles have a medium-low vulnerability to climate change.***

[318] U.S. Fish and Wildlife Service. Michigan: Nesting Behavior May Provide Clues to Climate Change Effects in Bald Eagles: http://www.fws.gov/news/blog/index.cfm/2011/6/10/Michigan-Nesting-Behavior-May-Provide-Clues-to-Climate-Change-Effects-in-Bald-Eagles
[319] ibid
[320] Audubon Society. Climate Endangered: Bald Eagle. http://climate.audubon.org/birds/baleag/bald-eagle
[321] ibid
[322] Wildlife experts within the 1854 Ceded Territory
[323] Minnesota Department of Natural Resources: Bald Eagle. http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ABNKC10010

4.11.2.3 Adaptation Strategies

Detailed adaptation strategies were not developed for bald eagles. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of bald eagles to climate change.

1. Reduce non-climate stressors such as contamination loads in rivers, lakes, and streams that may reduce the overall health of bald eagles and make them more susceptible to changing climate conditions.
2. Habitat and landscape management such as preservation of large diameter white pine trees, or other large diameter, tall trees in the vicinity of lakes will ensure continued nesting habitat availability for bald eagles.
3. Develop and implement methods to limit the amount of lead put into the environment (e.g., switch to non-lead bullets).
4. Nesting platforms to help address potential losses to nesting trees.

4.11.3 Gray Wolves (Ma-iingan)

Figure 47: Gray Wolf. Image Courtesy of the 1854 Treaty Authority.

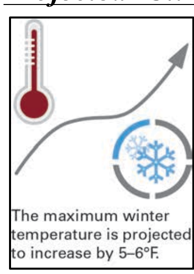
In the Ojibwe creation story, the Creator sent the wolf, Ma-iingan to keep man company while walking around creation.[324] Eventually, the Creator told the two they must separate, walking separate, yet parallel lives, noting: "*what happens to one will also befall the other.*"[325] As such, since the beginning of time the relationship between the wolf and Ojibwe people has been strong, with modern similarities being drawn between how both mate for life, have a Clan system and a tribe, have had land taken from them, and have been mistreated, but are recovering.[326]

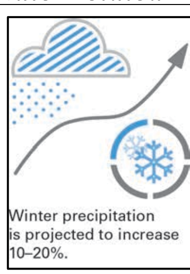
The history of the gray wolf in Minnesota is one of depletion and recovery. In the early 20th century, the northeastern corner of Minnesota sheltered one of the last remaining wild wolf populations in the United States.[327] In 1974, gray wolves were officially listed on the U.S. Endangered Species List due to "*severe overharvesting resulting from fur trapping, bounties, and livestock protection efforts.*"[328] By 1978, wolves in Minnesota were reclassified as threatened and since that time, the population has rebounded from a low of 350 to more than 3,000. Today, the gray wolf is listed as threatened in the 1854 Ceded Territory and Minnesota and endangered elsewhere in the Great Lakes region (and across the U.S.)[329].

4.11.3.1 *Climate Change and Gray Wolves*

Existing Conditions: Gray wolves are a highly adaptable species, when given the space. Their ability to hunt multiple prey items (i.e., moose, deer, beaver) and their ability to survive in a variety of habitats mean that wolves are currently doing well with the observed changes in climate across the region. The major threats to wolves are disease and human interference, either from direct human-wolf interaction or through land use changes.

Projected Climate-Related Impacts: Within the 1854 Ceded Territory and the reservations, winter temperatures are projected to increase between 5°-6°F by midcentury and winter precipitation is projected to increase by 10-20%, with more precipitation falling as rain as opposed to snow. These changes may modestly impact the hunting success of wolves, especially since wolves tend to be more successful hunters when there is more snowfall (because their prey struggle with deep snow).[330] Perhaps more important is how climate change will affect the viability of wolf prey. If moose populations





[324] White Earth Reservation Tribal Council, A/K/A White Earth Business Committee, White Earth Band of Chippewa Indians. ND. Declaration designating the white earth reservation as a Ma'iingana (wolf) sanctuary. https://whiteearth.com/data/upfiles/files/Ma_iingan_Proclamation_4.pdf
[325] ibid
[326] ibid
[327] Minnesota Department of Natural Resources. Wolves. http://dnr.state.mn.us/mammals/wolves/mgmt.html
[328] 1854 Treaty Authority. 2016. MA'IINGAN (Wolf). http://www.1854treatyauthority.org/wildlife/wolfresearchproject.htm
[329] ibid
[330] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center

within the 1854 Ceded Territory and on reservations continue to decline, wolves will lose a key food source. This, however, does not appear to be a significant impediment to wolf survival since they have other food sources in the region such as deer, that are projected to do well with climate change. Thus, wolves are projected to do well with projected changes in climate due to their generalist feeding patterns, their ability to survive in a variety of habitats, their high reproductive potential, their large home ranges, and their connection to other wolf populations throughout the Great Lakes region.

4.11.3.2 Vulnerability Assessment Results

Based on these factors, gray wolves have a very low sensitivity (S1) to changing climate conditions and have a relatively high adaptive capacity (AC3). This means that ***wolves have a medium-low vulnerability to climate change.***

4.11.3.3 Proposed Adaptation Strategies

Detailed adaptation strategies were not developed for wolves. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of wolves to climate change.

1. Continue to educate on the cultural significance of wolves and the role they play in the ecosystem.
2. Maintain protections and incentives to keep lands in forest as opposed to converting to agriculture or development.
3. Continue to monitor wolf populations, including population surveys, collaring projects, etc.
4. Manage prey species (ex. moose, deer).
5. Evaluate and implement protection strategies to manage wolf population.
6. Coordinate and consult with federal and state agencies on wolf management.

4.11.4 White-Tailed Deer

Figure 48: White-tailed deer. Source: mda.state.mn.us.

White-tailed deer are one of the most abundant species of wildlife currently found in Minnesota and in many parts of the 1854 Ceded Territory, with a population size of nearly 1,000,000 individuals. [331] White-tailed deer have not always been common in the 1854 Ceded Territory and on reservations, especially in the more northern forest habitats.[332] Instead, moose and caribou were the most prevalent species of the deer family found within the region, particularly in the early 19th century. Over time, land use changes such as clear cutting forests, hunting regulations, and the innate ability of white-tailed deer to readily adapt to their surroundings, have made them a common species within the 1854 Ceded Territory and on reservations.

White-tailed deer are opportunistic feeders, eating acorns, corn, soybeans, mushrooms, grasses, tree leaves, buds, twigs, bark, wild grapes, hay, apples, and other assorted shrubs.[333] This versatile pallet allows them to thrive in a variety of habitats. Their primary predators include wolves, coyotes, bears, bobcats, and humans. Within the 1854 Ceded Territory and the reservations, white-tailed deer are likely contributing to the current decline in moose numbers by expediting the spread of parasites such as liver fluke and brainworm.[334]

4.11.4.1 Climate Change and White-Tailed Deer

Existing Conditions: There are notable yearly variations in the deer population based on weather variables such as the length and severity of the winter season and average as well as extreme winter temperatures.[335] Milder winters, which occurred in 2015 and are projected to occur more frequently in the future, allow more deer to survive and may mean that does are healthy enough to support the physical demands of nursing their offspring.[336] Part of the reason for this growth is that milder winter temperatures can translate into lower snow depth, making vegetation easier to find and require less energy expenditure for mobility purposes.[337]

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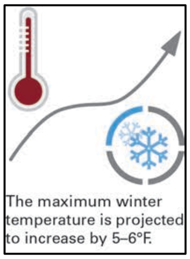
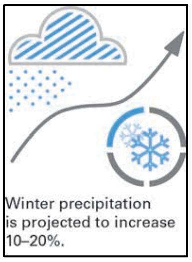
[331] Minnesota Department of Natural Resources. White-tailed deer. http://dnr.state.mn.us/mammals/deer/index.html
[332] ibid
[333] ibid
[334] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[335] Minnesota Department of Natural Resources. 2015. DNR mid-summer report: More deer seen after milder winter. http://news.dnr.state.mn.us/2015/07/28/dnr-mid-summer-report-more-deer-seen-after-milder-winter/
[336] ibid
[337] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service, Washington, DC.

Projected Climate Related Impacts: Projected changes to climate, specifically the projections that winter





temperatures will increase between 5°-6°F by the 2050s, are expected to benefit white-tailed deer.[338] Since the survival of white-tailed deer is inversely related to the frequency and severity of winter weather,[339] and projections show that winter is very likely to become milder under a climate-altered future, it is very likely that white-tailed deer populations are going to continue growing and thriving in the 1854 Ceded Territory and on the reservations. Climate change related shifts in forest cover types will likely increase browse availability to deer.

There are, however, potential changes in the winter precipitation regime that could negatively impact deer. For example, the likelihood of more winter precipitation falling as rain or freezing rain may also hinder deer populations, especially if this precipitation creates a hard crust on top of existing snow, making it harder for deer to traverse but easy for predators such as wolves and bobcats to navigate. Overall, however, white-tailed deer within the 1854 Ceded Territory and on the reservations are likely to benefit from a changing climate.

4.11.4.2 White-Tailed Deer Vulnerability Assessment Results

Based on these factors, white-tailed deer have an extremely low sensitivity (S1) to changing climate conditions and have a very high adaptive capacity (AC4). This means that ***white-tailed deer have a low vulnerability to changing climate conditions.***

4.11.4.3 Adaptation Strategies

Detailed adaptation strategies were not developed for white-tailed deer. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of white-tailed deer to climate change.

1. Continue to manage deer for population goals that do not negatively impact plant communities.
2. Work to restore predator-prey relationships to naturally keep white-tailed deer populations balanced.
3. Cooperate with other resource managers including the MNDNR on setting population goals.
4. Manage harvest seasons to meet population goals.
5. Enforce harvest regulations and address illegal harvest.
6. Implement or consult with other federal, state, and local land managers on projects (timber management, prescribed fire, etc.) providing deer habitat.
7. Monitor for and implement control measures for diseases (ex. chronic wasting disease, bovine tuberculosis).
8. Monitor deer abundance and distribution.
9. Implement strategies to reduce parasite transmission between deer and moose.
10. Manage deer through things such as a ban on recreational feeding of white-tailed deer and encouraging more harvest of venison.

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[338] Johnston, K., and O. Schmitz. 2003. Wildlife and climate change: assessing the sensitivity of selected species to simulated doubling of atmospheric CO2. Global Change Biology 3(6):531- 544.

[339] DelGiudice, G. D., M. R. Riggs, P. Joly, and W. Pan. 2002. Winter severity, survival, and cause-specific mortality of female white-tailed deer in north-central Minnesota. Journal of Wildlife Management 66:698–717

4.11.5 Birds and Waterfowl

Birds and waterfowl are important subsistence and cultural species within the 1854 Ceded Territory and across reservations. Species such as grouse and duck have been providing subsistence for band members for centuries and the hunting of these species provides an opportunity for band members to pass on traditional skills to future generations while also teaching youth about the natural balance of ecosystems. Birds and waterfowl within the 1854 Ceded Territory and on the reservations also provide important ecological benefits, helping to maintain healthy vegetation stands and serving as a food source for higher-level predators.

Figure 49: Grouse, photo courtesy of the 1854 Treaty Authority.

Of all the birds and waterfowl species present within the 1854 Ceded Territory and across the reservations, the bands and the 1854 Treaty Authority chose to focus this assessment on some of the most important species to cultural, traditional, and subsistence practices. In total, eight species were identified and grouped into two categories: birds (turkey, pheasants, ruffed grouse, and spruce grouse) and waterfowl (ducks, geese, loons, and trumpeter swans).

4.11.5.1 Climate Change and Birds and Waterfowl

Existing Conditions: Climate and weather related impacts to birds and waterfowl within the 1854 Ceded Territory and across reservations have mostly been seen through shifts in natural landscapes and the timing of migrations. Research has shown that species that are capable of migrating are often starting their migrations sooner and ending them later as the transition seasons shorten.[340] Outside of these impacts, however, climate change to-date has not significantly affected birds and waterfowl species within the region. Land use changes and human interactions are, instead, the primary factors affecting these species.

Projected Climate-Related Impacts: For all species of birds and waterfowl included in our analysis, there are likely to be climate-related mismatches between the timing of breeding and the availability of forage to support offspring.[341] In addition, since spring cues are coming earlier, species are likely to begin their migrations sooner than they have historically. This could lead to a timing mismatch between when migratory species arrive and when their food is available.[342] In general, bird ranges will shift northward or upward in elevation for nearly all species. For example, according to the US Fish and Wildlife Service's Climate Adaptation Plan, geese are already moving their ranges more northward, no longer venturing as far south as they used to.[343] It is expected these types of changes will continue to occur, perhaps more rapidly, as the climate changes.

Climate change will affect individual species in different ways based on the characterizations of that species and how it interacts with its habitat. Some species will do better than others as conditions change,

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[340] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service, Washington, DC.

[341] Visser, M. E., A. J. Vannoordwijk, J. M. Tinbergen, and C. M. Lessells. 1998. Warmer springs lead to mistimed reproduction in Great Tits (Parus major). Proceedings of the Royal Society of London Series B: Biological Sciences 265:1867–1870.

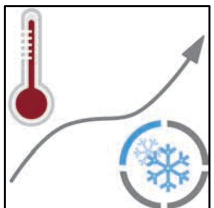
[342] Murphy-Classen, H. M., T. J. Underwood, S. G. Sealy, and A. A. Czyrnyj. 2005. Long-term trends in spring arrival dates of migrant birds at Delta Marsh, Manitoba, in relation to climate change. Auk 122:1130–1148.

[343] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service, Washington, DC.

so for the purposes of this analysis the species in this section have been grouped into two categories: those that will be 1) climate winners or experience little impact due to climate change (termed climate winners/neutral), and those that will be 2) climate losers. To help organize the remaining section, we will discuss the projected changes in climate and the associated impacts for climate winners/neutral and climate losers separately.

Climate Losers

Ruffed Grouse: According to the National Audubon Society, ruffed grouse are climate endangered, primarily due to a projected loss of 34% of their breeding range by 2080.[344] Furthermore, National Audubon Society's climate models found that the ruffed grouse's habitat may shift so much that the species will no longer be able to survive in the lower 48 states by the end of the century.[345] The main reason for this is that the forests the ruffed grouse depend on will likely be negatively impacted by a changing climate (see forestry section for more detail).[346] Loss of its preferred habitat and the fact that ruffed grouse are not a migratory species means that it's likely to be seriously impacted by changing climate conditions. This impact is compounded by historical habitat loss due to human interference and land use changes.[347]


The maximum winter temperature is projected to increase by 5–6°F.

Changes in precipitation can negatively impact the nesting and brooding success of ruffed grouse, meaning that more variable and intense periods of precipitation, all of which are projected with climate change, could lead to significant impacts to grouse reproductive success and population cycles.[348] In addition, decreases in snow can negatively impact ruffed grouse as snow is used for cover. It is not, however, only the absolute decline in snow quantity that can impact ruffed grouse, increases in winter temperatures (projected to increase 5°-6°F by the 2050s) that cause snow to melt and then re-freeze can create a hard crust on the top of snow, which also impedes the ability of ruffed grouse to burrow. Given that climate change will significantly impact winter temperatures and the quality of snow (more precipitation falling as rain and freezing rain as opposed to snow), ruffed grouse are likely to see significant population declines in the 1854 Ceded Territory and across reservations.[349]

Common Loon: Another species likely to be negatively impacted by climate change is the common loon. The same National Audubon Society study found that, by 2080, across the United States the common loon is projected to lose 56% of its current summer range and 75% of its current winter range.[350] This information was confirmed by the USDA Forest Service.[351] Within northeastern Minnesota, the biggest change is a northward shift in the loons preferred summer habitat, which will likely lead to a decline in loon numbers.[352] The National Audubon Society report concluded: "*it looks all but certain that Minnesota will lose loons in summer by the end of the century.*"[353]

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[344] Audubon Society. Climate Threatened: Ruffed Grouse. http://climate.audubon.org/birds/rufgro/ruffed-grouse
[345] ibid
[346] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[347] Wildlife Management Institute. 2008. Seasons' End: Global Warming's Threat to Hunting and Fishing. Bipartisan Policy Center
[348] ibid
[349] Matthews, S.N., L. R. Iverson, A.M. Prasad, A. M., and M.P. Peters. 2007-ongoing. A Climate Change Atlas for 147 Bird Species of the Eastern United States [database]. http://www.nrs.fs.fed.us/atlas/bird, Northern Research Station, USDA Forest Service, Delaware, Ohio.
[350] Audubon Society. Climate Threatened: Common Loon. http://climate.audubon.org/birds/comloo/common-loon
[351] Matthews, S.N., L. R. Iverson, A.M. Prasad, A. M., and M.P. Peters. 2007-ongoing. A Climate Change Atlas for 147 Bird Species of the Eastern United States [database]. http://www.nrs.fs.fed.us/atlas/bird, Northern Research Station, USDA Forest Service, Delaware, Ohio.
[352] Audubon Society. Climate Threatened: Common Loon. http://climate.audubon.org/birds/comloo/common-loon
[353] ibid

Spruce Grouse: In the northern portions of the Great Lakes, projected changes in climate could significantly impact spruce grouse viability by increasing temperature and precipitation regimes in such a way that the spruce grouse's preferred habitat is greatly reduced.[354,355] According to the State of Minnesota, *"declines in coniferous forests will have negative impacts on the plant and animal communities associated with them…for example, spruce grouse…"* (p. 22). Given that spruce grouse are currently at the southern portion of their range, any shifts to their preferred habitat could mean a significant reduction in population size throughout the 1854 Ceded Territory and across the reservations.

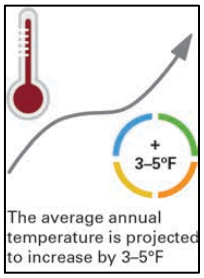


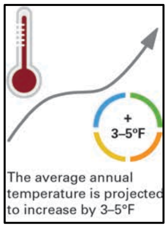
Figure 50: Spruce Grouse. Photo courtesy of the 1854 Treaty Authority.

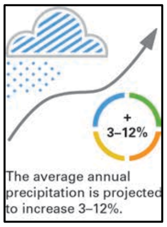
Trumpeter Swans: Trumpeter swans had once been eliminated within the Great Lakes region due to hunting.[356] However, conservation efforts have led to a reemergence of the species, especially during the breeding season across the Great Lakes region and specifically in northeastern Minnesota.[357] Due to the recent reemergence of the species, little is known about how regional climate change may affect it. Models show that, across the United States, the trumpeter swan faces a potential 67% loss of current winter range by 2080, necessitating a dramatic northward shift.[358] This could mean that the 1854 Ceded Territory and the reservations will see a marked increase in the number of swans by mid-to-late century. However, other models show that trumpeter swans within Minnesota (no data was specifically available for the 1854 Ceded Territory) are imperiled.[359] Given this wide variation in potential climate change impacts to trumpeter swans, it was determined that they belonged in the climate losers category.

Climate Winners: Climate winners and those deemed climate neutral have the demonstrated ability to forage on alternative food making them more likely to survive, if not thrive, in a climate altered future. Additionally, the species deemed climate winners/neutral are habitat generalists[360] capable of residing in a variety of habitat types. This means that even if their preferred habitat is disrupted due to climate change, they are likely able to find an alternative habitat.

[354] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[355] Anich, N.M., Worland, M., and Marin, K.J. 2013. Nest-site selection, nest survival, productivity, and survival of Spruce Grouse in Wisconsin. The Wilson Journal of Ornithology, 125(3): 570-582
[356] Audubon Society. Climate Threatened: Trumpeter Swan. http://climate.audubon.org/birds/truswa/trumpeter-swan
[357] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[358] Audubon Society. Climate Threatened: Trumpeter Swan. http://climate.audubon.org/birds/truswa/trumpeter-swan
[359] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[360] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota

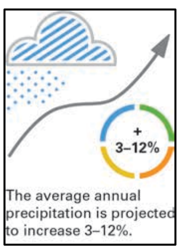
Pheasants: The US Fish and Wildlife Service found that pheasants across the United States are likely to face significant impacts associated with climate change.[361] One of the few regions where pheasants are projected to do well, however, is in northeastern Minnesota.[362] Today, pheasants are relatively rare within the 1854 Ceded Territory and across the reservations. However, the projected annual warming of 3-5^{o}F within the 1854 Ceded Territory, combined with projected seasonal and annual increase in precipitation (3-12% increase) by the 2050s will likely create more viable habitat and a more conducive climate for pheasants.[363]





Turkeys: According to the National Audubon Society, wild turkeys throughout the United States are considered climate threatened. This is because climate change is projected to eliminate 87% of the turkey's current winter range by 2080 due to shorter winter seasons.[364] The 1854 Ceded Territory and the reservations, however, are projected to be one of the few regions of the United States where wild turkeys will continue to do well. In fact, the National Audubon Society report found that, by midcentury wild turkeys will be able to reside in the 1854 Ceded Territory and the reservations year round.[365] Anecdotally, individuals within the 1854 Ceded Territory have already noted an increase in overall turkey numbers in the last several years.[366]

Wood Ducks: Similar to wild turkeys, the National Audubon Society's report[367] as well as work by the U.S. Fish and Wildlife Service[368] found that within the 1854 Ceded Territory and across the reservations wood ducks are projected to do well in a climate-altered future.[369] This is primarily due to projected increases in annual (3-12% increase by the 2050s) and seasonal precipitation changes, which may translate into more or larger habitats for ducks. In addition, warmer winters could translate into more viable wintering habitat for ducks, meaning that they are able to remain year round. Combined, these changes mean that wood duck populations within the 1854 Ceded Territory and reservations are likely to do well in a climate-altered future. It is possible, however, that warmer temperatures within the 1854 Ceded Territory could also speed the invasion of non-native grasses and pests and generally reduce the quality of foraging available to support wood ducks and other waterfowl.[370] Overall, however, these impacts are projected to be minor within the region.



Geese: According to NatureServe, Canadian geese are a climate secure species that is likely to continue expanding its range and population size in the 1854 Ceded Territory and across the reservations.[371] Right

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[361] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service, Washington, DC.

[362] Matthews, S.N., L. R. Iverson, A.M. Prasad, A. M., and M.P. Peters. 2007-ongoing. A Climate Change Atlas for 147 Bird Species of the Eastern United States [database]. http://www.nrs.fs.fed.us/atlas/bird, Northern Research Station, USDA Forest Service, Delaware, Ohio. http://www.nrs.fs.fed.us/atlas/bird/summ6pp_3091.html

[363] The Cornell Lab of Ornithology. 2015. Ring-Necked Pheasants. https://www.allaboutbirds.org/guide/Ring-necked_Pheasant/lifehistory

[364] Audubon Society. Climate Threatened: Wild Turkey. http://climate.audubon.org/birds/wiltur/wild-turkey

[365] ibid

[366] Wildlife expert within the 1854 Ceded Territory

[367] Audubon Society. Climate Threatened: Wood Duck. http://climate.audubon.org/birds/wooduc/wood-duck

[368] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service, Washington, DC.

[369] Audubon Society. Climate Threatened: Wood Duck. http://climate.audubon.org/birds/wooduc/wood-duck

[370] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service, Washington, DC.

[371] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)

now, most geese are breeding residents, meaning they are not present year-round. By mid-to-late century, however, there could be resident populations starting to emerge due to the warming of the region and extended periods where the regions lakes are ice-free.[372]

Table 7: Birds and waterfowl grouped based on how they are likely to fare in a climate-altered future.

Climate Winners / Neutral	Climate Losers
• Wood Ducks • Geese • Pheasants • Turkey	• Common Loon • Ruffed Grouse • Spruce Grouse • Trumpeter Swans

4.11.5.2 Birds and Waterfowl Vulnerability Assessment Results

Based on the aforementioned information, it was determined that turkey, wood ducks, pheasants, and geese, which were all deemed climate winners/neutral, have a low sensitivity to climate change (S1) and a relatively high capacity to adapt (AC3). This translates into a ***medium-low vulnerability to climate change***.

In contrast, ruffed grouse, spruce grouse, loons, and swans, which were all deemed climate losers, have a relatively high sensitivity to climate change impacts (S3) and a relatively low capacity to adapt (AC1), translating in to a ***medium high vulnerability to climate change***.

4.11.5.3 Adaptation Strategies

Detailed adaptation strategies were not developed for birds and waterfowl. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of birds and waterfowl to climate change.

1. Enhance species management for those species that excel in a climate-altered future.
2. Evaluate habitat and landscape management plans for the ability to support and protect more vulnerable species from changing climate conditions.
3. Continue to enhance wetland protection and restoration to ensure habitat availability for birds and waterfowl species that depend on those habitats.
4. Ensure that stands of closely interspersed younger and older trees are available in forest ecosystems to support ruffed grouse populations.
5. Corridors of immigration/emigration could be considered for wildlife species whose range will constrict out of or expand into Minnesota.
6. Protect and manage aspen forests for ruffed grouse.
7. Manage forests so as to enhance mast crops for turkeys.
8. Protect early successional habitat (young forest with densely growing young trees) as refugia for ruffed grouse.
9. Complete management of predators and furbearers (see below) through harvest management strategies.
10. Laws protecting endangered and threatened species may need to acknowledge that some species will become extirpated from Minnesota due to climate change, while some vulnerable species may need additional future protection.

[372] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)

11. Protect existing pine and spruce forests with structural complexity for spruce grouse.
12. Develop and conduct a coordinated regional ruffed and spruce grouse monitoring survey
13. Survey populations annually (ex. spring drumming count) and develop critical management thresholds, especially for spruce and ruffed grouse.
14. Conduct restoration activities if populations drop below historic averages. especially for spruce and ruffed grouse. Set other management thresholds based on population as necessary.
15. Define spruce grouse Habitat Management Units to a minimum standard (e.g., at least 124 acres in size).
16. Complete waterfowl surveys (aerial, shoreline, hunter bag checks, etc.).
17. Implement and enforce hunting regulations to allow for sustainability of species.
18. Consult with federal and state agencies on harvest seasons, hunting regulations, and habitat improvement projects.

4.11.6 Furbearers

Furbearers are any mammal that has been hunted or trapped primarily for the purpose of acquiring, utilizing, or selling the animal's fur. Within the 1854 Ceded Territory fisher, American marten, otter, beaver, muskrat, mink, fox, hare, coyote, lynx, bear, and bobcat have all been important furbearer species. While not all of these species can be trapped today, all are included in this analysis due to their historical (and often current) importance to the cultural, spiritual, and subsistence lifeways within the 1854 Ceded Territory and on the reservations.

Figure 51: Young American Marten. Source: www.dnr.wi.gov.

In addition to the economic and subsistence value provided by fur of these animals, these species also play a key role in forest and wetland ecosystems, helping to maintain the health and vitality of these environments. Many furbearers are also important cultural species with some being used in spiritual and cultural ceremonies, others playing a significant role in cultural history and stories, and some utilized as clans. Finally, the fur of many of these species has historically been used to provide clothing, warmth, and shelter for band members.

For the purposes of this assessment, furbearers have been grouped into two categories: climate winners/neutral and climate losers. Climate winners/neutral are generally those that are habitat generalists, meaning that they are widely distributed throughout Minnesota and are known to survive in multiple types of habitat and eat a variety of food sources. Within the climate losers category are both habitat specialists (those with a very specific preferred habitat type), and those habitat generalists that have a restricted range within the 1854 Ceded Territory or the reservations.

4.11.6.1 Climate Change and Furbearers

Existing Conditions: The habitat generalists deemed climate winners have generally done well with the climate variability and change experienced to date. They have been able to move to alternative habitats as their preferred habitat has shifted or adjusted over time. Sometimes these shifts lead to conflict, especially when preferred prey do not move as rapidly (or at all) and/or when they are forced into closer proximity with humans. In general, the 1854 Ceded Territory and/or the reservations are at the northern edge of the preferred habitat for species listed as climate winners/neutral.

Habitat specialists and species that have relatively small habitat ranges within the 1854 Ceded Territory and reservations have, in general, experienced more pressure due to changes in weather and long-term climate. This pressure is mostly tied to shifts in their desired habitat, including the loss of viable habitat and a loss of preferred food sources. Since most habitats are shifting at a quicker pace than these species are able to respond to, species in this category are struggling to survive in their current locations. As such, additional disruptions such as changes in predator-prey relationships, changes in vegetation cover, land use changes, and greater interactions with humans are and will likely continue to significantly affect the viability of these species.

Projected Climate-Related Impacts: Species listed as climate winners/neutral will, in general, experience less severe impacts associated with climate change than climate losers.[373] The primary reason for this is that they are capable of handling a wide variety of environmental conditions and variability and have the ability to utilize a variety of prey, and various habitats.

In contrast, species listed as climate losers are either habitat specialists which are at greater risk of losing the habitat they require for survival, or currently reside at the southern portion of their range meaning that ecosystem shifts have the potential to significantly disrupt their long-term survival (e.g. lynx) within the 1854 Ceded Territory and the reservations. The remainder of this section looks briefly at how climate change may affect the species listed as both climate losers and climate winners.

Climate Losers

Lynx: Lynx in the state of Minnesota are in the southern portion of their viable habitat. Within the 1854 Ceded Territory and on reservations, however, lynx will likely still have viable habitat, even in a climate-altered future. As the climate changes, however, the viability of the habitat within the 1854 Ceded Territory and the reservations for lynx may decline, and the species will continue to move further north. While no information on future lynx viability within the 1854 Ceded Territory in a climate-altered future was available from NatureServe, data for Michigan shows that lynx are critically imperiled due to climate change.[374] The State of Minnesota also found that "*the persistence of lynx in Minnesota…may be less likely due to changes in habitat and snow depth patterns associated with climate change*." (p. 23). Due to these factors, lynx are classified as climate losers and have a high likelihood of experiencing negative impacts associated with climate change within the 1854 Ceded Territory, especially around mid to late century.

American Marten: American marten are habitat generalists but, in Minnesota, they currently reside at the southern portion of their range.[375] American marten prefer boreal forests for habitat. As such, projected shifts to the boreal forest within the 1854 Ceded Territory will likely negatively impact American marten populations.[376] Anecdotal evidence from wildlife experts within the 1854 Ceded Territory supports this view.[377]

Snowshoe Hare: Snowshoe hare will very likely be negatively affected by changing climate conditions within the 1854 Ceded Territory, primarily due to shifts in the timing and extent of winter (projected to be 5-6°F warmer by the 2050s) and increased competition from other climate winners. Since snowshoe hare change their coats to coincide with the timing of winter, any changes in when winter occurs or the amount of snowfall will negatively impact the species by creating a situation where the hare's white coat is contrasted against green, gray, or brown of the snow-free landscape.[378] In addition, range shifts for aspen, birch, and balsam fir within the Territory and reservations could cause declines in the abundance and distribution of snowshoe hares.[379] Finally, browsing competition from large deer populations can also

[373] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[374] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[375] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[376] ibid
[377] Input from Wildlife Expert from the 1854 Treaty Authority
[378] Stakeholder input from the 1854 Treaty Authority
[379] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota

degrade habitat for snowshoe hare, further reducing the species survivability.[380] These factors combined led to the categorization of snowshoe hare within the 1854 Ceded Territory as climate losers.

Climate Winners

Beaver: Beaver are a secure species that are projected to do well with climate change.[381] As a habitat generalist, beaver are versatile and able to live in a variety of different areas throughout the U.S. and Minnesota. Their diet consists of woody vegetation and herbaceous plants, but the beaver is flexible in its choice of woody plants,[382] meaning that climate related changes to forest composition are unlikely to significantly impact beaver within the 1854 Ceded Territory and on the reservations.

Black Bear: Black bear in the state of Minnesota are in the southern portion of their viable habitat. Within the 1854 Ceded Territory and on reservations, however, black bear will likely still have viable habitat, even in a climate-altered future. As a habitat generalist and opportunistic feeder, black bear are poised to respond well to shifts in climate within the 1854 Ceded Territory and across the reservations. NatureServe lists black bear in the Great Lakes region as "climate secure" meaning that they are likely to do well in a climate-altered future (note: no specific information was available for black bear in Minnesota).[383]

Bobcat: Bobcats in the state of Minnesota are in the southern portion of their viable habitat. Within the 1854 Ceded Territory and on reservations, however, bobcat will likely still have viable habitat, even in a climate-altered future. As the climate changes, however, the viability of the 1854 Ceded Territory and the reservations for bobcat may decline, with suitable habitat for the species continuing to move further north. Bobcats are, however, habitat generalists and opportunistic feeders, meaning that they are able to survive in a variety of ecosystems and feed on an array of food sources. Because of this, bobcats were listed as climate winners/neutral within the 1854 Ceded Territory and on reservations.

Coyote: Coyotes are deemed "secure" to climate change throughout the U.S. and in the northern Great Lakes region (no specific information was available for Minnesota).[384] As a habitat generalist[385] and opportunistic feeder, coyotes are able to survive in a wide variety of environments including forests, cropland, grasslands, and shrublands.[386] In northern regions, coyote populations have an inverse relationship with wolf populations: rising when wolf numbers are low.[387] Overall, however, coyotes within the 1854 Ceded Territory and reservations are expected to do well in a climate-altered future.

Fisher: Fishers are habitat generalists that are able to survive in an array of environments.[388] According to NatureServe, fishers are a climate secure species, especially in northeastern Minnesota where changing climate conditions are likely to create more viable habitat for the species.[389] Wildlife experts within the 1854 Ceded Territory noted, however, that fisher within the area may be more vulnerable to climate

[380] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[381] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[382] ibid
[383] ibid
[384] ibid
[385] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[386] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[387] ibid
[388] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[389] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)

change than those found outside the region.[390] Detailed information to substantiate this observation, however, could not be found so fishers were kept in the climate winners' category.

Fox: According to NatureServe, red foxes within Wisconsin are deemed "apparently secure" to climate change (note: no information was available for red foxes within Minnesota).[391] As a habitat generalist and opportunistic feeder capable of eating mammals, fruit, and plant material, foxes are well positioned within the 1854 Ceded Territory and across the reservations to respond well to changes in climate.[392]

Mink: Throughout Minnesota, mink are deemed habitat generalists.[393] Mink prefer forested and permanent/semi-permanent wetlands, both of which are likely to be only moderately impacted by climate change within the 1854 Ceded Territory (see forestry and wetlands sections for more details). They have a wide pallet, eating small mammals, waterfowl, crayfish, and aquatic vertebrates.[394] Given their high adaptability and ability to survive in multiple ecosystems, mink were deemed to be climate winners within the 1854 Ceded Territory and on reservations.

Muskrat: Similar to other species in the climate winners category, muskrat are habitat generalists that are able to eat a wide variety of vegetation and aquatic invertebrates.[395] They prefer fresh or brackish marshes, lakes, ponds, swamps, and other bodies of slow-moving water, which are and will likely continue to be abundant in the 1854 Ceded Territory.[396] Due to their versatility and high adaptability, muskrat were deemed climate winners within the 1854 Ceded Territory and across the reservations.

River Otter: Similar to many other furbearers, river otter are habitat generalists that are capable of surviving in an array of environments.[397] They also consume a diversity of food types, especially fish, which are abundant within the 1854 Ceded Territory and on the reservations. As such, river otter are projected to do well in a climate-altered future.

Climate Losers	Climate Winners/Neutral			
• Lynx	• Beaver	• Black Bear	• Bobcat	• Coyote
• American Marten	• Fisher	• Fox	• Mink	• Muskrat
• Snowshoe hare	• River Otter			

Table 8: Furbearers Grouped by how they are likely to fare in a climate-altered future.

4.11.6.2 *Furbearers Vulnerability Assessment Results*

Based on these factors, species deemed climate losers (lynx, American marten, and snowshoe hare), have a relatively high sensitivity (S3) to changing climate conditions and a low adaptive capacity (AC1). Combined, these factors indicate that these ***species have a medium-high vulnerability to climate change***.

Species deemed as climate winners/neutral (beaver, black bear, bobcat, coyote, fisher, fox, mink, muskrat, and river otter) also have a relatively high sensitivity to changing climate conditions (S3) but have a greater capacity to adapt (AC3).

[390] Wildlife expert within the 1854 Ceded Territory
[391] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org
[392] ibid
[393] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[394] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[395] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota
[396] Natureserve. 2016. NatureServe Web Service. Arlington, VA. U.S.A. Available: http://services.natureserve.org. (Accessed: March 23, 2016)
[397] Wildlife Climate Change Working Group. 2008. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources. Division of Fish and Wildlife: Minnesota Department of Natural Resources. St. Paul, Minnesota

This translates into ***a medium-low climate change vulnerability for species listed as climate winners***.

4.11.6.3 Proposed Adaptation Strategies

Detailed adaptation strategies were not developed for furbearers. Instead, generalized strategies were identified that can serve as a foundation that the bands and 1854 Treaty Authority can build upon over time to reduce the vulnerability of furbearers to climate change.

1. Adjust species management as necessary for population projected to excel in a climate-altered future (such as fisher).
2. Continue to refine habitat and landscape management for climate vulnerable species.
3. Regularly monitor and regulate hunting and trapping to create stable populations.
4. Harvest management strategies may need to be adjusted to accommodate changes in bag limits and harvest seasons for furbearers.
5. Laws protecting endangered and threatened species may need to acknowledge that some species will become extirpated from Minnesota due to climate change, while some vulnerable species may need additional future protection.
6. Conduct population surveys to establish thresholds for management.
7. Develop and implement forest management guidelines to protect furbearers, especially fisher and American marten.
8. Protect and enhance movement corridors for furbearers, especially fisher and American marten.
9. Develop and maintain core current and projected American marten habitat areas and corridors by maintaining preferred ecosystems closer to their natural range of variability.
10. Identify and map key habitats for American marten and other climate loser furbearer species. An example includes areas that may have burned less frequently in the past, like north facing slopes and riparian areas.
11. Prioritize key American marten habitat and corridors for protection and/or management action.
12. Avoid the creation of uncharacteristically large gap openings and fragmentation of forest ecosystems in key habitat and corridors for fisher and American marten.
13. Protect stands like hemlock, spruce, and yellow birch, which are all preferred habitats for American marten.
14. Map and monitor the landscape suitable for resting and denning, particularly for American marten and fisher.[398]
15. Coordinate and consult with federal, state, and local agencies on land management activities benefiting habitat for furbearers.

[398] Purcell, K.L., Thompson, C.M., and Zielinski, W.J., Managing Sierra Nevada Forests. Chapter 4: Fishers and American Martens. U.S. Forest Service. General Technical Report PSW-GTR-237. Available at: http://www.fs.fed.us/psw/publications/documents/psw_gtr237/psw_gtr237_047.pdf

5. Implementation and Plan Maintenance

The information and details presented in this report represent an important step in building resilience to climate change within the 1854 Ceded Territory and across the reservations. To truly prepare, however, the actions identified in this plan need to be implemented. In many cases, this will necessitate the assignment of implementation responsibilities, multi-reservation collaboration, partnerships with state, federal, and local managers, and the securing of additional funding to finance the on-the-ground implementation of key adaptation actions. This section highlights some of the important next steps that need to be taken to ensure this plan leads to a more resilient natural and human community within the 1854 Ceded Territory and across reservations.

5.1 Summary of Adaptation Actions and Implementation Steps

Included in this plan are hundreds of general as well as detailed adaptation strategies that will help key species and ecosystems within the 1854 Ceded Territory and on reservations to adapt to the impacts associated with a changing climate. Broadly speaking, these actions fall into one of five categories: collaboration; conservation, preservation, and maintenance; education; monitoring and assessment; and restoration. While not every possible species or ecosystem of concern is profiled in this plan, the process used to create this plan can and could be replicated as new information or species of concern are identified.

For now, this plan represents a holistic assessment of how climate change is, and could continue, to impact 35 species, groups of species, or ecosystems within the 1854 Ceded Territory. To operationalize this plan, the Bois Forte, Fond du Lac, and Grand Portage bands and the 1854 Treaty Authority will need to undertake the following:

1. Identify key parties responsible for implementing adaptation strategies.
2. Determine metrics to gauge the success of identified actions. These metrics can be used to track progress as well as the effectiveness of implemented actions.
3. When necessary, secure additional funding to implement the desired actions.
4. Collaborate with colleagues both across the reservations and across jurisdictional boundaries to ensure the actions are implemented in a coordinated and comprehensive manner.
5. Monitor and report on implementation progress.
6. Revise and adjust actions as needed to accommodate for changes in climate science, local impacts, or other political/social factors.
7. Share successes, celebrate, and begin updating your plan, incorporating in new information.

5.2 Techniques for Maintaining the Plan

It is strongly recommended that this plan be updated at least every 5 years, and ideally every 3 years. This will ensure that new information in climate science, new details about local climate impacts, and any additional information about how species/ecosystems are adapting to climate change can be fully integrated into the adaptation efforts in the 1854 Ceded Territory and across reservations. When updating the plan, it is strongly recommended that the core team and subject matter experts be reconvened to provide critical input. The plan could be updated as a whole in a similar collaborative manner, or the responsibility for building resilience could be distributed and mainstreamed into the variety of resource management and other departments as appropriate and each party could use and update their own plans based on their needs and priorities.

During the plan update, there is not necessarily a need to create a new plan but there is a need to ensure that the vulnerabilities identified are still relevant and that the actions prioritized are still viable. During this process, it will be important to catalogue all on-going climate resilience efforts and identify where further or continued updates are necessary. During this review, it is highly likely that additional species/ecosystems may need to be added to the plan and that adaptation actions may need to be revised to reflect changes in science or policy. The bands and 1854 Treaty Authority could also synchronize this review process with the normal update cycle of the various habitat and resource management plans and use those existing review and update processes to ensure that climate change impacts are being adequately considered and addressed. This is a normal process and one that indicates that the bands and 1854 Treaty Authority are embracing an adaptive approach to planning for climate change.

6. Conclusion

Preparing for climate change is a process, not an outcome. This plan represents an important step in that process for the 1854 Treaty Authority and the Bois Forte Band of Chippewa, Fond du Lac Band of Lake Superior Chippewa, and Grand Portage Band of the Lake Superior Chippewa. Their success in preparing for climate change will depend on whether the strategies identified in this plan are implemented to their fullest potential, and whether an iterative process is established to frequently revisit this plan and all the other plans and programs used to manage the species and habitat in the region. The long-term vitality of the natural and cultural resources that are critical to the lifeways of people who live in or exercise treaty rights within the 1854 Ceded Territory and on the reservations will depend on this continued ability to incorporate new information and plan for the future.

With this project and the information contained within the report, the foundation for these future collaborations has been built. It is now up to the bands involved in this project to use build upon that foundation and take action and create a climate resilient region.