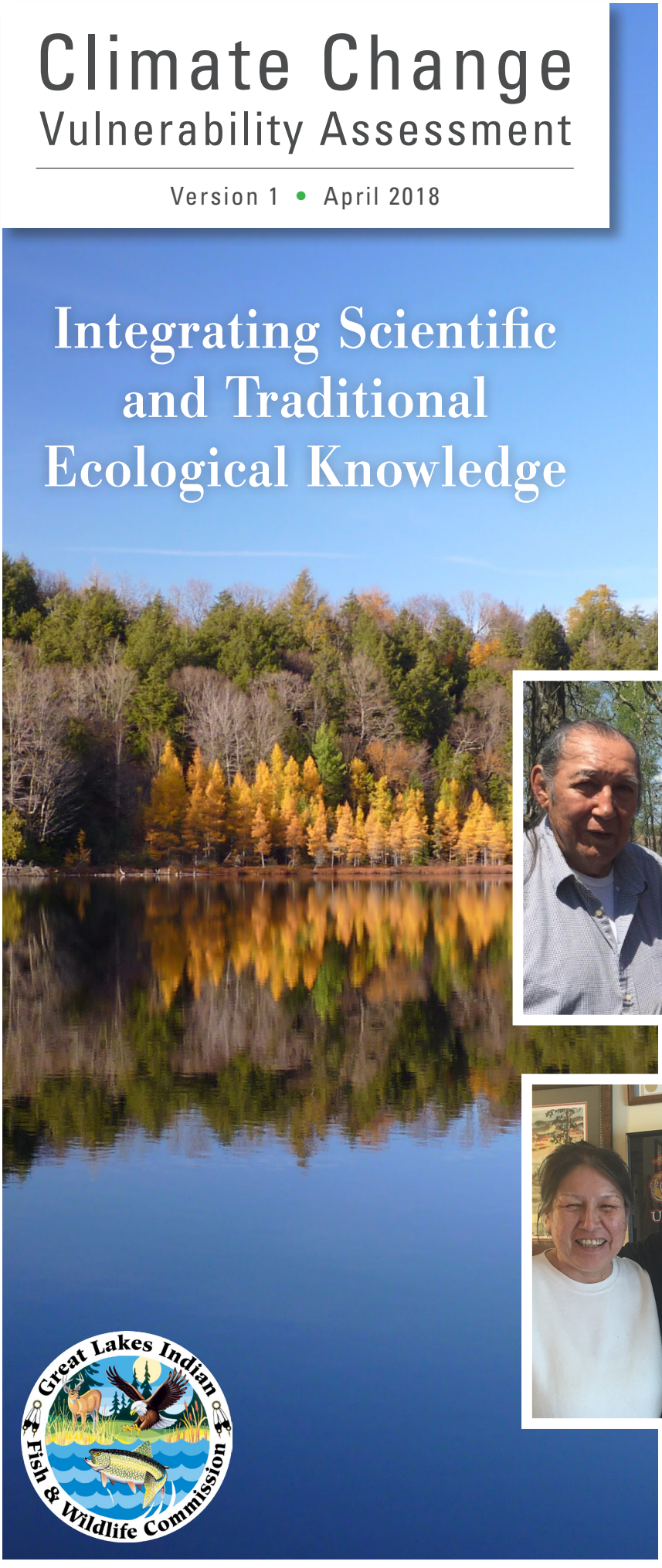
Climate Change
Vulnerability Assessment

Version 1 • April 2018

Integrating Scientific and Traditional Ecological Knowledge



Great Lakes Indian Fish & Wildlife Commission

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For additional information on the GLIFWC Climate Change Program, visit www.glifwc.org/ClimateChange

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Reference list can be provided upon request.

Table of Contents

Acknowledgements

This report is the product of a collaboration between GLIFWC and its 11 member tribes:

Misi-zaaga'iganiing (Mille Lacs Band of Ojibwe Indians)
Bikoganoogan (St. Croix Chippewa Indians of Wisconsin)
Mashkiigong-ziibiing (Bad River Band of Lake Superior Tribe of Chippewa Indians)
Waaswaaganing (Lac du Flambeau Band of Lake Superior Chippewa Indians)
Zaka'aaganing (Sokaogon Chippewa Community (Mole Lake Band))
Odaawaa-zaaga'iganiing (Lac Courte Oreilles Band of Lake Superior Chippewa Indians)
Nagaajiwanaang (Fond du Lac Band of Lake Superior Chippewa)
Gaa-miskwaabikaang (Red Cliff Band of Lake Superior Chippewa Indians)
Ginoozhekaaning (Bay Mills Indian Community)
Gete-gitigaaning (Lac Vieux Desert Band of Lake Superior Chippewa Indians)
Gakiiwe 'onaning (Keweenaw Bay Indian Community)

As an intertribal agency committed to the infusion of Ojibwe culture and values into all aspects of its work, we would like to first acknowledge the environment, the beings/species, and all of the manidoog (spirits) that assure the continuation of human life on this earth. We would like to thank the elders, harvesters, and community members who offered their time to speak with us about climate change and shared their incredible knowledge. We believe it is important to rely on Traditional Ecological Knowledge (TEK) when addressing the effects of climate change impacts, and their openness and willingness to share made this possible. We would also like to thank the many regional experts that reviewed these assessments. Lastly, we would like to thank the many GLIFWC staff who advised us in this process and reviewed drafts of the report.

Introduction

Background

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is an intertribal natural resource agency that assists its 11 member Ojibwe (also known as Chippewa, or Anishinaabe) tribes in the implementation and protection of off-reservation treaty rights to hunt, fish, and gather in territories ceded (or sold) to the United States. In the treaties of 1836, 1837, 1842, and 1854, courts have found that GLIFWC's member tribes reserved the right to continue to practice their ways of life on these lands, which are now in parts of Minnesota, Wisconsin, and Michigan (Figure 1). GLIFWC's member tribes depend on treaty resources to meet spiritual, ceremonial, medicinal, subsistence, and economic needs. GLIFWC provides natural resource management expertise, conservation enforcement, legal and policy analysis, and public information services to its member tribes. More information about GLIFWC can be found at www.glifwc.org.

While the treaty rights of the Ojibwe people in their Ceded Territories are now firmly established in law, a different force is affecting their ability to hunt, fish, and gather resources: climate change. Climate change poses many threats to the natural resources upon which tribes rely. As a changing climate affects entire ecosystems, various beings/species (in Ojibwe culture, the word 'beings' refers to those which are both animate (such as a fish) and inanimate (such as a rock), and implies an equal importance to all) utilized by tribes may experience declines, range shift out of Ceded Territory areas where the Ojibwe exercise their treaty rights, or become extinct. With the loss of beings/species, many of the cultural connections to the natural world are changing or are being lost. For example, tribal members have expressed concern that younger generations will never see a snowshoe hare in their backyard, and traditional knowledge and stories about snowshoe hares will soon only be memories. Collectively, climate change threatens local plant and animal beings/species, ecosystems, and tribal sovereignty, economy, and culture.

To understand how climate change might affect treaty resources, GLIFWC climate change staff are in the process of completing a climate change vulnerability assessment of over 60 beings/species of interest to GLIFWC's member tribes across the Ceded Territories. This assessment is unique in that it seeks to integrate Traditional Ecological Knowledge (TEK) and Scientific Ecological Knowledge (SEK) to examine the vulnerability of beings/species to climate change. TEK, also known as traditional knowledge or indigenous knowledge, is expressed orally, through languages, stories, songs, and laws. One way to view it is a knowledge system that reflects an intergenerational world view of interrelationships with the environment. This integration of TEK and SEK will make results of the assessment more useful to our member tribes, strengthen our understanding of how beings/species may respond to climate change, and help GLIFWC respond to climate change in accordance with the cultural values of its member tribes.

Our Approach

In this vulnerability assessment, TEK interviews were used to identify beings/species of concern and to provide evidence of how these beings/species have been or may be affected by climate change. TEK interviews were conducted with tribal elders, harvesters, and knowledge holders from each of the GLIFWC member tribes. At least one interview per member tribe has been incorporated into the assessment. Beings/species were selected for inclusion in the vulnerability assessment primarily based on mention in TEK interviews. Others were included if they are beings/species for which GLIFWC issues permits or tracks harvest numbers.

Interviewees were approached following GLIFWC's Guidelines for Conducting Traditional Ecological Knowledge Interviews. Specifically, GLIFWC's Outreach Specialist incorporated the following principles into the interview process: 1) the need to be consistent and in long-term

contact with tribal members, 2) the need to be sensitive to Ojibwe culture, and 3) the need to be transparent with how the information would be used by GLIFWC. Most importantly, informal consultation was carried out with spiritual advisors through the entire process to ensure that interviews were conducted in a culturally sensitive manner and that information shared was understood in deeper, more abstract ways. Interviews were conducted with individuals and groups, and were semi-directed, in which the interviewer had the option of providing a questionnaire that focused on changes in the environment over time to prompt knowledge and memory sharing. All interviews were recorded using Zoom Audio recorders and transcribed in ELAN, an open source language archive software available online.

After interviews were transcribed, information pertinent to effects of climate change (e.g., timing of spawning, changes in precipitation) was compiled into a summary, which included keywords, species, and locations mentioned. Raw transcripts and audio were retained. Limited amounts of historical accounts and Ojibwe stories obtained through a combination of personal knowledge of the Outreach Specialist, oral interviews, and books were used to supplement interviews in cases where species were mentioned infrequently.

The SEK component of the GLIFWC vulnerability assessment used NatureServe's Climate Change Vulnerability Index (CCVI) to quantify the vulnerability of each species to climate change by mid-century (2050). The CCVI is an excel-based tool that has been widely used to assess the vulnerability of both aquatic and terrestrial taxa to climate change. The tool examines three categories for each being/species: exposure, sensitivity, and adaptive capacity to climate change. Exposure is the amount of change a given being/species will experience based on regional climate change projections. Sensitivity and adaptive capacity measure how a being/species will be affected by changes in climate and be able to adapt to those changes. Both sensitivity and adaptive capacity were assessed using natural history information collected during a review of scientific literature. Ecologists at GLIFWC and regional experts (e.g., Wisconsin Department of Natural Resources, U.S. Fish and Wildlife Service, GLIFWC member tribes) reviewed and scored this information. An overall vulnerability score and confidence level was generated for each being/species based on answers to questions in each of the three categories.

Climate change projections used in the assessment came from two global climate models dynamically downscaled under the RCP 8.5 (high) emissions scenario. A low-end and a high-end model, quantifying the least possible and most possible amount of change, respectively, were used to define vulnerability in terms of best-case and worst-case scenarios.

Expanded Vulnerability Assessment

The expanded version of this report, including results for over 60 beings/species, will be available in early 2019. Once completed, GLIFWC will share it with tribal leadership and natural resource departments, expert reviewers, TEK interviewees, elected officials, and agencies with whom we share co-management responsibilities. The report will also be available to the general public and will be disseminated through newspapers and social media.

The expanded version of this assessment will form the basis of an adaptation plan for our member tribes and the resources they depend on in their Ceded Territories. The adaptation plan will guide GLIFWC's efforts to help its member tribes respond to climate change and to ensure that treaty rights are protected. Information gathered using SEK and TEK will also be incorporated into other species management plans, allowing cultural management techniques to be revitalized and improving member tribes' abilities to sustainably harvest natural resources.

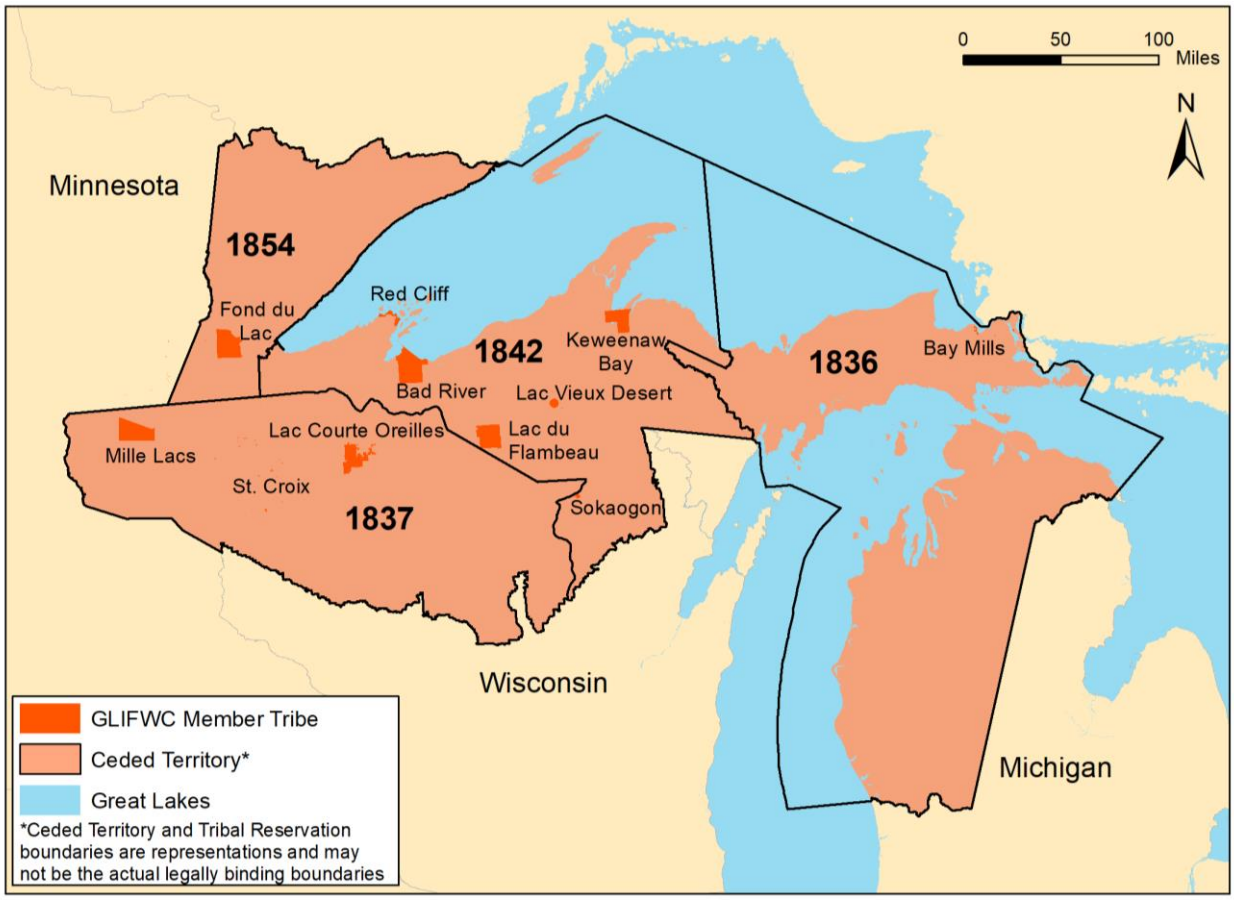

Figure 1. The four Ojibwe Ceded Territories (1836, 1837, 1842, and 1854) used as the assessment area for the GLIFWC climate change vulnerability assessment.

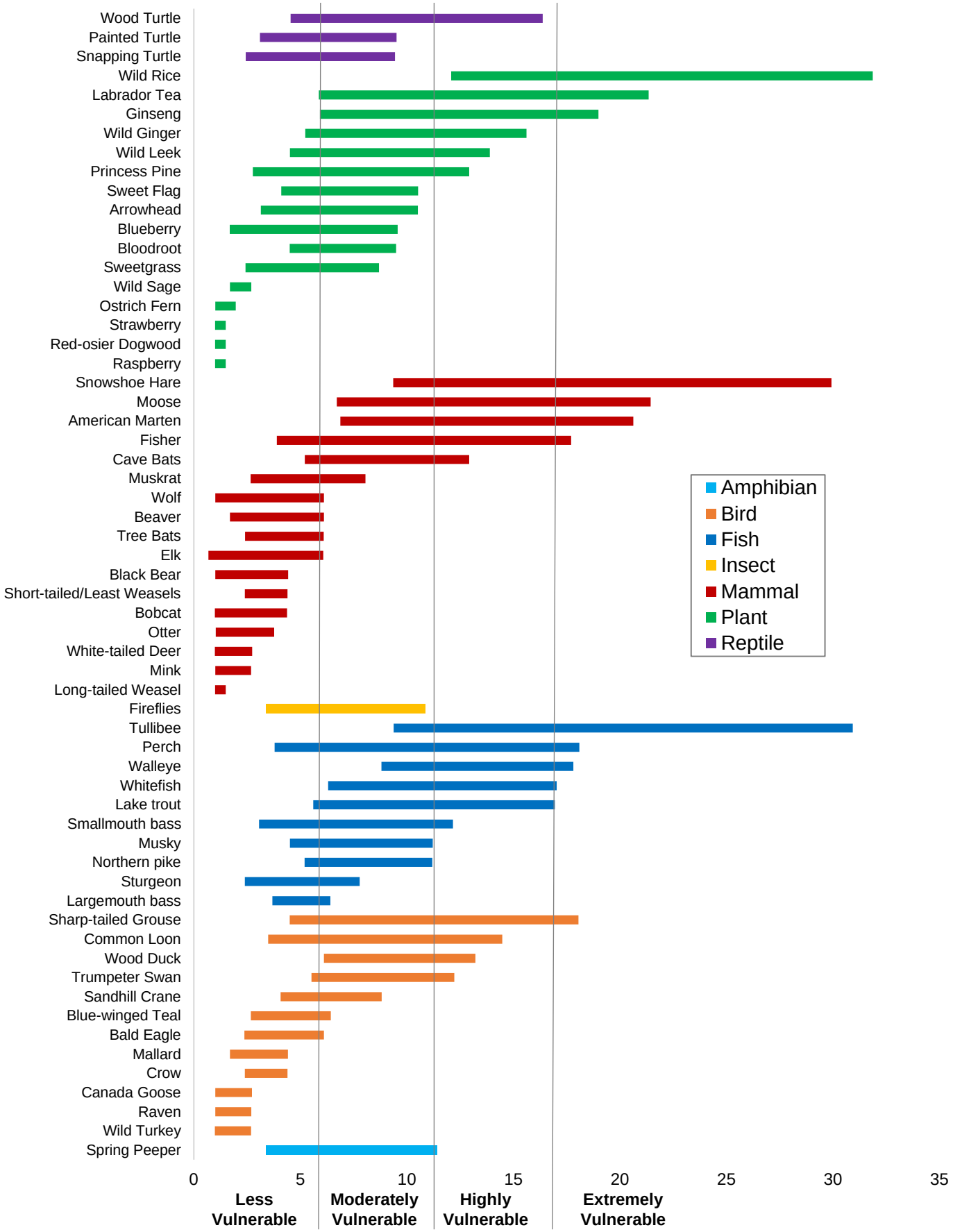

Figure 2. Vulnerability of 60 species to climate change by mid-century (2050). The assessment area included the 1836, 1837, 1842, and 1854 Ceded Territories. Bar width indicates the best-case to worst-case scenarios projected by models dynamically downscaled using data from the latest IPCC report.

Ginoozhe (Northern Pike)

Esox lucius

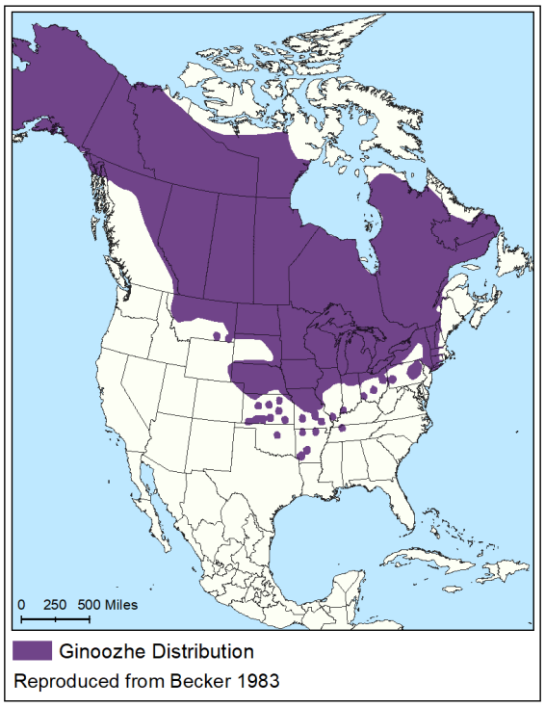

Figure 3. Range map of ginoozhe.

Less - Highly Vulnerable
(Confidence Level: Moderate)

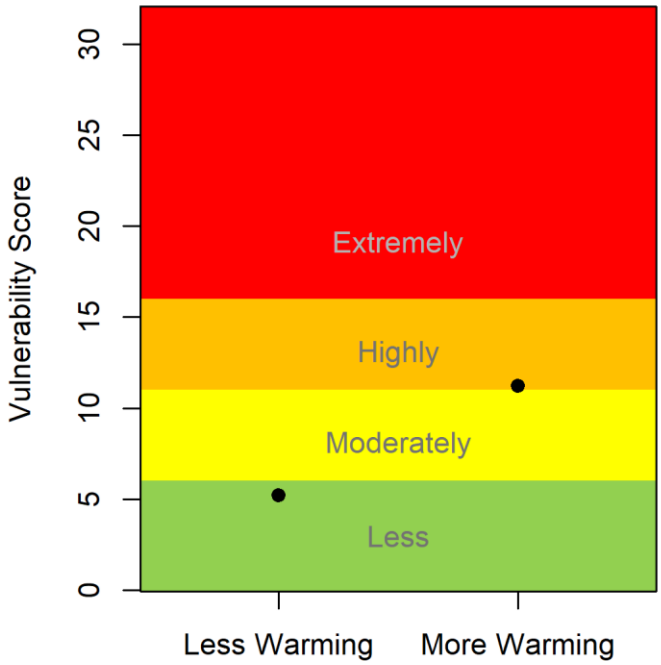

Figure 4. Vulnerability of ginoozhe on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score. No error bars exist for this species because there was no variability in its scores.

General Description:

Ginoozhe is not as commonly harvested as other fish beings/species such as ogaa (walleye) but it remains an important part of the Anishinaabe lifeway. It is carved for fish decoys on the Lac du Flambeau reservation. The Ojibwe name for the Bay Mills Indian Community is Ginoozhekaaning, which refers to the place of the pike. Ginoozhe is also the main subject of many Anishinaabe dibaajimowinan (stories) told around the Great Lakes as well as other areas such as the Lac La Croix First Nation of Ontario, Canada, where the creation of ginoozhe is said to have occurred near the reserve at Pictured Rocks.

Ginoozhe lives in lakes and rivers throughout the Ceded Territories and is harvested by Anishinaabe and state anglers (Figure 3). Ginoozhe spawns over flooded vegetation (e.g., wetlands) in early spring, shortly after ice-out. Young ginoozheg avoid predators by seeking shelter in vegetated habitat. Adult ginoozheg prefer similar habitats so they can ambush prey from cover.

The population of ginoozhe is unknown in most waterbodies in the Ceded Territories, but it is believed to be stable. In the well-studied Mille Lacs Lake, the population of ginoozhe, on average, has increased by approximately 12,500 fish per year between 1993 and 2006.

Some tribal members mentioned ginoozhe in the context of climate change during their interviews. One member from the St. Croix tribe indicated that food web interactions might be altered as the climate changes, with a specific reference to the timing of spawning of ginoozhe influencing other species. A Mille Lacs band member indicated that ginoozhe populations have increased in Mille Lacs Lake, but this increase might or might not be climate-related.

Summary of climate threats:

Ginoozhe was in the 44th percentile of vulnerability relative to other fish in the assessment. Relative to other beings/species in the vulnerability assessment, ginoozhe was in the 66th percentile. The following factors increased its vulnerability to climate change: natural and anthropogenic barriers (e.g., connectivity of inland lakes, roads), hydrological niche (e.g., droughts), thermal niche (loss of coolwater habitat), and sensitivity to pathogens (i.e., more susceptible to infections and parasites) (Figure 4).

Factors that increase ginoozhe's vulnerability to climate change:

SI — Natural barriers: Limited connectivity of inland lakes will limit the ability of ginoozhe to move to suitable habitat as the climate changes. Moreover, migration routes such as shallow waterways have the potential to warm faster than lakes, thereby creating a barrier for this coolwater species. Conversely, an increase in frequency and intensity of extreme weather and precipitation events could potentially create new migration routes between waterbodies. Collectively, natural barriers are likely to impede dispersal as the climate changes to a limited extent.

SI — Anthropogenic barriers: Barriers such as dams and road crossings can impede movements of ginoozhe in lakes and rivers. These barriers are likely to impede dispersal as the climate changes to a limited extent.

SI — Physiological thermal niche: Thermal niche for ginoozhe, a coolwater species, depends on the life stage. For eggs, the optimum temperature has not been defined, but mortality occurs when water temperature drops below 41°F or exceeds 60.8°F. For fry (young fish capable of feeding themselves), optimal temperature for growth and survival is 69.8-78.8°F, with higher mortality occurring at temperatures less than 42.4°F. Upper lethal temperature is not defined for this life stage. Optimal temperature for growth of juvenile ginoozhe (young fish that have developed scales and working fins) is approximately 66.2-69.8°F, with growth ceasing at 82.4°F (lethal limits are not defined). For adult fish (capable of reproducing), optimum temperature is approximately 66.2°F with lethal temperatures between 84.2-86°F (lower lethal limit is not defined). Water temperature is predicted to increase as the climate changes and potentially reduce thermal habitat for ginoozhe by 10-40%. This would have negative consequences for growth and survival of this species.

SI — Historical hydrological niche: The area ginoozhe occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

SI — Physiological hydrological niche: Water drawdown or retention can negatively influence wetlands, an important habitat for adult (needed for reproduction) and juvenile ginoozhe in the Ceded Territories.

SI — Disturbance regime: More variable precipitation patterns (droughts, floods) might negatively impact wetlands, a key habitat for this being/species.

SI — Sensitivity to pathogens: Ginoozhe bioaccumulates environmental toxins and is a host to many known parasites (e.g., fungi, protozoa, worms, leaches, mollusks, and crustacea) and pathogens (e.g. lymphosarcoma and esocid herpesvirus-1). As the climate warms, coolwater beings/species might be crowded into smaller spaces that might increase parasite and pathogen transmission. Warm water temperatures might also force fish and their parasites and pathogens to migrate northwards, thereby acting as a vector for transmission to fish in the receiving waterbody. Extreme weather and elevated water temperature might increase stress in fish, making them more susceptible to pathogens because of reduced immune function. Overall, pathogen and parasite abundance, distribution, and effectiveness will likely increase as the climate changes.

Legend

GI — **Greatly Increase**: This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase**: This factor may increase or greatly increase vulnerability	I — **Increase**: This factor increases vulnerability
SI/I — **Somewhat Increase/Increase**: This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase**: This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase**: This factor may not increase or may somewhat increase vulnerability

Namegos (Lake Trout)

Salvelinus namaycush

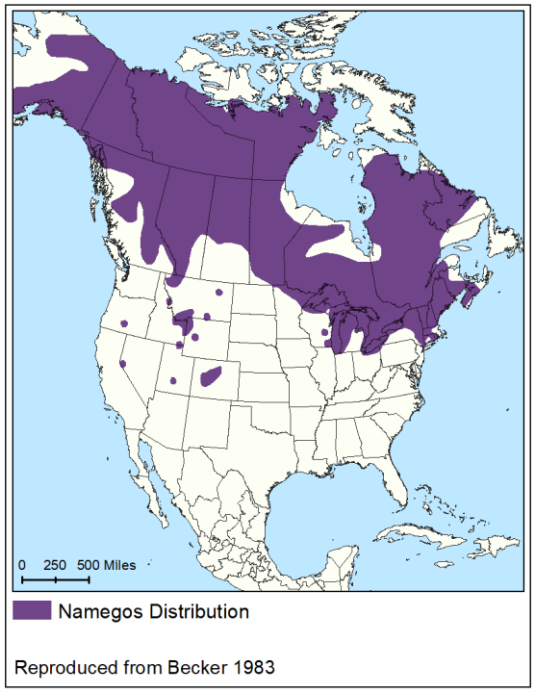

Figure 5. Range map of namegos.

Less – Extremely Vulnerable
(Confidence Level: Moderate)

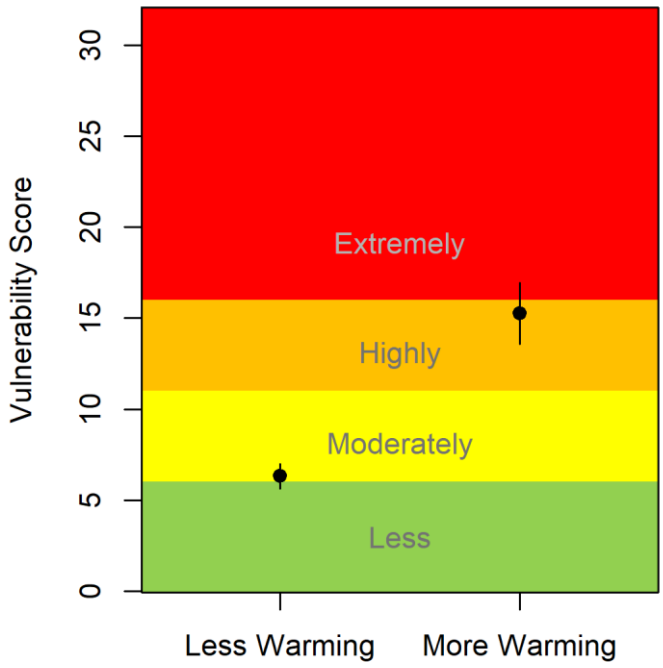

Figure 6. Climate change vulnerability scores for namegos on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

Namegos is known as a culturally significant being/species to the Ojibwe people. The fish clan is part of the Ojibwe clan system and those who are part of it are known to be sky watchers that hold knowledge of all that is in the sky, such as the sun, stars, and moon, connecting the earth to the sky.

Namegos is found in Lake Superior and some deep inland lakes throughout the Ceded Territories, often preferring clear, cold, infertile waterbodies (Figure 5). It is harvested by Anishinaabe people and is considered a highly prized sportfish among recreational anglers. Namegos spawns in the fall (mid-October to December; 46-51.9°F) at water depths of inches to 90 feet over low-sediment rocky bars. Young namegosag feed primarily on opossum shrimp (mysis), but also consume insects and small fish. As namegos grows larger, fish (e.g., ciscos and smelt) become an important part of its diet.

The namegos population collapsed in the early to mid-1900s and was effectively extirpated from the Great Lakes except for Lake Superior. Predation by non-native sea lamprey further reduced populations in the mid-1900s. Stocking programs as well as sea lamprey control have aided recovery of most spawning populations of namegos in Lake Superior, but some populations have declined. For example, in management unit WI-2 (North of Ashland, WI), relative abundance nearly doubled from 0.69 adult fish per kilometer of net in 1980 to 1.16 fish per kilometer of net in 2015. Conversely, in management unit MI-2 (Northeast of the Michigan/Wisconsin border), relative abundance has declined from approximately 1.83 fish per kilometer of net in 1980 to 0.64 fish per kilometer of net in 2015. Namegos rarely occurs in inland waterbodies, but the two well-known inland namegos lakes, Black Oak and Trout Lake, have experienced declines or no recruitment in

recent years. This has spurred management agencies to initiate stocking in both of these lakes. Overall, most namegos populations appear to be stable or increasing in Lake Superior, but declining in inland Ceded Territory lakes.

Namegos was not as frequently mentioned as other beings/species in TEK interviews. However, some mentioned the existence of specific places related to namegos, likely because of a story relating to that area or the presence of namegos. Gaa-namegosikaang (Chicagon Lake), east of Watersmeet, Michigan, is known as the place of namegos.

Summary of climate threats:

Namegos was in the 56th percentile relative to other fish in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, namegos was in the 84th percentile. The following factors increased its vulnerability to climate change: natural and anthropogenic barriers (e.g., low oxygen zones, effluent), thermal niche (loss of coolwater habitat), hydrological niche (less precipitation), disturbance regime (wind and waves can damage eggs), restriction to uncommon landscapes (spawns on shallow, rocky bars), sensitivity to natural enemies (susceptible to sea lamprey attacks), competition (smallmouth bass might outcompete namegos for food), and a loss of genetic variation (Figure 6).

Factors that increase namegos's vulnerability to climate change:

N/SI — Natural barriers: Low dissolved oxygen concentrations may limit dispersal/vertical movements in inland waterbodies, but might not be barrier to dispersal in Lake Superior.

N/SI — Anthropogenic barriers: Changes in the watershed (e.g., effluent from septic systems) can result in eutrophication and low-oxygen zones. These zones might act as barriers to dispersal.

SI — Physiological thermal niche: Lean and siscowet namegos are consider coldwater fish with a preferred temperature of 50°F and 39.2°F, respectively. As water temperature increases, both types of namegos are expected to seek deeper, cooler habitats. Most recent analyses indicate lean namegosag have experienced an increase in preferred thermal habitat of 6 days, while siscowet namegosag have experienced a loss in preferred thermal habitat of 3 days.

SI — Historical hydrological niche: The area that namegos occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

SI — Disturbance regime: The intensity and frequency of severe weather is predicted to increase in the future. Wind and wave action associated with severe weather might damage or displace eggs on relatively shallow reefs.

SI — Uncommon landscape features: Namegos is restricted to spawning on shallow rocky bars that have little silt. Loss of these spawning reefs could negatively affect reproduction and recruitment.

I — Pathogens or natural enemies: The introduction of sea lamprey into the Great Lakes resulted in a decrease in namegos populations. White sucker mortality rates increase when sea lamprey feed on them at elevated temperatures. Similarly, namegosag that are hosts to sea lamprey might experience higher mortality rates as water temperature increases in the future.

SI — Competition: Pacific salmon, steelhead, and smallmouth bass compete for food resources with namegos. Smallmouth bass, a warmwater being/species, is predicted to be favored under future environmental conditions.

SI — Genetic variation: A substantial loss of genetic diversity occurred when many populations of namegos were extirpated or severely depressed in the mid-1900s.

Legend

GI — **Greatly Increase** — This factor greatly increases vulnerability

I/GI — **Increase/Greatly Increase** — This factor may increase or greatly increase vulnerability

I — **Increase** — This factor increases vulnerability

SI/I — **Somewhat Increase/Increase** — This factor may somewhat increase or increase vulnerability

SI — **Somewhat Increase** — This factor somewhat increases vulnerability

N/SI — **Neutral/Somewhat Increase** — This factor may not increase or may somewhat increase vulnerability

Ogaa (Walleye)

Sander vitreus

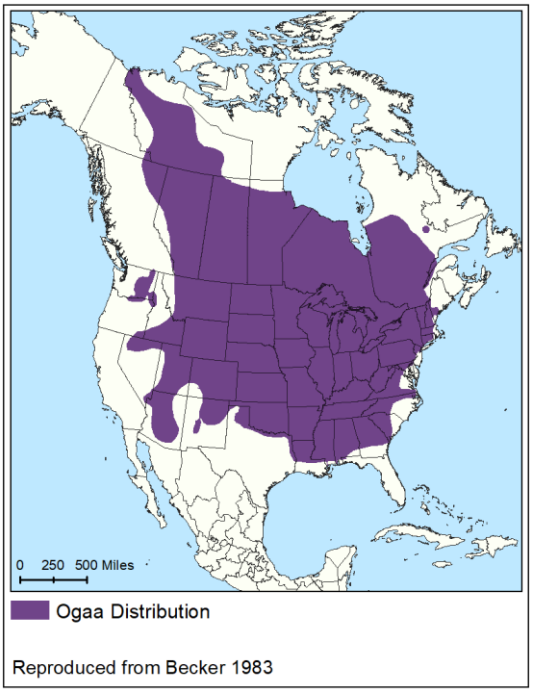

Figure 7. Range map of ogaa.

Moderately - Extremely Vulnerable
(Confidence level: High)

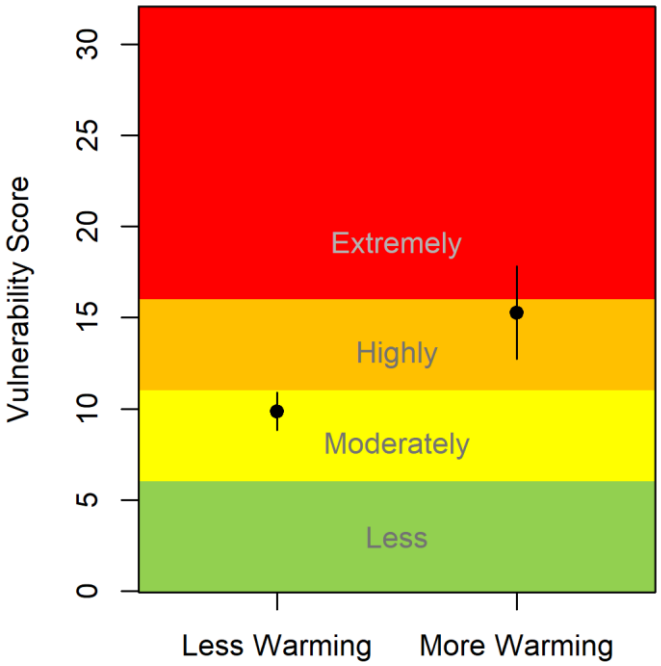

Figure 8. Climate change vulnerability scores for ogaa on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

Like many of the swimmers, ogaa is highly respected in Ojibwe culture. Ogaa features prominently in many traditional stories and personal memories illustrating how Ojibwe people have depended on fishing as a means of survival. In a historical interview from 1992, Mille Lacs tribal member Doug Sam emphasized how his people have relied on ogaa and other swimmers for their subsistence needs:

"We used to go out here [Mille Lacs] … used to have big barrels full of salted fish to last all winter... and early spring there you go put a little tepee out there and get a golden northern or a walleye. That was your meal. You didn't get a whole bunch. You just got what you needed for... it was a good life."

Traditional stories of ogaa depict its interconnectedness with other beings/species. A tribal member from Red Cliff remembered her mother from the Bad River Tribe describing how the frogs would make noise to indicate the start of the ogaa season.

Ogaa was a main focus of protests by non-Indians during the "Walleye Wars" of the late 1980s. Sports fishermen and others opposed to tribal members spearing ogaa led protests at boat landings on Ceded Territory lakes. These protests, which sometimes turned violent, came after the landmark court case of Lac Courte Oreilles v. Wisconsin, which recognized the Ojibwe people's treaty-reserved rights to hunt, fish, and gather off-reservation in Wisconsin's Ceded Territories.

Ogaa is found in many lakes and rivers throughout the Ceded Territories and is commonly harvested by tribal members and recreational anglers (Figure 7). Ogaa gains a competitive advantage over other species in turbid or stained, low-light waterbodies with limited plant growth. It typically spawns at night in early spring, shortly after ice-out over shallow (<6 feet) gravel and/or cobble bars. Young ogaawag commonly move offshore into

the pelagic zone after gaining the ability to swim. Juvenile and adult ogaawag tend to use deeper, darker water during the day and move into the nearshore environment (littoral zone) at night to feed.

The ogaa population has declined in many waterbodies throughout the Ceded Territories in recent years. For example, ogaa in Lac Vieux Desert Lake has declined from a high of ~3 adult fish/acre in 1998 to approximately 0.5 fish/acre in 2016, an amount quite low relative to other Ceded Territory lakes (average 2.5 fish/acre). Similarly, ogaa in Mille Lacs Lake declined by approximately 90,000 pounds per year between 1998 (biomass ~2.5 million pounds) and 2016 (biomass ~0.89 million pounds). Ogaa stocks are predicted to decline in many other lakes throughout the Ceded Territories.

In interviews with tribal members, ogaa was frequently mentioned. Tribal members are seeing a decrease in the population in a majority of the lakes where ogaa are present. Current contamination and the potential for future contamination have been consistently mentioned as a concern. One tribal member from Mille Lacs voiced concern about the change in color of some ogaa, noting that some are darker grey and, during processing, the meat won't separate from the skin and tends to shrink to one-third of the size. Another consistent observation and concern noted during interviews is that cooler ogaa-dominated lakes are getting warmer.

Summary of climate threats:

Ogaa was in the 78th percentile relative to other fish in the assessment. Relative to other beings/species, ogaa was in the 90th percentile. Factors that increased ogaa's vulnerability to climate change include: natural and anthropogenic barriers (e.g., connectivity of inland lakes, dams), thermal niche (loss of coolwater habitat), hydrological niche (e.g., droughts), disturbance regime (more intense floods), dietary versatility (availability of specific prey items), sensitivity to competition (ogaa competes with bass species), sensitivity to pathogens (i.e., more susceptible to infections and parasites) and documented (e.g., decline in abundance) and predicted response (e.g., range contraction) to climate change (Figure 8).

Factors that increase ogaa's vulnerability to climate change:

SI — Natural barriers: Limited connectivity of inland lakes will reduce the ability of ogaa to move to suitable habitat as the climate changes. Moreover, migration routes such as shallow waterways have the potential to warm faster than lakes, creating a barrier for this coolwater species. Conversely, an increase in frequency and intensity of extreme weather and precipitation events has the potential to create new migration routes between waterbodies. Natural barriers are likely to impede ogaa dispersal as the climate changes, but some dispersal will still occur through river systems.

N/SI — Anthropogenic barriers: Barriers such as dams and road crossings can impede movements of ogaa in rivers and are likely to impede ogaa dispersal to a limited extent as the climate changes. Ogaa in lakes are less affected by this factor as few anthropogenic barriers exist in lakes.

SI — Physiological thermal niche: Thermal niche for ogaa, a coolwater species, depends on the life stage. For eggs, the optimum temperature is 48-59°F, with high mortality occurring when temperatures remain below 42°F or above 66°F for extended periods. Optimal temperature for growth of fry (young fish capable of feeding themselves) is 59°F, and no growth occurs at temperatures below 50°F or above 68°F (upper lethal temperature is 70°F; lower lethal temperature is 42°F). Optimal temperature for growth of juvenile ogaa (young fish that have developed scales and working fins) is approximately 70-77°F, with no growth occurring at temperatures below 54°F or above 84°F. For adult fish (capable of reproducing), optimum temperature is approximately 64-72°F with performance decreasing at 79°F and lethal temperatures at 84-93°F (lower lethal limit is not defined). Water temperature is predicted to increase as the climate changes, potentially reducing thermal habitat for ogaa by 10-40% and resulting in negative consequences for growth and survival of this species.

SI — Historical hydrological niche: The area ogaa occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

N/SI

Disturbance regime: An increase in the intensity and frequency of extreme precipitation events might decrease ogaa recruitment in some lakes and rivers.

N/SI

Dietary versatility: Ogaa diet is flexible across life stages, but due to its small mouth (i.e., gape limitation), newly hatched ogaa typically consume zooplankton. It is possible that this prey item might not be available as the climate changes, thereby limiting food for this life stage.

SI

Sensitivity to competition: Ogaa's sensitivity to competition depends on the fish community in the individual waterbody. Ogaa is likely to experience more competition in lakes and rivers containing largemouth bass and smallmouth bass, a situation likely to be exacerbated as the climate changes because these species perform better at elevated temperatures.

SI

Documented response to climate change: Distribution and abundance of ogaa has been declining in recent decades and has been correlated with environmental conditions associated with climate change (e.g., growing degree days, water clarity).

I

Modeled change in range or population size (2050): The number of lakes that support naturally reproducing stocks of ogaa is predicted to decrease by 65% in Wisconsin. A similar decline will likely occur in lakes throughout the Ceded Territories.

SI

Overlap of modeled future (2050) range with current range: It is predicted that only 35% of the lakes that currently support naturally reproducing stocks of ogaa will do so by 2050.

I

Occurrence of protected areas in modeled future (2050) distribution: Less than 5% of ogaa habitat in the Ceded Territories is predicted to be in a protected area by 2050.

Legend

GI — **Greatly Increase** — This factor greatly increases vulnerability

I/GI — **Increase/Greatly Increase** — This factor may increase or greatly increase vulnerability

I — **Increase** — This factor increases vulnerability

SI/I — **Somewhat Increase/Increase** — This factor may somewhat increase or increase vulnerability

SI — **Somewhat Increase** — This factor somewhat increases vulnerability

N/SI — **Neutral/Somewhat Increase** — This factor may not increase or may somewhat increase vulnerability

Waabooz (Snowshoe Hare)

Lepus americanus

Moderately - Extremely Vulnerable

(Confidence Level: High)

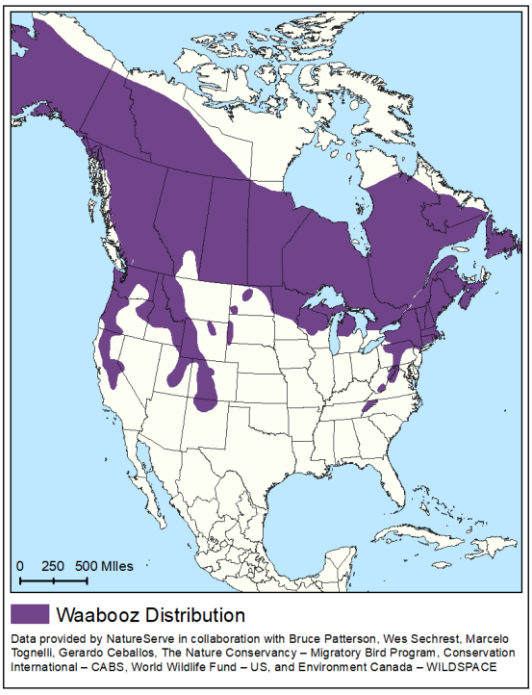

Figure 9. Range map of waabooz.

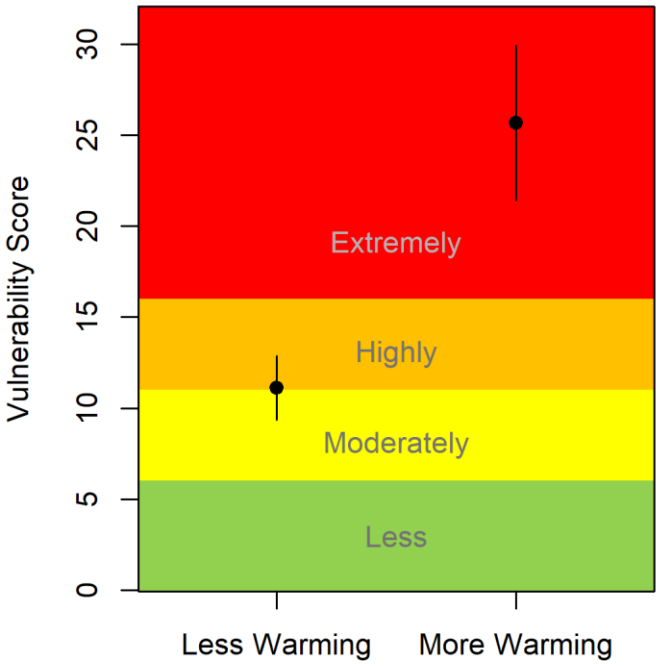

Figure 10. Climate change vulnerability scores for waabooz on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

A traditional teaching about the waabooz describes him telling Nenabozhoo (a main spirit in many Anishinaabe legends) how he would help the Anishinaabe when they arrived: "'Here, I have something too. I too have something to offer the Anishinaabe.' The rabbit was looking at Nenabozhoo. 'Who do you think you are? Look at you and how small you are. You don't even have much meat on you.' And the rabbit said: 'Nope, don't think of me that way. I will sense when the Anishinaabe is struggling to find food to eat. I will not go anywhere. Whenever I see a round snare, that is where I will put my head. That is how much I care about the Anishinaabe. There are a lot more, such as my white fur jacket. Anishinaabe will know how to use my gift, like sometimes, somewhere, when they get a skin rash, such as how children suffer with that. They will use my rabbit fur, my hide. I will not be far away. All they need to do is look around, and they will find my trail; this is where they can get me.'"

Waabooz utilizes primarily coniferous and mixed forest, as well as bogs, swamps, lowland shrub, and forest edges. Early successional forests often have a higher waabooz abundance. Waabooz also requires a dense understory for cover. Areas with greater than 60% forest cover and dense understories have the highest probability of having waabooz.

As forest was cleared for agriculture in the late 1800s, the waabooz range contracted northward. Currently, waabooz is at the southern end of its range in the Ceded Territories, and its range continues to shift northward (Figure 9). From 1980 to 2014, waabooz's range has shifted 18.4 miles north in Wisconsin, and 28 miles north over the last 20 years in Michigan. Waabooz populations undergo cyclical patterns in abundance, though at the southern end of its range these cycles are not as dramatic as in other regions.

Nearly all TEK interviewees have expressed concern about a decline in the waabooz population. The days of noticing tracks in the snow, seeing it in the backyard, and setting numerous snares to trap it are now mostly gone. When TEK interviewees were asked how long they had been noticing the population decline, the average response was 15 years. Most interviewees also noted a decrease in snowfall during that time frame, which some feel is contributing to the waabooz decline. There are concerns about the loss of traditional teachings and stories regarding the waabooz and waabooz trapping. Tribal members fear the traditional knowledge and stories about it will soon only be memories and younger generations will have never seen a waabooz in their backyard.

Tribal members also shared information about waabooz habits. Waabooz tends to eat any vegetation and its population normally goes in two- to three-year cycles. It used to be a major source of food and was also used for furs, traditional crafts, and general livelihood. Most tribal members used to look for waaboozoog but could not hunt them until it got cold enough – if they were harvested too soon, the waaboozoog would often have blisters on and underneath their skin, making them unfit for consumption. Recently, it is rare for waabooz to be sought after as a source for food.

One individual recalled walking from his house on Lake Superior in Red Cliff, Wisconsin, to Oak Island on the ice in order to snare waaboozoog: "It was tough going over in the winter time, got over there and had no shack over there. They had a halfway decent stove, one of those air tights, and you had to keep adding wood like you would never believe. Waaboozoog, we snared like ten waaboozoog the first night. The fishermen used to go by there. They would come in and trade waaboozoog for fish, which we did… We had to walk out there, then they would give us a ride home… I haven't seen a waabooz in 15 years and I shot hundreds and hundreds of them. I used to sell waaboozoog to go to the show and if you shot them you'd get 50 cents for them and if you snared them you'd get a dollar. My aunt used to ask what is the difference. When you shoot them you lose all the blood. If you snare them, we add that blood to the soup."

Summary of climate threats:

Waabooz was in the 94th percentile relative to other mammals in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, waabooz was in the 95th percentile. Waabooz is among the most vulnerable beings/species in our assessment. Its population is strongly linked to the duration of snow cover, which is likely to continue to decline, especially at the very southern end of its range. Many other factors contribute to waabooz's vulnerability, including natural and anthropogenic barriers, sensitivity to increasing temperatures, increased predation risk, and phenological mismatches. This being/species is the subject of much ongoing research, including models projecting waabooz's future range (Figure 10).

Factors that increase waabooz's vulnerability to climate change:

SI — Natural barriers: Edge habitat in fragmented landscapes is a barrier to waabooz. Any increases in unsuitable non-forested habitats would likely increase mortality.

SI/I — Anthropogenic barriers: Agriculture, roads and other urban development can all be barriers to waabooz.

I/GI — Physiological thermal niche: Waabooz is a winter-adapted being/species restricted to cold environments that will continue warming, particularly in the winter. Models have linked local waabooz extinction in Michigan to an increase in maximum summer/fall temperature.

SI — Historical hydrological niche: The area waabooz occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

GI — Dependence on snow or ice: Snow cover is a critical component of waabooz habitat and may be the primary factor in its vulnerability to climate change. Decreases in duration and depth, and increases in the density of the snowpack are expected to negatively impact waabooz. Reductions in the depth of the snowpack will decrease the availability of browse on upper branches. Waabooz is also dependent on snow cover for camouflage, and fewer days with snow on the ground has been linked to increases

in predation. Decreasing duration of snow cover has been found to be the most important driving factor in the range shift of waabooz in Wisconsin.

SI — Pathogens or predators: Waabooz is a major prey item for many carnivores that are less vulnerable to or may benefit from climate change in the Ceded Territories, including gidagaabizhiw (bobcat), wiisagazi ma'iingan (coyote), and ojiig (fisher).

N/SI — Interspecific interactions: Population cycling in waabooz has been tied to specific predators (especially lynx) and beings/species with overlapping ranges (such as ruffed grouse). If those beings/species are also affected by climate change, waabooz population cycles may be dampened and abundance may be affected.

N/SI — Genetic variation: Northern and eastern populations of waabooz in Canada and the eastern US are generally characterized by high genetic diversity, but at the southern end of its range in the Ceded Territories, genetic diversity is lower.

I — Phenological response: Two Montana studies found waaboozoog did not vary the date or rate of fall molt (turning color from brown to white) with the timing of snowfall, indicating that fall molt is initiated by day length and not presence of snow. The spring molt did vary with longer or shorter snow seasons. The consistent timing of the waabooz fall color change will cause waabooz to stand out more to predators if snows come later in the year. However, the studies did find some variation in timing and rate of molt among regional populations of waabooz, and another study found waabooz in Pennsylvania had less white winter coats than in northern Canada. Both of these may indicate some ability in waabooz to adapt to changing winter conditions. However, models in Wisconsin and Michigan show waabooz is currently not able to keep pace with recent declines in snow cover. Continuing phenological mismatches will cause waabooz to lose its camouflage, particularly in the fall, and be subject to increased predation.

SI/I — Documented response to climate change: Waabooz has already begun responding to climate change; waabooz range receded northward in the Ceded Territories at an average rate of 5.4 miles per decade from 1980 to 2014. This recession is primarily linked to duration in snow cover.

SI — Modeled future range: Models show waabooz range continuing to move northward, though uncertainty about snowfall projections complicates the models, especially given snow cover is likely the primary driver of waabooz range.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Waawaashkeshi (White-tailed Deer)

Odocoileus virginianus

Less Vulnerable
(Confidence Level: High)

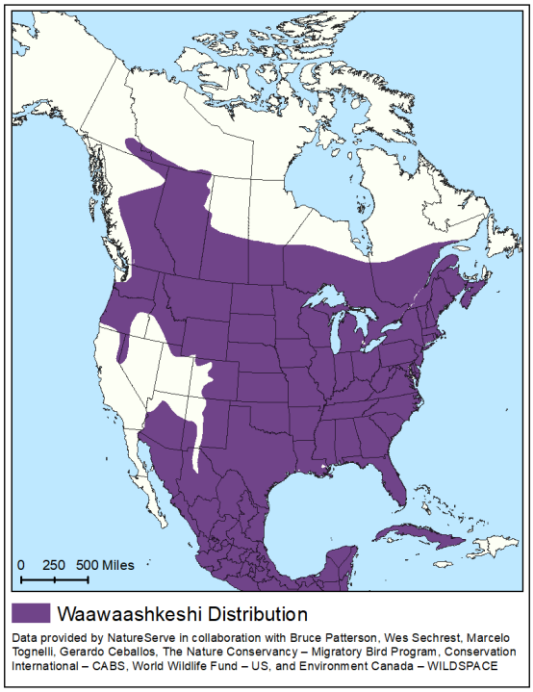

Figure 11. Range map of waawaashkeshi.

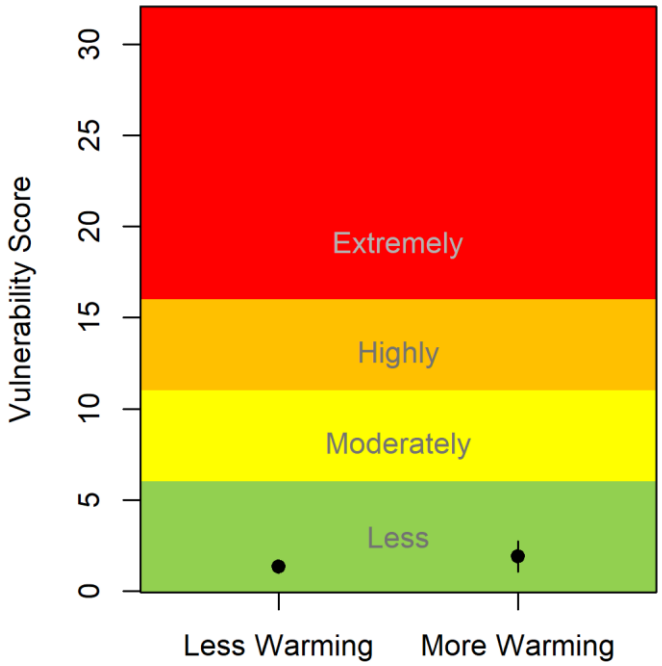

Figure 12. Climate change vulnerability scores for waawaashkeshi on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

Waawaashkeshi is highly respected by many indigenous people, including the Ojibwe, for which waawaashkeshi is one of the main clan animals. Members of the waawaashkeshi clan tend to carry traits of kindness and gentleness, which are also associated with waawaashkeshi. Historically, waawaashkeshi clan members were responsible for taking care of social aspects within their community such as feasts, ceremonies, and various gatherings. These roles still exist today but are mostly shared by members of all clans. The Ojibwe utilize waawaashkeshi as a food source, and nearly all parts of the waawaashkeshi are used for clothing, tools, and in ceremonies such as first kill feast for young boys.

Waawaashkeshi occupies a wide variety of habitats in the Ceded Territories, including woodlands, shrublands, grasslands, croplands, and residential areas (Figure 11). It is often associated with early successional vegetation. In some regions, waawaashkeshi shifts its habitat in the winter, particularly in areas with cold temperatures and deep snow such as the Upper Peninsula of Michigan. In these locations, waawaashkeshi may exhibit seasonal migratory behavior between summer and winter ranges and congregate in 'waawaashkeshi yards,' or areas with lower snow cover, such as mature northern white cedar stands nearer the Great Lakes shoreline.

The population of waawaashkeshi is primarily controlled by hunter harvest in the Ceded Territories, and fluctuates considerably from year to year. Population estimates are difficult, but waawaashkeshi is generally managed at high densities throughout the region as a result of social pressure on wildlife managers. Waawaashkeshi was one of the beings mentioned most often during TEK interviews. The first observation of fireflies (around July 1st) indicates that waawaashkeshi will start coming around and it is time to start hunting. In

order to encourage a successful hunt, bearberry is used as a charm. Waawaashkeshi tends to favor oak during winters that have a lot of snowfall and if it doesn't have access to many acorns, the winter will be hard. When the acorns start dropping, it's time to hunt the oak stands for waawaashkeshi, especially where there was frost on the acorns, which makes them sweeter. The presence of trilliums indicates that waawaashkeshi is most likely in the area.

Various concerns regarding waawaashkeshi were mentioned during the interviews, with most of them focusing on the health of the animals. A tribal member referred to waawaashkeshi as a canary in a coal mine – when waawaashkeshi health and population declines, its habitat is not healthy. The recent rise in chronic wasting disease (CWD) and contaminates such as lead are directly impacting the harvest of waawaashkeshi. It was also noted that there seem to be more cases of CWD in southern Wisconsin, which a tribal member feels is due to the waawaashkeshi not having access to the proper plants (such as northern white cedar and Canada yew) to medicate itself and a loss of their habitat due to logging. One tribal member estimates that the waawaashkeshi herd in northwestern Wisconsin has decreased 50 percent between 2010 and 2015.

One elder spoke of his diet consisting of mostly waawaashkeshi and fish while growing up. There was a large population on Stockton and Basswood Islands (two of the Apostle Islands in northern Wisconsin) several years ago, and he would snare them with an emergency cable from a car. The same elder mentioned that when he was growing up, there was always snow on the ground in mid- to late November during waawaashkeshi season. During the last 20 to 30 years, the snow is coming nearly a month later, which seems to affect the hunting season.

Summary of climate threats:

Waawaashkeshi was in the 24th percentile relative to other mammals in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, waawaashkeshi was in the 19th percentile. As waawaashkeshi is a highly adaptable and versatile being/species, climate change is not likely to be a large threat to its population. However, diseases such as epizootic hemorrhagic disease (EHD) may increase with warming temperatures and have the potential to impact the population. Cold temperatures and deep snows cause direct (through malnutrition) and indirect (neonatal) mortality and an increase in lake effect snow as Lake Superior warms could reduce waawaashkeshi populations in heavy snow regions, though this effect is likely to lessen as climate change continues (Figure 12).

Factors that increase waawaashkeshi's vulnerability to climate change:

SI — Historical hydrological niche: The area that waawaashkeshi occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

N/SI — Pathogens or predators: Epizootic hemorrhagic disease (EHD) has progressed northward from its previously known range, and may continue moving north as climate conditions improve for the vector, the biting midge. If EHD affects waawaashkeshi populations in the Ceded Territories, significant periodic losses are possible, potentially leading to more frequent fluctuations in localized populations. CWD is also a threat to waawaashkeshi. Though there is little evidence to suggest that CWD prevalence is related to climate change, CWD may spread more quickly through a herd if climate conditions continue to favor waawaashkeshi and population densities increase. Since evidence suggests that climate change is a primary driver of waawaashkeshi range expansion at the northern extent of its range, individual waawaashkeshiwag could also potentially carry CWD into areas with other ungulate species, such as mooz (moose) and caribou, and affect their populations. Waawaashkeshi predators, particularly coyotes, are also expected to increase, which could increase predation mortality on waawaashkeshi.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Makwa (Black Bear)

Ursus americanus

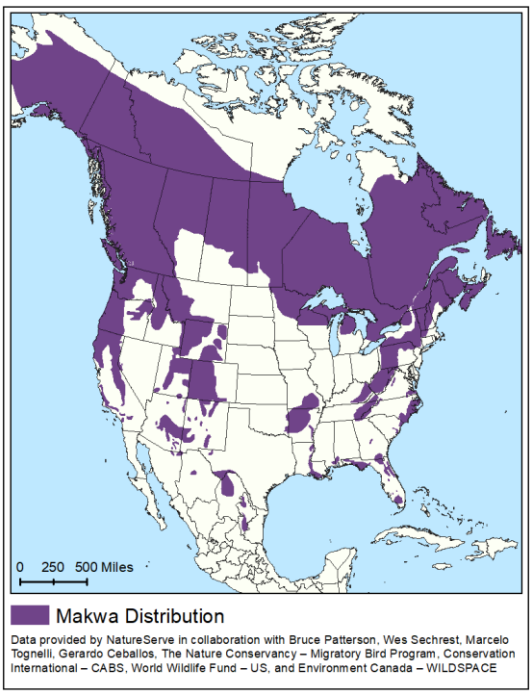

Figure 13. Range map of makwa.

Less Vulnerable
(Confidence Level: Moderate)

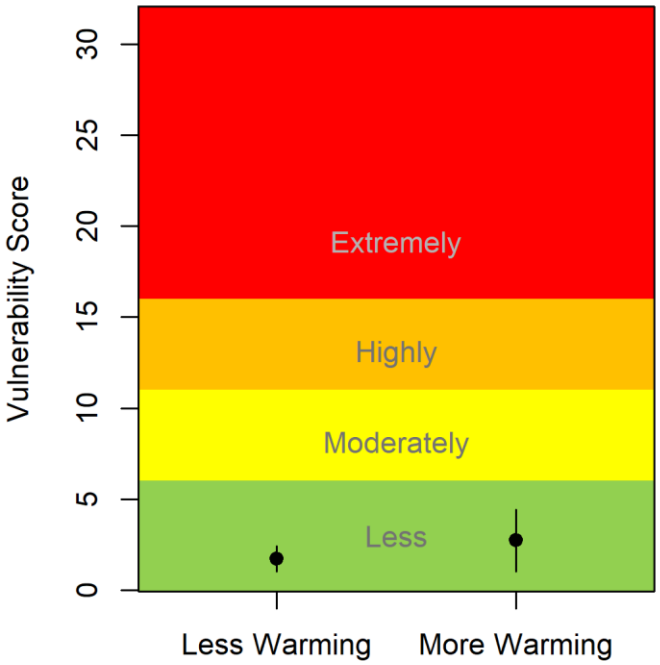

Figure 14. Climate change vulnerability scores for makwa on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

Makwa is highly respected by many indigenous people, including the Ojibwe, for which makwa is one of the main clan animals. Those who belong to the makwa clan tend to be strong protectors of family, friends, community, and their environment. They are also known to be people who hold a strong connection with plants and often carry knowledge about medicines and healing. The spirit of makwa is incorporated into aspects of ceremonies still practiced today, such as drum and healing-related ceremonies. Makwa is rarely hunted but when it is, nearly all parts of the animal are used – the meat is used for food; the fat for making grease; the hide, bones, claws, and teeth for medicinal- and ceremonial-related use.

Makwa uses a mixture of habitats, including deciduous lowland forests, riparian areas, alder and ash swamps, mature and early-successional upland forests, wet meadows, and forest openings. Upland forests provide hard mast (acorns, hazelnuts, etc.) and young forests and open habitats provide soft mast (berries) and herbaceous vegetation. In the Ceded Territories, makwag move to dens in the winter when food is scarce. While makwa generally prefers large undeveloped areas, it is becoming more common in suburban and fragmented habitats.

Makwa populations have been increasing in the Ceded Territories since the 1980s. In Wisconsin, the estimated population has risen from about 9,000 in 1989 to just under 29,000 in 2017; makwa has also expanded its range to the south and southwest in the state due to the large population and presence of suitable habitat (Figure 13). Populations in Michigan have also been rising, particularly in the Upper Peninsula, which has an estimated population of around 10,000.

Makwa was described in interviews as medicine, a deep sleeper, and more sensitive to change than other beings/species. It is also known to cause occasional problems, though this was attributed mostly to humans feeding them or not disposing waste properly. One tribal member mentioned that several years ago he observed a much larger population in northwestern Wisconsin. In those days, it was legal to sell makwag, so many people would obtain a license to harvest them.

Summary of climate threats:

Makwa was in the 6th percentile relative to other mammals in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, makwa was in the 12th percentile. Makwag are generalist mammals and will likely be able to accommodate most climate changes. Makwag are primarily affected by human-related sources of mortality – hunting, elimination of nuisance makwag, and vehicle collisions. Any climate-related changes in food sources that bring makwag into closer contact with humans may result in more negative makwa-human interactions. A shorter winter season might result in changes to the timing of winter denning, but more importantly, warmer temperatures might cause flooding and abandonment of dens (Figure 14).

Factors that increase makwa's vulnerability to climate change:

N/SI — Anthropogenic barriers: Major highways can be a barrier to makwa, and any reduction in food production caused by climate change will lead to more road crossings and, therefore, increased mortality. Highways account for around 100 road kills each year in the Upper Great Lakes region.

SI — Historical hydrological niche: The area that makwa occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

N/SI — Dependence on snow or ice: Makwa is not dependent on snow for denning, but can be adversely affected by thawing of a snowpack and flooding of winter dens. This can cause it to vacate the den at times of the year when food is not readily available and could result in weight loss or cub mortality. Den flooding and abandonment has been documented in Minnesota in two recent winters.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Migizi (Bald Eagle)

Haliaeetus leucocephalus

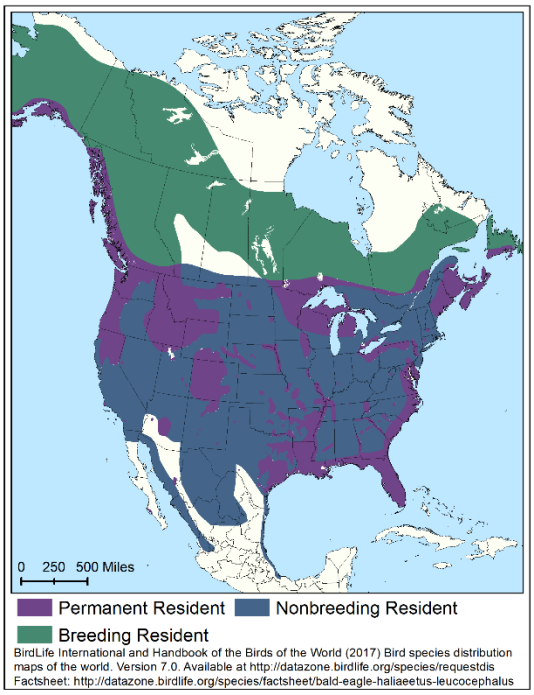

Figure 15. Range map of migizi.

Less – Moderately Vulnerable
(Confidence Level: Moderate)

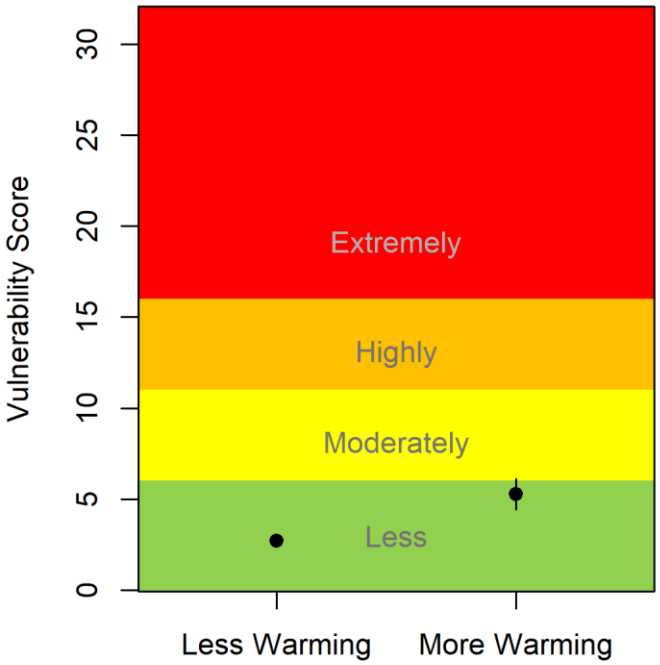

Figure 16. Climate change vulnerability scores for migizi on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

To the Ojibwe people, migizi is known as a bird closest to the Creator and who carries up messages and prayers. Many pray with tobacco when one is seen in order to show respect and appreciation. Migizi is part of the bird clan; those who belong to this clan are known to be keepers of knowledge and responsible for sharing this knowledge. Like many other sacred articles, it is a great honor when gifted with or being a caretaker of feathers from this being/species. The feathers from migizi are treated with great respect and taken care of by cleaning them, feasting them, and/or keeping them from falling to the ground at powwows. Other parts of migizi, such as bones and talons, are used in ceremonies, celebrations, healings, and everyday cultural practice.

Migizi lives near rivers, large lakes, and other large areas of large open water. Nests are built in mature or old-growth conifers or hardwoods in areas with good visibility, near water, and with ample prey. Nests made of sticks, grasses, mosses, and other woody material are 5 to 6 feet in diameter and can weigh up to 3 tons. Migizi prefers areas with minimal human development and disturbance. Some migiziwag remain in the Ceded Territories for the winter if there is enough food; others migrate short distances (Figure 15).

The migizi population declined in the 1900s due to settlement, bounty hunting, logging, and pesticides. The biggest threat to migizi was DDT, a pesticide used to control mosquitoes, which was used heavily in the late 1940s. Migiziwag ate fish contaminated with a byproduct of DDT, causing them to lay thin-shelled eggs that broke before hatching. This devastated migizi populations for decades, and in 1963 there were only 417 nesting pairs remaining in the continental United States. DDT was banned in 1972, and the population has since rebounded and is now widespread in North America. There are now 1590 documented migizi nests in the

state of Wisconsin, and there is some indication that suitable nesting habitat in the northern part of the state is saturated for this being/species. Migizi was removed from the Endangered Species list in 2007.

Even though migizi is so highly respected and commonly used by the Ojibwe, it wasn't mentioned in TEK interviews as frequently as other beings/species. Some discussed the lengthy process a tribal member is required to use to obtain feathers and/or an entire migizi through the United States Fish and Wildlife National Eagle Repository. A Fond du Lac Band tribal member who had been tapping sugar maple trees for nearly 40 years stated that migizi would fly over his sugar bush every time and carry news of his efforts to the Creator. He believed migizi would tell the Creator that the gift of sugar maple was being used by the Anishinaabe people.

Summary of climate threats:

Migizi was in the 42nd percentile relative to other birds in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, migizi was in the 36th percentile. The migizi population is currently high in the Ceded Territories, and it is a mobile being/species unlikely to be affected by climate change. However, there are pathogens that could increasingly affect migizi, and previous population bottlenecks might have resulted in low genetic diversity (Figure 16).

Factors that increase migizi's vulnerability to climate change:

SI — Historical hydrological niche: The area that migizi occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

N/SI — Pathogens or natural enemies: Several diseases have been shown to affect migizi, including avian pox, peritonitis, pneumonia, enteritis, septicemia, avian cholera, aspergillosis, hepatic necrosis, and myocardial infarction. There has been a possible occurrence of avian pox in Chequamegon Bay. These diseases may become more prevalent as conditions change. Humans and environmental contaminants remain the biggest threat to migizi.

I — Bottlenecks: In 1963 there were only 417 nesting pairs remaining in the continental United States, and only 103 individuals in the state of Wisconsin. This bottleneck might have reduced genetic diversity, although more research is needed.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Aandeg (American Crow)

Corvus brachyrhynchos

Less Vulnerable
(Confidence Level: High)

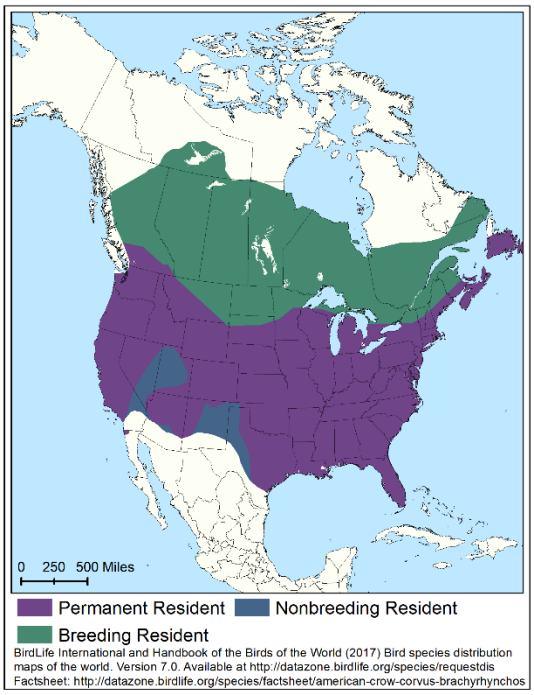

Figure 17. Range map of aandeg.

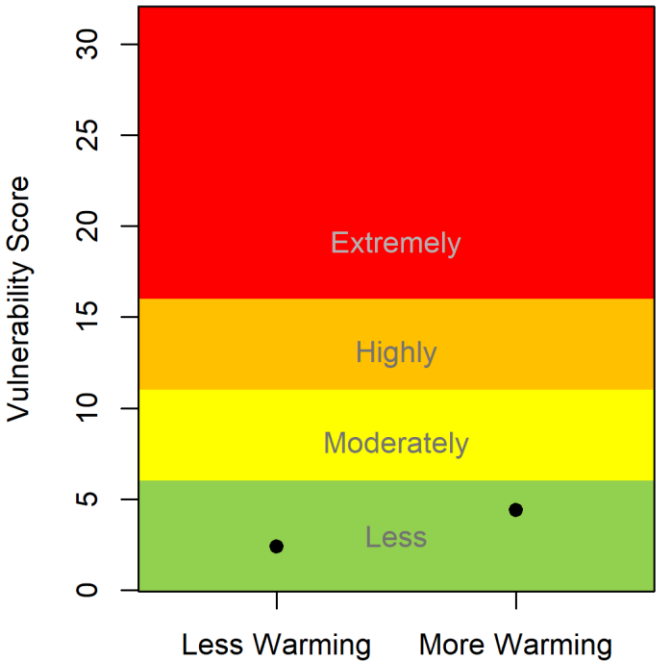

Figure 18. Climate change vulnerability scores for aandeg on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score. No error bars exist for this species because there was no variability in its scores.

General Description:

Aandeg, like all fliers (birds), is highly respected by and symbolic to Indigenous people, including the Ojibwe. Many traditional stories have been shared over the years about this being/species. One particular story describes its connection to fire when the climate changed from constant cold and darkness to yearly seasonal changes and light. Some stories tell of how the being/species came to have feathers with an iridescent look. Others speak to why aandeg talks and sings with a rasp, yet has the ability to mimic human and other animal sounds. Stories such as these are incorporated into sacred songs. For many, aandeg reminds them of teachings that speak to having a purpose in life. Like migizi, aandeg is often a messenger and carries out this responsibility in many ways.

Aandeg is found in a variety of habitats, particularly open landscapes with scattered trees and woodlots, but also in farmland, pasture, parks, golf courses, cemeteries, yards, and the shores of streams and marshes. Forest clearing, suburbanization, and agriculture have created abundant habitat for aandeg, which generally avoids large forested areas.

Aandeg was uncommon before the mid-1800s, but became widespread in the Ceded Territories by the late 1800s due to abundant habitat created by clearing land (Figure 17). The population increased in the assessment area from 1966 – 2015 by more than 0.25% per year.

Some interviewees mentioned that they know it is time to start tapping sugar maples when aandeg arrives with the news. Tribal members described being inside their homes when hearing the news and offering tobacco to aandeg in thanks. They also mentioned that aandeg often follows them around when they are carrying out

activities in the forest, and believe that aandeg communicates to others that they are respecting and utilizing the gifts given by the Creator.

Summary of climate threats:

Aandeg was in the 33rd percentile relative to other birds in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, aandeg was in the 34th percentile. Aandeg is an adaptable and mobile being/species with a broad distribution, and is unlikely to be affected to a large extent by climate change. However, West Nile virus is a threat that has the potential to affect a large amount of birds (Figure 18).

Factors that increase aandeg's vulnerability to climate change:

SI — Historical hydrological niche: The area that aandeg occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

I — Pathogens or natural enemies: West Nile virus was identified in New York in 1999 and has since spread throughout North America, killing 57,000 aandegwag in the first three years. Aandeg is particularly sensitive to the virus, and outbreaks have caused local extirpations. West Nile virus is present in the Ceded Territories and has been found in over half of Wisconsin counties. It is carried by mosquitoes and can be transmitted in food or water. Higher temperatures and lower summer precipitation are likely to lead to more cases and a wider distribution of West Nile virus.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Miskwaadesi (Painted Turtle)

Chrysemys picta

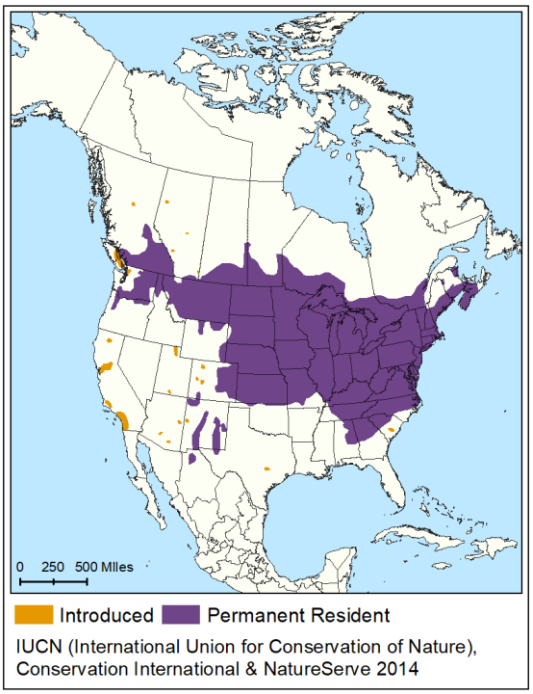

Figure 19. Range map of miskwaadesi.

Less - Moderately Vulnerable
(Confidence Level: Moderate)

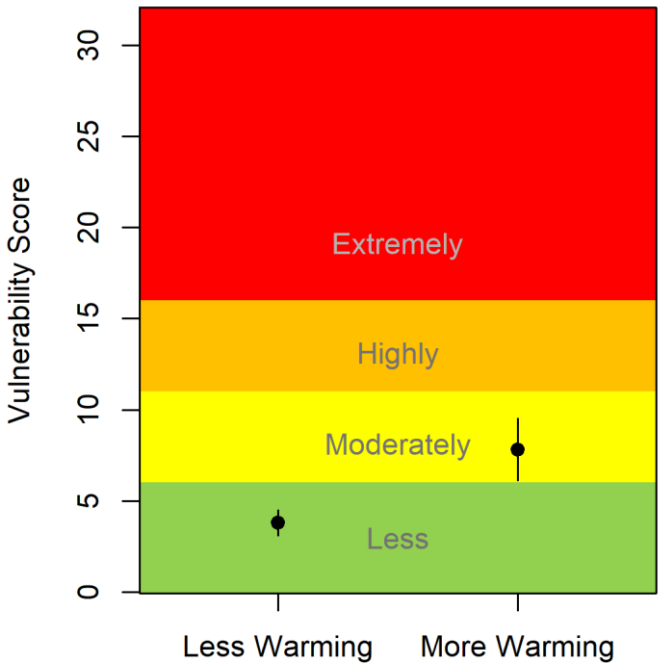

Figure 20. Climate change vulnerability scores for miskwaadesi on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

Some stories featuring miskwaadesi tell of how the makwa (bear) came to have a back with a hump in it. Miskwaadesi fed what was said to be blueberries to makwa. Makwa then asked where the blueberries were and miskwaadesi told him that they were up over the hill. Makwa realized they weren't really blueberries and wrestled with miskwaadesi and killed him. Eventually miskwaadesi came back to life and wrestled with makwa, breaking makwa's back and killing him. It is said from that moment on, all makwag have humps on their backs.

Miskwaadesi lives in shallow water habitats with slow-moving water, such as ponds, lakes, marshes, and creeks. It uses sites that have soft or muddy bottoms, basking sites, and dense aquatic vegetation. Miskwaadesi eats aquatic vegetation, insects, crustaceans, and fish. During the day, it can often be seen basking on logs or rocks for warmth. In the winter, miskwaadesi hibernates in the mucky bottom. Eggs are laid on land in soft sandy soil in the spring.

Miskwaadesi, like other turtles, has low reproductive success due to high levels of egg predation, but females live long lives (there are reports of one individual surviving to 55 years) and produce large clutches (4-10 eggs). The western painted turtle is the more abundant of the two subspecies found in the Ceded Territories, although the midland painted turtle is also found in the region (Figure 19). Habitat loss and road crossings are the two biggest threats to miskwaadesi.

Miskwaadesi wasn't spoken of in interviews as much as other beings/species, but it was mentioned as a culturally significant being/species to the Ojibwe people. Miskwaadesi was a major food source for the Ojibwe

for many years but is rarely eaten today. Today, the shell is commonly used for rattles and shields for both ceremonial and craft purposes. There are numerous stories involving turtles, one of which is of great importance to the Ojibwe people and tells of the creation story in which earth was placed on the back of a turtle to create Turtle Island, also known as North America. The Ojibwe follow a lunar calendar system which references thirteen moons on the turtle's back.

Summary of climate threats:

Miskwaadesi was in the 33rd percentile relative to other reptiles in the vulnerability assessment. Relative to other beings/species in the vulnerability assessment, miskwaadesi was in the 48th percentile. Miskwaadesi may be vulnerable to climate change in many ways, including natural and anthropogenic barriers, limited dispersal, increased disturbances, and an increase in pathogens and predators. Temperature directly affects the sex of miskwaadesi offspring; warmer temperatures mean more females will hatch from nests. In the Ceded Territories, this may have a positive effect on the miskwaadesi population (Figure 20).

Factors that increase miskwaadesi's vulnerability to climate change:

N/SI — Natural barriers: Lake Superior is a barrier to the north of the Ceded Territories that would limit miskwaadesi northward movement.

SI — Anthropogenic barriers: Roads and railroads are barriers to miskwaadesi movement. Many individuals are killed by vehicles when attempting to cross roads (often to lay eggs in the spring), and females tend to move farther than males and are therefore more prone to road mortality. Farm equipment can be harmful to miskwaadesi attempting to cross agricultural fields.

SI — Dispersal: Although miskwaadesi is capable of dispersal, it is a slow disperser. It also hides when threatened by vehicles and other potential threats, slowing down dispersal. Some literature questions miskwaadesi's ability to disperse to its preferred habitat as the climate changes.

SI — Historical hydrological niche: The area that miskwaadesi occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

N/SI — Disturbance regime: Extreme precipitation events can wash out or erode miskwaadesi nests or prevent them from drying, which can reduce hatching rates.

SI — Pathogens or natural enemies: Unknown and known fungal and/or bacterial pathogens such as herpesvirus and ranavirus could proliferate in warming climates. These viruses can increase stress, compromise immune systems, and potentially lead to range-wide or isolated declines in population.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Waawaatesi (Firefly)

Photinus pyralis

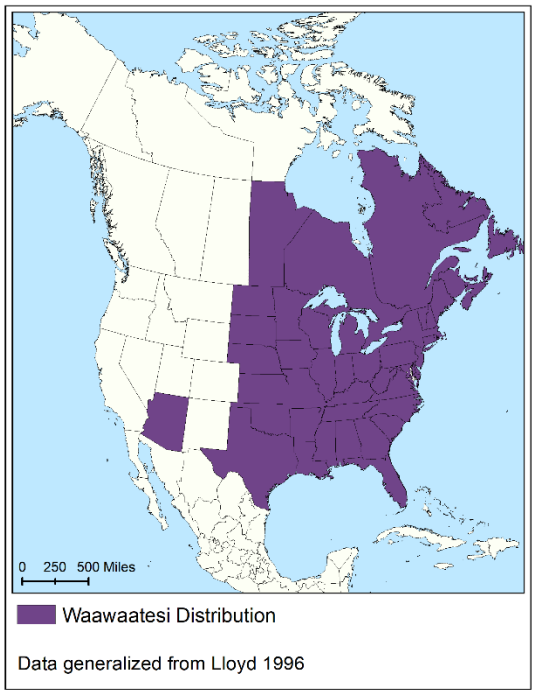

Figure 21. Range map of waawaatesi.

Less – Moderately Vulnerable
(Confidence Level: Low)

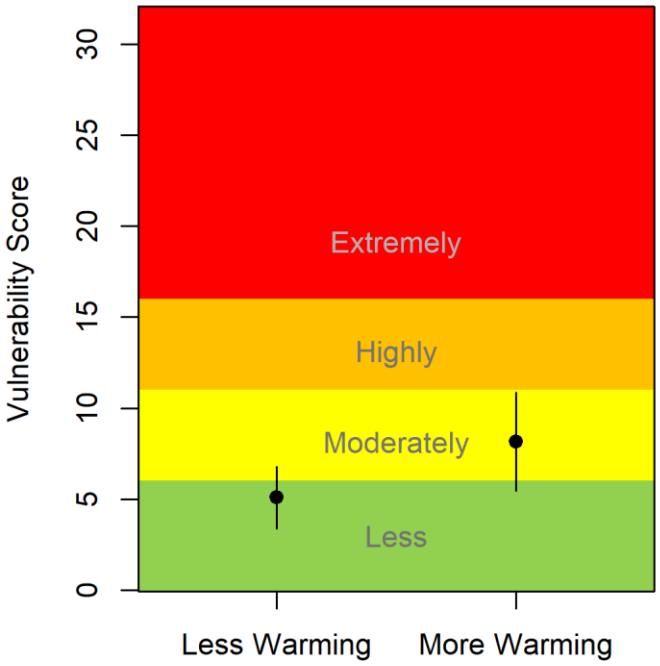

Figure 22. Climate change vulnerability scores for waawaatesi on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

To some, waawaatesi may be a simple small insect that children catch in jars in the summertime. However, in many cultures, waawaatesi is the subject of many stories, often symbolizing enlightenment and beings/species that bring help to those in need. The Ojibwe people also have stories about these little beings/species, often in connection with waawaashkeshi (deer).

Waawaatesi lives in a wide variety of habitats, including meadows, lawns, at the edges of woodlands, and near streams. Waawaatesi uses its light in summer evenings to attract mates, and each species has a different light pattern. Eggs are laid in moist soil, and when larvae hatch, they live in moist places on the ground, under bark, and near streams. Larvae spend the winter underground and emerge as adults the following summer.

Little is known about waawaatesi populations, as there are over 2,000 species, many of which are extremely difficult to identify, and each has a unique habitat and life history. Waawaatesi is generally considered to be in decline in many parts of North America, but research is limited (Figure 21).

Most tribal members that mentioned waawaatesi spoke of it as being one of the first signs that it is acceptable to start hunting waawaashkeshi. Numerous generations observed that when waawaatesiwag are first seen around June or early July that waawaashkeshi will start coming around.

Observations by tribal members indicate fewer waawaatesiwag and some years they seem to be appearing later in the year. There was also concern expressed regarding the use of pesticides, herbicides, and fertilizers, which many feel is contributing to habitat loss for these beings/species. It is known that waawaatesiwag need

clean water and undisturbed streams to survive, and some feel pollution is negatively affecting these beings/species.

Summary of climate threats:

Relative to other beings/species in the vulnerability assessment, waawaatesi was in the 55th percentile. Although little is known about waawaatesi in general, there are several factors that make it vulnerable to climate change, including anthropogenic barriers, changes in precipitation, and susceptibility to predators (Figure 22).

Factors that increase wazhashk's vulnerability to climate change:

SI — Anthropogenic barriers: Logged areas and forest clear-cutting, as well as wetland fragmentation and loss, are likely to reduce habitat with adequate soil moisture for waawaatesi. Light pollution is thought to negatively affect waawaatesi by disrupting its flash communication. In general, most of these barriers are unstudied.

SI — Historical hydrological niche: The area that waawaatesi occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

SI/I/GI — Physiological hydrological niche: Waawaatesi larvae require mesic conditions with ample soil and substrate, and waawaatesi is therefore dependent on adequate soil moisture and aquatic habitats. Changes in precipitation could cause areas to become either too dry or too wet for waawaatesi.

SI/I — Disturbance regime: Flooding and drought could both negatively affect conditions required for waawaatesi larvae.

N/SI — Pathogens or natural enemies: Waawaatesi has many predators, including ants, bats, birds, centipedes, crustaceans, fish, flies, frogs and toads, mites, snails, spiders, true bugs, and wasps, some of which are likely to increase in a warmer climate. Waawaatesi is not highly affected by parasites, as it exudes a milky substance that acts as a protective agent.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
SI/I — **Somewhat Increase/Increase** This factor may somewhat increase or increase vulnerability	SI — **Somewhat Increase** This factor somewhat increases vulnerability	N/SI — **Neutral/Somewhat Increase** This factor may not increase or may somewhat increase vulnerability

Manoomin (Northern Wild Rice)

Zizania palustris

Highly - Extremely Vulnerable
(Confidence Level: Moderate)

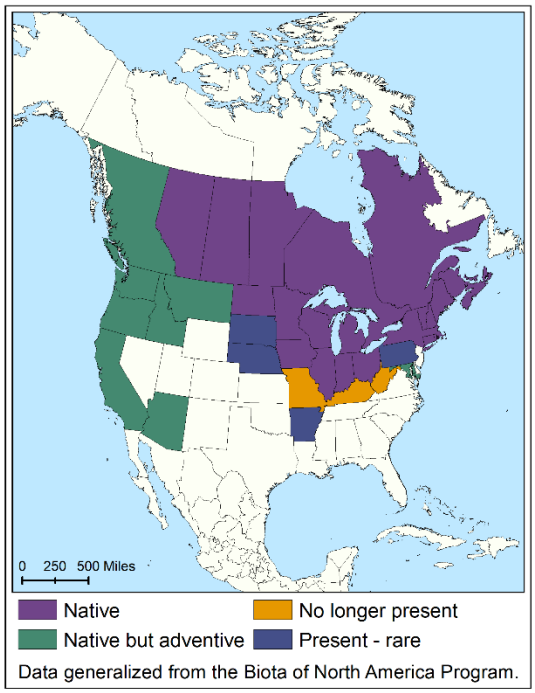

Figure 23. Range map of manoomin.

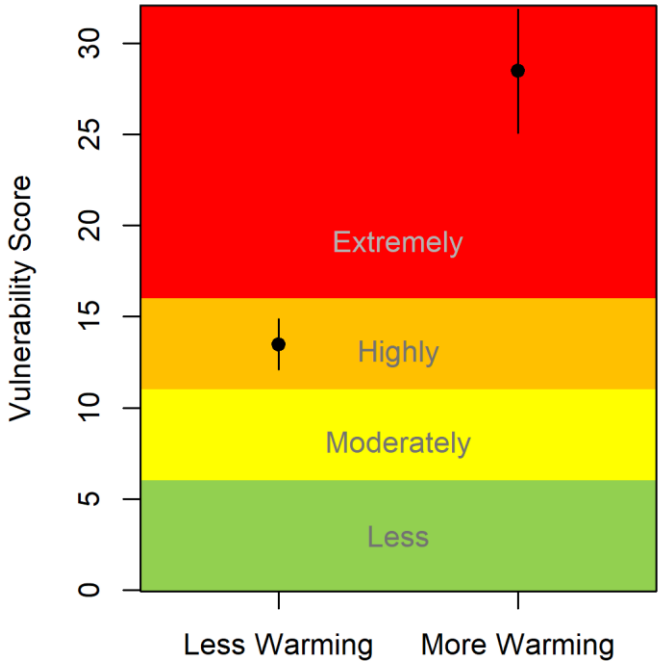

Figure 24. Climate change vulnerability scores for manoomin on a scale of 0 (lowest vulnerability) to 32 (highest vulnerability). Dots indicate average score; lines indicate possible range of scores for each warming scenario.

General Description:

To the Ojibwe, manoomin is considered a special gift from the Creator that ties them to this plant both spiritually and culturally. During their migration, the Anishinaabe followed a miigis (cowrie) shell to the place where food grows on water (manoomin). One particular story about manoomin talks about Wenabozho (a subject of many Ojibwe stories) worrying about what the Anishinaabe people would eat during long hard winter months. Many winters went by where little food was available and the Anishinaabe people were suffering. Wenabozho wanted to help them, so he went into the woods to fast for four days. He dreamed of dancing with others in a river. The Ojibwe dancers with them wore elaborate headdresses with the feathers waving back and forth. When he woke up he remembered the dream and saw tassels waving above the water. As he went closer to them he realized that long seeds were hanging from the tassels. He gathered some of the seeds and brought them with him to continue his fast. When he fell back asleep he had another dream of gathering the seed and eating it. He returned to his village to share his dream with the people. Together, they harvested enough manoomin to get them through the long winter.

Manoomin typically grows in lakes, streams, and rivers, in shallow water (1-3 feet) in places with soft, organic sediment. It grows best in places with some moving water, and in waters with low levels of sulfide. It is an annual plant that grows from seed each spring. Its life stages include a submergent stage, in which the plant is developing under the water, a floating leaf stage, in which one or two leaves float on the surface of the water, and an emergent stage, in which the plant grows out of the water. It then develops flowers and seeds that ripen in late summer/early fall.

Manoomin is found across the Ceded Territories, mostly concentrated in northern Minnesota and northern Wisconsin (Figure 23). Manoomin varies substantially in abundance from year to year, depending on factors including weather, water and/or nutrient levels, and presence of pests, though not all of these factors are well understood.

A lot of effort has been made within GLIFWC to gather TEK specific to manoomin; the following are a few of the major themes mentioned across interviews.

Concern was expressed by many tribal members regarding the decrease of manoomin in many areas throughout the Ceded Territories. In Lac du Flambeau, manoomin was once plentiful, but after the installation of a dam is now mostly just present on the rivers. Some feel it is being destroyed in areas such as Clam Lake, but efforts are underway to remove carp and restore manoomin. Brown spot infestation has been seen in certain areas since 2003. Most interviewees feel that manoomin is vulnerable to climate change due to changes in water level, stronger and more frequent storm events, pollution, and more. Overall, all manoomin harvesters would like to see it be more plentiful on the landscape and are strong advocates of restoration.

Summary of climate threats:

Manoomin was the most vulnerable being/species in this assessment, and has already begun to respond to climate-related effects. There are numerous climate-related threats to manoomin, and it is sensitive to different potential climate effects in each stage of its life cycle. It is also sensitive to many anthropogenic changes. Factors that affected the vulnerability of manoomin include natural barriers, human land use changes, limited dispersal, thermal and hydrological niche, disturbance, dependence on snow and ice, uncommon landscape features, sensitivity to pathogens and predators, competition, and genetic variation (Figure 24).

Factors that increase manoomin's vulnerability to climate change:

SI — Natural barriers: Upland habitat and Lake Superior form natural barriers to manoomin.

SI — Human land use changes: Land use changes resulting from human responses to climate change vary, but warmer temperatures may cause increased boat traffic, which could disturb manoomin. Hydroelectric dams, installed as renewable energy sources, would likely negatively affect manoomin through artificial controls of water levels. Altered land use in response to climate change and an increase in tourism in the Ceded Territories would negatively affect manoomin.

I — Dispersal: Manoomin is capable of dispersing downstream when moving water transports seeds, but not upstream or across unsuitable upland habitat. Its seeds are heavy, without wings, and generally fall into the water near the plant. Many manoomin beds are the result of human seeding, because the plant's natural dispersal is so limited.

I — Physiological thermal niche: It is likely that warmer temperatures will decrease seed production. Following milder winters, spring germination rates appear to be lower. Manoomin is also found near the central or southern end of its range in the Ceded Territories, and warming temperatures may negatively affect manoomin.

SI — Historical hydrological niche: The area that manoomin occupies has experienced slightly lower than average variation in precipitation in the past 50 years.

I — Physiological hydrological niche: Manoomin is sensitive to changes in water level. It is well adapted to annual fluctuations in water levels; however, changes in precipitation that cause multiple years of low or high water are likely to prevent it from growing in a given location. Inter-annual fluctuations can also affect manoomin – high water during the floating leaf stage can drown or uproot the plant.

SI/I — Disturbance regime: Manoomin does depend on some level of disturbance (such as fluctuations in annual water level), but major disturbance events can be detrimental. A 2012 flood destroyed entire

manoomin beds, and a 2016 flood also negatively affected the manoomin crop for the year. Hail, heavy rain, and wind can also damage plants directly.

I — Dependence on snow or ice: Ice cover on waterbodies in the winter provides low oxygen conditions that help the seed emerge from dormancy in the spring. Thickness and duration of ice cover also has an influence on aquatic plant competition – thicker and longer-lasting ice will prevent perennial and/or invasive beings/species from outcompeting this annual plant.

N/SI — Uncommon landscape features: Manoomin depends on a particular type of wetland which is not common in the Ceded Territories – wetlands with water depths of 1-3 feet; soft, organic sediment; and slow-moving water.

SI/I — Pathogens or natural enemies: Warm, humid nights (with dewpoints above 70°F) support diseases such as brown spot disease. These conditions have already and will continue to increase in the Ceded Territories. Brown spot disease causes lesions on the plant's leaves that can reduce seed production by up to 90%. Common carp can also disturb sediments and reduce aquatic vegetation, including manoomin. "Rice worms," a moth larvae, bore into manoomin stems and also cause a large decrease in seed production. Warmer winter conditions are likely to allow these "worms" to overwinter in higher numbers.

SI — Competition: Many native and invasive aquatic plants have the potential to outcompete manoomin, including pondweeds, water lilies, hybrid cattail, flowering rush, and *Phragmites*.

N/SI — Genetic variation: Research is limited, but suggests that genetic interchange between populations may be lower than historical levels, because of locations that can no longer support manoomin.

I — Documented response to climate change: GLIFWC data show a reduction in abundance that is consistent with climate effects – flooding, disease outbreaks, etc.

Legend

GI — **Greatly Increase** This factor greatly increases vulnerability	I/GI — **Increase/Greatly Increase** This factor may increase or greatly increase vulnerability	I — **Increase** This factor increases vulnerability
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