06.01.2016

BAD RIVER RESERVATION

SEVENTH GENERATION CLIMATE CHANGE MONITORING PLAN

Sunset in the Kakagon/Bad river Sloughs, photo by Mike Wiggins, Jr. (top left)
Showy Lady's-Slipper, photo by Bad River Band Natural Resources Department (top right)
Kakagon/Bad River Sloughs from the Air, photo by Jim Meeker, Eric Epstein, and Ted Cline (bottom)

Prepared by the Bad River Band of Lake Superior Tribe of Chippewa Indians with Assistance from Abt Associates, Inc. of Boulder, Colorado

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Contents

1. Introduction

This Seventh Generation Climate Monitoring Plan (the Plan) was developed by the Bad River Band of Lake Superior Tribe of Chippewa Indians (the Tribe) to detect potential climate change impacts to the ecosystems and natural resources found on the Bad River Indian Reservation (the Reservation). The purpose of the Plan is to monitor for what can sometimes be subtle changes associated with climate change that can occur over many years.

In the Lake Superior region, climate change is projected to have a range of effects, including, for example, higher average temperatures; increased winter and spring average precipitation (with more precipitation in the winter falling as rain instead of snow); and more-intense precipitation events, with more dry days between those events (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011; Huff and Thomas, 2014).

> *"Observed and future impacts from climate change threaten Native peoples' access to traditional foods such as fish, game, and wild and cultivated crops, which have provided sustenance as well as cultural, economic, medicinal, and community health for generations."*
>
> *National Climate Assessment; Chapter 12: Indigenous Peoples, Land and Resources (Bennett et al., 2014, p. 298).*

These anticipated changes to the regional climate will likely have secondary effects on the environment (Kling et al., 2003; NWF, 2007; Glick et al., 2011; NOAA, 2011), including the habitats and associated ecosystems on the Reservation. More-intense precipitation events are likely to result in increased flooding and greater erosion rates. Increased water temperatures may result in more frequent algal blooms and hostile thermal conditions for coldwater or coolwater fisheries. Increased evaporation rates can lead to reduced summer water levels that may result in reductions of wet habitat, including small streams and wetland areas. Changes in temperature and rainfall patterns may affect the distribution of forests and other vegetation, consequently altering the distributions of species that depend on these habitats. These types of secondary effects on the environment can cascade through the ecosystem. For example, there may be shifts in the timing of reproduction of some species. Food supplies may be available earlier in the year, but may be diminished in the hotter months of summer, affecting the ability of migratory species to find food. The distributions of fish and other aquatic species could change, and invasions by non-native species that prefer warmer temperatures may become more likely (Glick et al., 2011).

Because of the unique and inextricable relationships between Tribal members and their surrounding natural resources, the cultural fabric of the Tribe may be affected by climate change in profound and unique ways.

Accordingly, this Plan was developed to summarize projected climate changes and probable physical, biological, chemical, and cultural impacts on the Reservation, and to outline a monitoring approach to identify changes anticipated from climate change. In order to enable the Tribe to proactively address and adapt, the Plan incorporates monitoring for early warning signs of negative impacts of climate change, as well as benchmark dates for assessing potential climate change impacts over the long-term. The Tribe has designed the Plan to be a "living," flexible guide to climate monitoring. This flexibility will allow the Tribe to make changes to the Plan as

needed to adapt to new conditions, unforeseen events, and any advances in the state of the science on climate change that may occur over its seven-generation lifespan.

The remainder of the Plan is organized as follows:

- Section 2 provides the Tribe's Vision Statement, beliefs, and Tribal membership involvement in developing the Plan.
- Section 3 includes general background information on the Reservation, including location, population, environmental setting, and cultural uses and importance of natural resources.
- Section 4 provides an overview of projected climate changes within the Reservation's area (Lake Superior region) and the impacts that are anticipated to occur, or that are already affecting the Tribe's natural resources and cultural practices.
- Section 5 discusses the Tribe's approach to developing this Plan – including convening an expert working group that provided input and guidance, and the process the Tribe followed for prioritizing resources for climate monitoring.
- Section 6 provides the Tribe's ecosystem-based monitoring approach for detecting adverse effects of climate change.
- Section 7 includes potential adaptation strategies the Tribe may consider implementing, if needed, depending upon the monitoring results.
- Finally, Section 8 provides a summary.

2. Vision Statement, Beliefs, and Tribal Involvement in this Plan

The motivation for this Plan is in part derived from the Tribe's Vision Statement for the Reservation, and the Tribe's beliefs, which appear in the Bad River Band's Integrated Resource Management Plan (IRMP), and are stated below (Bad River Band, 2001), followed by an overview of Tribal membership involvement in this Plan.

2.1 Vision Statement

The Tribe hopes to achieve the following vision of its Reservation:

> Our vision is of a Reservation where all living things are in natural balance and are no longer threatened with negative anthropogenic (human-made) impacts; where all individuals and institutes value the gifts of Mother Earth and willingly choose to act in a manner which ensures achievement of sustainable environmental and economic goals; where every Bad River member, young and old, shares in the benefits of a healthy environment; where each Bad River

member maintains the traditional cultural values necessary to live harmoniously with the natural world; where every Bad River member accepts the personal responsibilities and challenge of pollution prevention in his or her daily life, and is committed to moving from a consumer-oriented society to a conservation-minded society; where the Bad River Band gives high priority to the protection of its environment, its natural resource base, and the functions of the natural systems on which all life depends; where the majority of the Bad River Band's subsistence needs are provided for by the local community.

2.2 Beliefs

We believe the Earth is a living entity and deserves the respect and honor that every living thing is entitled to receive.

We believe that the Bad River Indian Reservation and the Bad River Band have been so historically joined that, as a People, no other place can be called home.

We believe water is the life blood of the environment and the quality of the water determines the quality of life.

We believe we have a moral responsibility to the Seventh Generation.

We believe that in order to ensure the Seventh Generation shares in a high quality of Reservation resources, all human development activities must proceed in the most conservative manner possible.

We believe that the reduction of over-consumption and waste will reduce the burden on the environment and will contribute to a higher quality of life for all Tribal members.

We believe that healthy ecosystems will be maintained by understanding, respecting, rehabilitation, and protecting natural resources and ecological processes.

We believe that maintaining and promoting biological, social, and cultural diversity is essential for a long-term sustainable environment, and that such diversity creates a resilient base for the ecosystem.

We believe there is a limit to the amount of resources that can be safely removed from a healthy ecosystem.

We believe that environmental protection and enhancement strategies must be improved in order to meet the environmental challenges of the future.

We believe the Bad River Band must take a leadership role in the development and implementation of sustainable development policies and standards of conduct.

We believe Tribal members must return to their traditional roots for the spiritual foundation that is needed to suppress the urge to take more than they need.

2.3 Tribal Membership Involvement

Tribal members have been involved in developing this Plan from the onset. Many of the Bad River Natural Resource Department (BRNRD) staff members who have led the technical work involved in developing this Plan are Tribal members. Also, Tribal members and elders participated in an expert working group that was convened to guide the development process. This Plan also underwent a 30-day period of public review and a public meeting was held to give all Tribal members the opportunity to provide input into the Plan. The Plan was then presented to the Tribal Council for approval. Tribal members are also involved with implementing the Plan, including the collection of climate monitoring data. Finally, this Plan is a flexible, living document, which may evolve as needed to meet conditions encountered over the next seven generations, a process that will once again be guided by Tribal members.

3. The Reservation

In this section, we describe the population, local climate, topography, habitat types (including their ecological and cultural importance), and threatened and endangered species found in the area. Most of the presented information is taken from the 2001 IRMP, which the Bad River Band is currently in the process of updating at the same time this Plan is being finalized (Bad River Band, 2001). However, once the updated IRMP is released, this Plan can be revised (if needed) to reflect any changed information.

3.1 Location and Population

The Reservation is located along the southern shore of Lake Superior, in Ashland and Iron counties in Wisconsin (Figure 1). The Reservation covers around 125,000 acres, which includes approximately 200 acres on Madeline Island. Data taken from the 2011 National Land Cover Dataset (NLCD) produced by the Multi-Resolution Land Characteristics Consortium (MRLCC, 2011) indicate the Reservation is dominantly forested (76%) and wetlands are the next most dominant land cover (17%). Developed lands, including farmland, and residential communities and roads make up only a small percentage (3%) of the Reservation.

The total Tribal enrollment is more than 8,000 Tribal members, including members who live on and off the Reservation. Approximately 1,700 Tribal members live on the Reservation, and an additional 100 members live within a 50-mile radius of the Reservation boundary. The total population (including Tribal members and non-members) on the Reservation is 2,100. The main communities on the Reservation are Old Odanah, New Odanah, Frank’s Field, Birch Hill, and Aspen Acres, and the smaller community of Diaperville.

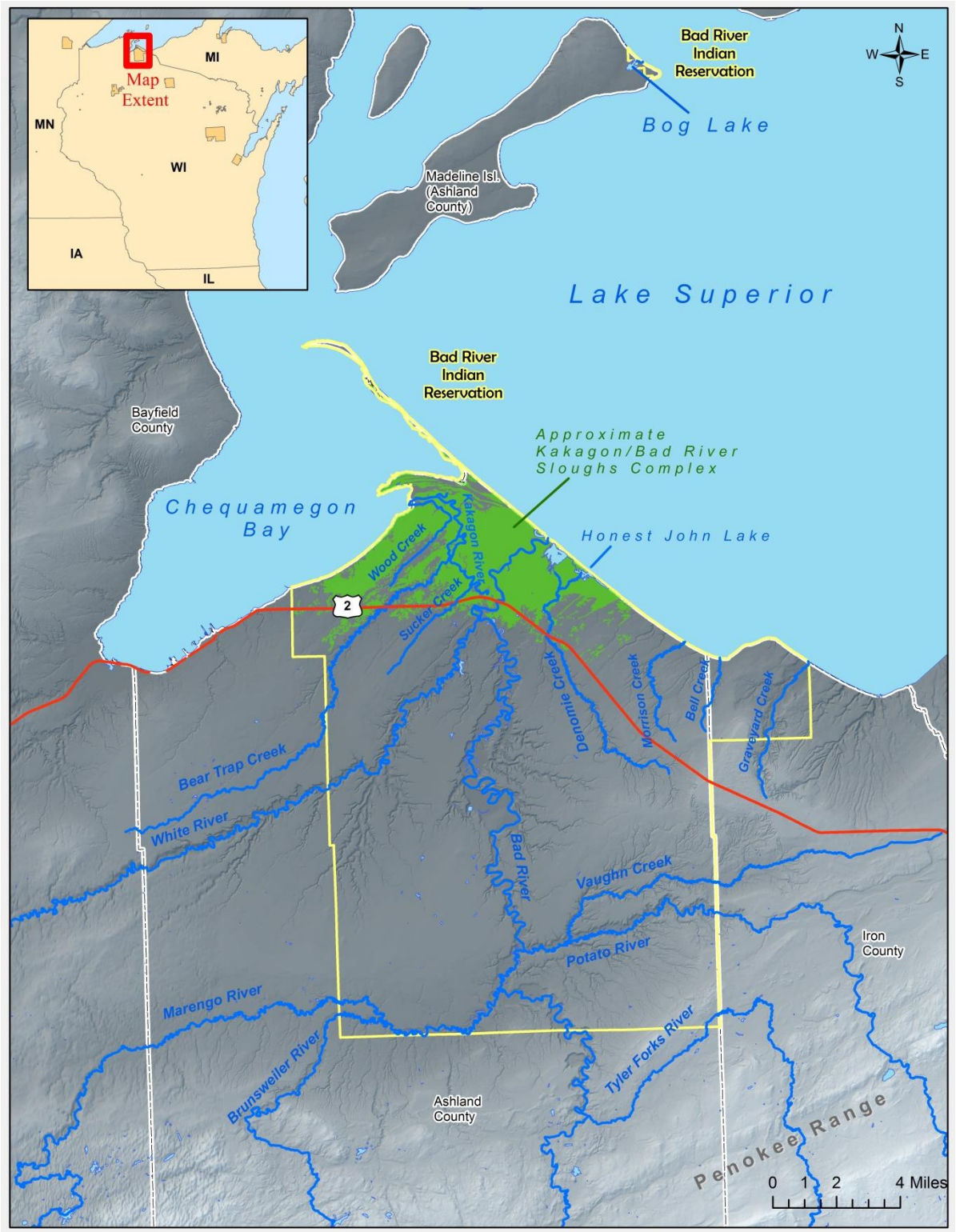


Figure 1. Location of the Reservation on the south shore of Lake Superior.

3.2 Climate

The Reservation has a humid continental climate with four distinct seasons. Winters are long and cold, influenced by continental polar air masses from northwest Canada and the Arctic. Summers are cool to warm, dominated by moist tropical air masses from the Gulf of Mexico. The spring and fall seasons are transition periods with frequent fronts moving through the area.

Temperature, precipitation, and snowfall data from 1981 to 2010 were obtained from the Midwestern Regional Climate Center (MRCC, 2016). The Tribe recently installed a meteorological station for ambient air monitoring in 2003 in Odanah, and it was upgraded in 2011. Temperature and precipitation trends on the Reservation are as follows:

- ***Temperatures*** range from approximately 48°F to 78°F in the summer months (June, July, and August), and approximately 1°F to 28°F in the winter months (December, January, and February), based on data collected between 1981 and 2010 in Gurney, WI and Madeline Island, WI (MRCC, 2016). Figure 2 shows 30-year average precipitation patterns across the Reservation, developed by the BRNRD, using the Parameter-Elevation Regression on Independent Slopes Model (PRISM) that was developed at Oregon State University (Daly et al., 2015). The 2001 IRMP reports that daily and annual temperatures generally increase from north to south on the Reservation, because of the moderating effect of Lake Superior on lakeshore climate and the increase in elevation and gradient at the south of the Reservation (Bad River Band, 2001).

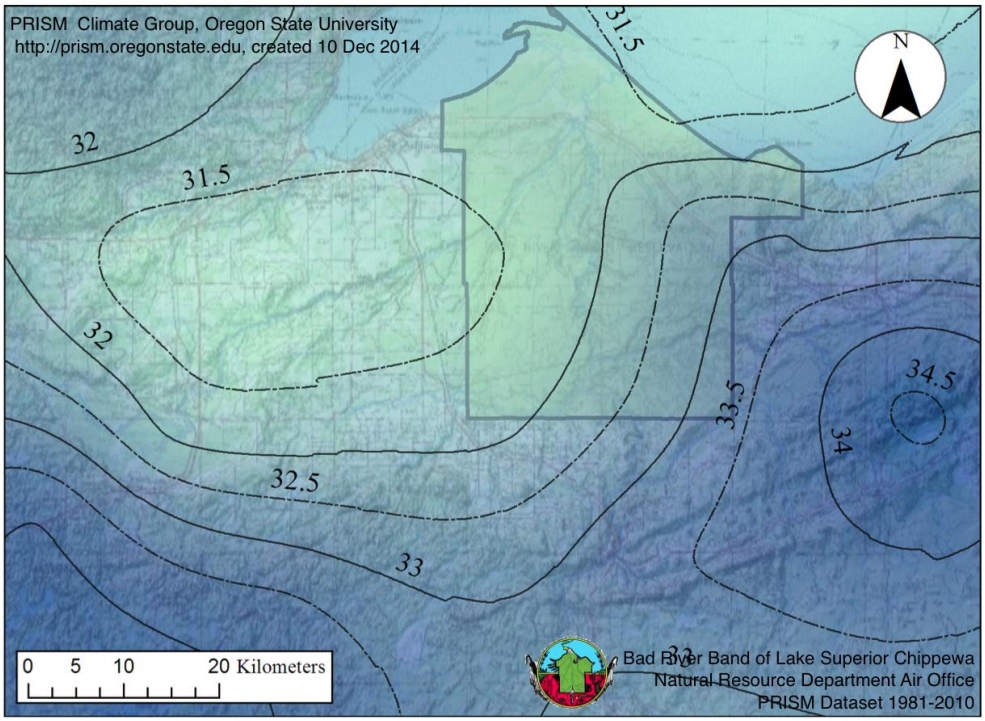


Figure 2. The 30-year average precipitation patterns across the Reservation, developed by the BRNRD, using PRISM. The lines show total precipitation and the outlined green area is the Reservation.

- ***Precipitation*** occurs in all months of the year, with maximum precipitation in August at approximately 4.4 inches, and minimum precipitation in February at approximately 1 inch, based on data collected between 1981 and 2010 in Mellen, WI. During this same time period, the annual precipitation was 33.3 inches in Mellen, WI (MRCC, 2016).

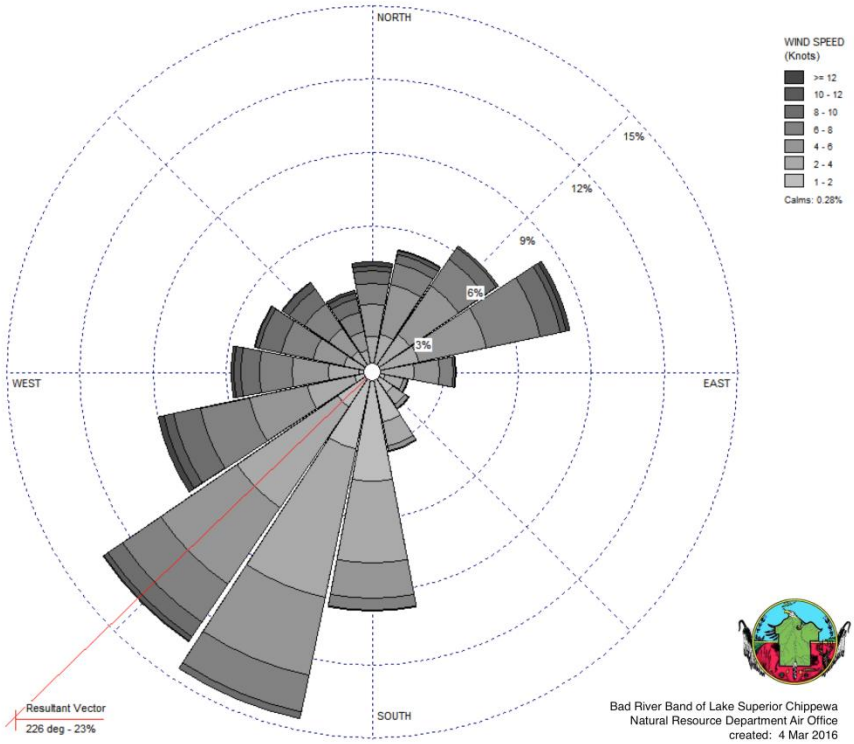
- ***Snowfall*** varies relatively widely from year-to-year and spatially (Bad River Band, 2001). Between 1981 and 2010, the mean annual snowfall was approximately 103.3 inches to 132.2 inches in Mellen and Gurney, WI, respectfully (MRCC, 2016).

- ***Wind patterns*** across the Reservation vary between seasons and distance from Lake Superior, but fall within the expected pattern of westerly prevailing winds (Figure 3). Wind direction and speed measured at the Bad River Band's ambient air monitoring site between 2011 and 2014 shows that prevailing winds across the Reservation predominately blow from southwest to northeast (26% of the time southwest or south-southwest) at an average annual speed of 4.8 miles per hour (4.15 knots, measured at 10 meters above ground level). Lake Superior influences wind patterns in the spring months, with 25% of the wind blowing on-shore from the northeast and east, which is most notable closest to the shoreline in March, April, and May each year.

3.3 Topography

The Reservation falls within a region of low relief known as the Lake Superior Lowland, which is located between Lake Superior's southern shoreline, and the Penokee Hills to the south. The topography of this region formed as a result of glacial sculpturing that occurred between 23,000 and 9,000 years ago. Continental ice sheets covered northern Wisconsin repeatedly over this time period. As glaciers advanced and retreated through the area now comprising the Reservation, they crushed underlying landforms and deposited reworked sediments, mainly as finely ground, clayey materials. These deposited clays were waterlogged and fluid, forming a relatively flat landscape as they de-watered (Bad River Band, 2001).

The flat clay deposits are now dissected by widely spaced, steep-sided valleys that contain highly sinuous rivers and streams. These valleys and streams were created by subsequent rainfall and erosion, which formed drainage systems in the clayey deposits. The rivers and streams discharge into a large lowland area located roughly between Highway 2 and the south shore of Lake Superior. This low, flat region – consisting of open water, bog, and marsh – lies in a broad ancient valley that formed during periods in the glaciation when the surface level of Lake Superior was lower than present-day levels. As lake levels rose, the valleys filled with sediment and organic matter, forming the coastal wetlands and estuaries that exist there today, including the Kakagon/Bad River Sloughs, which are described further below. In addition, there are many inland wetlands, lakes, and ponds within the Reservation boundaries. These have typically formed by water collecting in shallow depressions in the poorly draining deposited clays (Bad River Band, 2001).



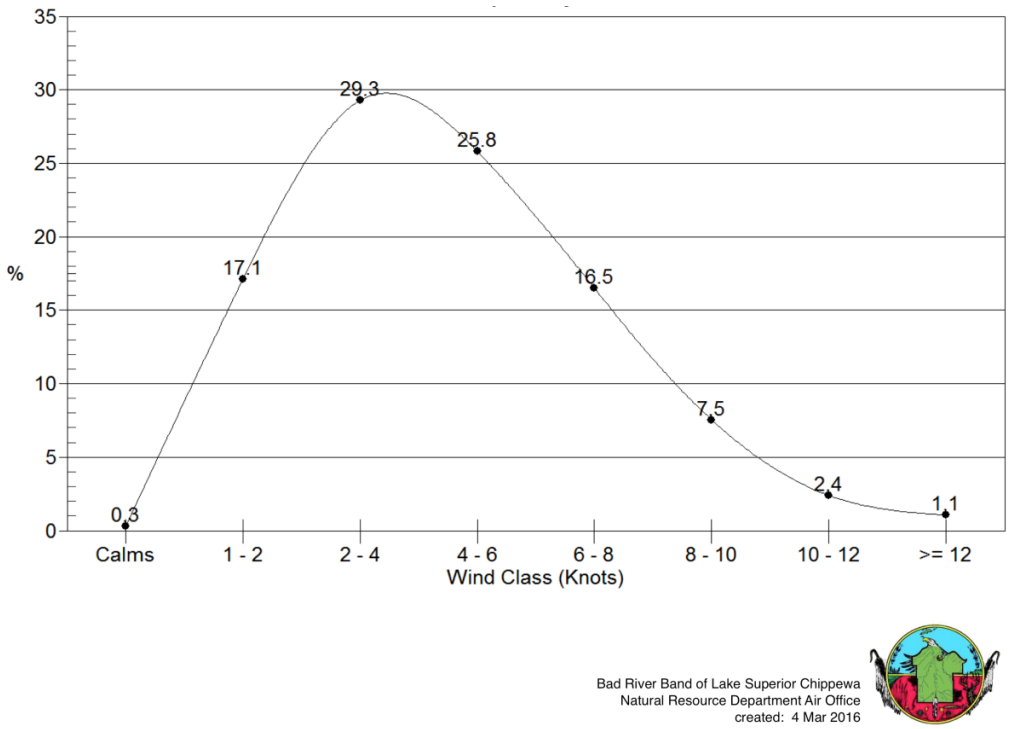


Figure 3. Wind speed and direction measured on the Reservation between 2011 and 2014 (top graph); distribution of wind speeds measured on the Reservation for the same time period (bottom graph).

Toward the southern boundary of the Reservation, the clay deposits meet steeper rims in locations where the underlying bedrock was more resistant and was not ground down by the glaciers. These sloping landforms show evidence of old remnant beachlines from times of higher

lake levels. Elevations on the Reservation range from 602 feet above sea level at Lake Superior to 1,280 feet on the southern end (Bad River Band, 2001).

3.4 Habitat Types and their Cultural Importance on the Reservation

Habitat types found on the Reservation include (1) coastal habitats, including wetlands, estuaries, and beaches; (2) inland aquatic habitats, including lakes, wetlands, ponds, and rivers and streams; and (3) upland habitats, including forested and agricultural lands. Habitats found on the Reservation are connected to and dependent upon habitats located upstream and adjacent to the Reservation. Each habitat, including those within the Reservation and those interconnected with them, has cultural importance to the Tribe. Further, while the Plan separates these habitats for discussion purposes, each is connected to and influenced by the other.

3.4.1 Coastal habitats

Coastal habitats on the Reservation include coastal wetlands, estuaries, and beaches.

Coastal wetlands and estuaries – Vast expanses of marsh and peat-dominated wetlands occur within the large lowland area along the southern shore of Lake Superior that formed during the last period of glaciation (described in Section 3.3). Of these, the largest wetland complex on the Reservation is the Kakagon/Bad River Sloughs, a 16,000-acre estuarine wetland complex that has formed behind a series of sand spits on the south shore of Lake Superior, and extends southward roughly to the point where Highway 2 cuts across the landscape (see Figure 1). The Kakagon/Bad River Sloughs comprise around 13% of all coastal wetlands in the Lake Superior Basin, and over half (55%) of the coastal wetlands within the Wisconsin portion of the basin.

The Kakagon/Bad River Sloughs are important foraging, spawning, and nursery grounds for many fish species, including walleye, yellow perch, and northern pike. Furbearers – such as otter, beaver, mink, and muskrat – also inhabit the Kakagon/Bad River Sloughs, in addition to the inland wetlands described below (Bad River Band, 2001). The Kakagon/Bad River Sloughs are a migratory stopover habitat in the fall and spring for many bird species, including passerines, raptors, shorebirds, and water birds, and provide breeding habitat for yellow rail, Virginia rail, northern harrier, sedge wren, Le Conte's sparrow, northern waterthrush, Blackburnian warbler, and golden-winged warbler (Wisconsin Wetlands Association, Undated).

Kakagon/Bad River Sloughs – An internationally recognized ecological jewel and cultural centerpiece

The Kakagon/Bad River Sloughs have received numerous designations and recognitions over the years due to its vast size, unique and diverse habitats supporting unique and diverse species, and the Tribe's stewardship of this ecosystem over generations. Some of the recognitions received are:

- *A Wetland of International Importance under the Ramsar Convention.*
- *An Important Bird Area under the Wisconsin Bird Conservation Area.*
- *A Wetland Gem site by the Wisconsin Wetland Association.*
- *A National Natural Landmark.*
- *A Nature Conservancy Priority conservation Area*
- *A Blue Globe Award by the World Wetland Network*
- *An Important Habitat Site under the Lake Superior Lakewide Management Plan. It is the only site in the entire Lake Superior Basin that met all of the important habitat site criteria.*

Waterfowl, like these mallard ducks, rely on the wild rice beds in the sloughs for food and cover. Source: BRNRD

As an indication of their ecological importance, the U.S. Department of the Interior (DOI) designated the Kakagon Sloughs as a National Natural Landmark, describing the complex as an "excellent representative of a true freshwater delta by virtue of its large size, complex mixture of marsh, bog, and dune vegetation types, and undisturbed conditions" (National Natural Landmarks Program, 2009, p. 106).

The plant community within the Kakagon/Bad River Sloughs consists of vast areas of sedge meadow, wiregrass meadow, and shallow- and deep-water marshes (Elias and Meeker, 1999), as well as Sphagnum bog and conifer swamps scattered throughout the slough (Elias and Meeker, 1999). Within these plant communities, most notable are the extensive wild rice (*manomin*) beds and cranberry bogs.

The rice beds are of central importance to the Tribe's culture. Wild rice, or manomin, is a sacred food that is integral to the religion, culture, livelihood, and identity of the Tribe and the *Anishinabe* (Ojibwe) people. According to the migration story, the Anishinaabe moved west until they found the place "where food grows on the water" – the Kakagon/Bad River Sloughs (Bad River Band, 2006). Wild rice harvesting has been a cornerstone of Tribal culture, subsistence, and commercial enterprises for several generations. Wild rice is also ecologically important, both migrating and resident wildlife feed on the nutritious seeds of the wild rice; it provides important nesting and breeding habitat for many waterfowl, and many other bird species use wild rice shoots as nesting material. Muskrat and white tailed deer eat the entire plant. Further, wild rice plants can help to stabilize shorelines (MDNR, 2008).

Tribal members ricing along Beartrap Creek on the Reservation. Source: BRNRD.

Shoreline of the south side of Long Island during a high water year (2014). Source: BRNRD.

The Kakagon/Bad River Sloughs are an important source of subsistence for Tribal members as the bulk of fish caught and wild rice harvested occurs in the Kakagon/Bad River Sloughs. The Kakagon/Bad River Sloughs also have cultural and spiritual significance for the Tribe. In fact, the 2001 IRMP describes this wetland complex as the Tribe's "most culturally important wetland." As described in the IRMP, wetlands – including the Kakagon/Bad River Sloughs – are culturally important because "hunting, fishing, trapping and gathering activities are important to the cultural and spiritual identity of Tribal members. Healthy and functioning wetland ecosystems are necessary to maintain a resource base, which in turn contributes to the preservation of the culture. It is important to protect not only threatened and endangered plants and animals, but also to protect the lifestyles and ways important to the very existence of the individual Tribal member.

In addition to the Sloughs complex, coastal wetlands are found on the Reservation along Long Island, surrounding Bog Lake, and bordering Graveyard Creek near its mouth. Bog Lake and its surrounding wetlands are located on Madeline Island. Tribal members traditionally harvested wild cranberries in the wetlands around Bog Lake.

Beach habitats – Beach habitat is found on the Reservation along the northern boundary of the Reservation, comprising 38 miles of Lake Superior shoreline (Bad River Band, 2015). Beach habitat is important ecologically and is also used by the Tribe for swimming and other activities in warm summer months. In particular, beach habitat is along the Long Island/Chequamegon

Point sand spit. This sand beach has been formed over time by sediment discharging from the Bad River and its tributaries, such as the White River. Historically, Long Island was a true island, separated from Chequamegon Point by a shallow channel of water. In 1975, the same storm that sank the Edmund Fitzgerald also closed the channel and connected Long Island to Chequamegon Point. These beaches provide important habitat for sensitive species including piping plover, the dune tiger beetle, and beach grass. Both increases in water levels and erosion can decrease the amount of suitable piping plover nesting habitat.

3.4.2 Inland aquatic habitat

Inland aquatic habitats on the Reservation include rivers, creeks, lakes, inland wetlands, ponds, and other surface waters.

Rivers and creeks – There are over 200 miles of rivers and creeks that flow through the Reservation and around 280 miles of mapped intermittent waterways (Bad River Band, 2015). Originating in headlands south of the Reservation, the Bad River flows around 30 miles before entering the Reservation and continues to meander for almost 45 miles before reaching Lake Superior (Figure 1). Major coldwater tributaries to the Bad River within the Reservation include the Potato and Tyler Forks rivers. Important cool water rivers that also drain the Bad River Watershed (BRWS) are the Brunsweiler, White, and Marengo rivers. Downstream of its confluence with the Marengo River, the mainstem of the Bad River supports many anadromous and resident fish species. Lake sturgeon, walleye, white and longnose sucker, and silver and shorthead redhorse are among the anadromous species. Resident fish species include northern pike, muskellunge, yellow perch, small mouth bass, rock bass, and a variety of minnow species. Invasive species including sea lamprey, rainbow smelt, common carp, and ruffe have also been reported in this lower stretch (Bad River Band, 2001).

The Kakagon River (which is also part of the BRWS), Bear Trap Creek, Sucker Creek, and Wood Creek also drain into the Kakagon/Bad River Sloughs. While these rivers drain a much smaller area of 30,500 acres, they also provide critical spawning and nursery habitat for walleye and habitat for other coolwater species, including northern pike, yellow perch, smallmouth bass, rock bass, bluegill, pumpkinseed, black crappie, black bullhead, suckers, and redhorse. Invasive species such as carp, ruffe, white perch, and rainbow smelt are also present. Finally, smaller creeks also found within the Reservation boundary provide important areas for spawning, resident, and foraging fish species, including Morrison, Bell, Winks, Vaughn, Trout Brook, Billy, and Graveyard creeks, which discharge directly into Lake Superior. Of these, all but Morrison are coldwater creeks. Graveyard Creek is particularly notable because it is a coldwater stream and it contains a remnant brook trout population that historically used Lake Superior shoreline waters. While historically widespread, coasters (brook trout that use Lake Superior waters) are now quite rare. The Tribe undertook a rehabilitation project in 2001 on Graveyard Creek to improve in-stream brook trout habitat and spawning areas, including placing gravel and brush bundles, and taking beaver control measures. In 2013, additional fish habitat was constructed and implemented in Graveyard Creek, which included a root ball, two cross logs, two k-dams, and five half logs to enhance the brook trout population. Fish surveys have since been conducted; 56 brook trout were captured where fish habitat had been installed, and spawning activity has also been observed at the artificial reef.

The rivers and creeks, and the fish they support, are culturally important to the Tribe: "…the fishery resources of the Reservation are some of the most highly valued resources to Tribal members, for cultural, social, subsistence and recreational purposes. Based upon response to the IRMP questionnaire – fishing was the most highly regarded recreational activity among Tribal members living on or off the Reservation" (Bad River Band, 2001). We note also that the Important Bird Area under the Wisconsin Bird Conservation Area noted above in Section 3.4.1 also extends to the corridors of the Bad, White, Marengo, and Potato rivers.

The Bad River drainage system extends beyond the boundaries of the Reservation, draining a total of approximately 650,000 acres (1,016 square miles).

Bad River at Elm Hoist on 8/4/2014, as it typically appears in summer months, flow rate of 208 cubic feet per second (cfs). Source: BRNRD, U.S. Geological Survey (USGS) gage.

Bad River at Elm Hoist on 8/25/2014, after a large storm, flow rate of 1,020 cfs. Source: BRNRD, USGS gage.

Many high-quality waters are present within the Reservation. The Tribe designated the Kakagon River and the majority of the Bad River as Outstanding Tribal Resource Waters (Chi minosingbii) under the Anti-degradation Policy in their federally approved water quality standards (Bad River Band, 2011). The Tribe's antidegradation tiers are further described below (Bad River Band, 2011):

- ***Outstanding Tribal Resource Waters*** (Chi minosingbii or "best waters") are waters considered largely pristine and constitute a significantly important cultural and ecological resource. These waters are important for the cultivation of wild rice or the spawning of lake sturgeon, or have other special resource values. This classification is roughly equivalent to the U.S. Environmental Protection Agency's (EPA's) Tier 3 classification under its antidegradation policy, though this classification may be more protective than the Agency's policy.

  Waters designated as Outstanding Tribal Resource Waters (Chi minosingbii) include:

  - Kakagon Slough and the lower wetland reaches of its tributaries that support wild rice
  - Kakagon River

- Bad River Slough
- Honest John Lake
- Bog Lake
- A portion of the Bad River, from where it enters the Reservation through its confluence with the White River
- Potato River.

- ***Outstanding Resource Waters*** (Chi minosibii or "large good river") are waters considered to be high quality and culturally important for the fisheries and ecosystems they support. This classification is more stringent than EPA's Tier 2 classification and could be described as Tier 2.5 water under the Agency's antidegradation policy.

  Waters designated as Outstanding Resource Waters (Chi minosibii) include:

  - A portion of Bad River, from downstream of its confluence with the White River to Lake Superior
  - White River
  - Marengo River
  - Graveyard Creek
  - Bear Trap Creek
  - Wood Creek
  - Brunsweiler River
  - Tyler Forks
  - Bell Creek
  - Vaughn Creek.

- ***Exceptional Resource Waters*** (Anishinaabosibiing or "good watering place") are waters considered to be high quality and culturally important for the ecosystems they support. This classification is roughly equivalent to EPA's regulatory definition of a Tier 2 water under the Agency's antidegradation policy, though this classification may be more protective than the Agency's policy.

  Any surface water not specifically classified as Outstanding Tribal Resource Water or Outstanding Resource Water is classified as Exceptional Resource Water.

The Tribe's health and welfare depends upon maintaining and advancing the pristine quality of Tribal waters. As described in the Bad River Band's Water Quality Standards:

> The history of the Bad River Band, as well as our future survival and growth, is inextricably intertwined with pure water. Anishinabe considers Water, Nibi, as the most sacred living part of our Mother, the Earth. Without water, there is no life. Water, is the life-blood of our Mother the Earth, and without healthy blood, illness prevails. Water is a finite resource, with its health being contingent on all sides of the environment that surrounds the water: above, below, and all around. Water is a primary component in the migration story of the Anishinabe people, and the migration story describes a search for a place where food grows on the water; that food is wild rice. The waters flowing throughout the entire Bad River

> Reservation provide a variety of sacred resources, such as Manomin (wild rice), Name (lake sturgeon), Ogaa (walleye), and other fish and game species, and serve as critical navigation routes that we rely upon for cultural, subsistence, health and economic wellbeing" (Bad River Band, 2011).

As such, promulgation and enforcement of these Tribal water quality standards is essential to protecting political integrity, economic security, and health and welfare (Bad River Band, 2011).

Inland wetlands, lakes, and ponds – There are 545 acres of lakes and ponds and over 30,000 acres of mapped wetlands (many of these are inland wetlands) within the Reservation (Bad River Band, 2015). Forested and scrub/shrub wetlands comprise the majority of the Tribe's wetlands. Many of the inland wetlands, lakes, and ponds on the Reservation formed as the result of water accumulating in natural depressions in the poorly drained clay soils that dominate the Reservation. Honest John Lake is one of the larger lakes on the Reservation. It is a 97-acre bog lake surrounded by wiregrass meadow, Sphagnum bogs, and conifer bogs (Elias and Meeker, 1999). Honest John Lake is also habitat for cranberry bushes, which are picked by Tribal members.

Wetlands are also found beyond the banks of rivers where flooding occurs seasonally. Former river beds and oxbows along the rivers on the Reservation have become wetlands when the rivers changed their course. Many different wetland types are found on the Reservation, including coniferous swamps, lowland hardwood swamps, alder thickets, coniferous bogs, open bogs and fens, sedge meadows, deep and shallow marshes, and shallow open-water communities. As noted above, these wetlands are important because they provide spawning and nursery habitat for many species of fish, and habitat for furbearers and many species of birds (Bad River Band, 2001).

Like the Kakagon/Bad River Sloughs, inland wetlands are culturally important to the Tribe. The idea that "healthy and functioning wetland ecosystems are necessary to maintain a resource base, which in turn contributes to the preservation of the culture" is also true for inland wetlands (Bad River Band, 2001).

3.4.3 Upland habitats

Upland habitats on the Reservation include forested habitats and agricultural lands.

Forested habitat – The Reservation lies in a transition zone between the boreal forests of the north and the mixed conifer-hardwoods of the Great Lakes region. Because of this transitional location, the forests are diverse, and elements of both major forest types exist. There are at least 29 native tree species on the Reservation, including many types of pine, spruce, birch, aspen, ash, maple, elm, and oak. Presently, the most abundant tree species are aspens, red maple, paper birch, balsam fir, and white pine. The composition of present forests has been influenced by historical timber harvesting practices, particularly clear-cutting that occurred around the turn of the last century. That activity reduced the number of conifers, which are desirable trees for timber, wildlife, habitat, and erosion control; in their place, aspen trees grew. The forested habitat supports game species, such as white-tail deer, ruffed grouse, wild turkeys, black bear,

snowshoe hare, and gray squirrels. Furbearing species include bobcat, beaver, coyote, raccoon, red fox, mink, weasel, muskrat, otter, and fishers (Bad River Band, 2001).

Historically, the largest crop collected by the Tribe from the forests was maple syrup (Bad River Band, 2001). In addition, balsam boughs, cedar, black ash, and birch bark are also collected by Tribal members, and are culturally important.

Agricultural – Some lands on the Reservation are also used for farming. Farmed land is a relatively small proportion of overall land coverage, located mainly in upland areas.

Traditionally, farming took place at the confluence of the Bad and White Rivers, known as "Gete Gititaaning" an area rich in topsoil due to the flooding of the two Rivers, the people would plant in the spring and return in the fall to harvest (Bad River Band, 2006). However, in more recent times, these floodplains have not been farmed and the majority of the lands still used for agriculture are located in the southwest corner of the Reservation. According to the 2011 NLCD, about 1% of the Reservation is used for agriculture (MRLCC, 2011). Portions of the southwest section of the Reservation are owned by private, non-Tribal landowners that raise beef cattle, hay, and some crops.

3.5 Tribally Protected Species

As of 2015, the Tribe has a list of 46 species found on the Reservation that are designated as Tribally protected species. This encompasses all federal and state threatened or endangered species found on the Reservation, including several bird, insect, mammal, and plant species; one mussel; and one reptile. Appendix A provides a full list of the Tribally protected species and their federal and state status.

4. Climate Change Projections and Impacts

Climate change projections are made using large complex models, and these models have been used to make projections for the Lake Superior region and the Reservation. As discussed below, the potential physical and cultural impacts of climate change are profound.

4.1 Brief Overview of Climate Change and How Projections Are Made

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), it is now generally accepted in the scientific community that anthropogenic climate change is occurring, and is impacting global ecosystems. Scientists have documented changes to air and water temperatures. Changes in extreme precipitation events have also been detected. These changes have been linked to increased carbon dioxide and other greenhouse gases (GHGs) in the atmosphere. The GHGs trap infrared radiation emitted from the Earth's surface, which results in increased air

temperatures, which in turn affect many other environmental variables and processes, such as water temperature, atmospheric circulation, and precipitation patterns (IPCC, 2014).

In order to understand the possible effects of climate change in the years, decades, and centuries to come, scientists use the output of general circulation models (GCMs) to make climate change projections. GCMs are complex models that simulate atmosphere, ocean, and land processes. The GCMs simulate changes in climate under different scenarios of future GHG emissions. The scenarios represent plausible future states that may evolve from present conditions, given various driving forces, including world population growth, economic development, and other factors (IPCC, 2014). Table 1 presents the scenarios that are the basis for much of the climate change modeling that has been conducted for the Lake Superior region, including most of the research cited by Huff and Thomas (2014) in their "Lake Superior Climate Change Impacts and Adaptation" report. As an illustration of how quickly climate science is evolving, the IPCC has recently published "Representative Concentration Pathways," which are similar to the scenarios in Table 1, but encompass a broader spectrum of possible future pathways (IPCC, 2014), and are now being used in climate change modeling.

Table 1. Summary of IPCC emissions scenarios for GCMs

Scenario	Economic development	Global population	Technology changes	Theme
A1	Very rapid	Peaks around mid-21st century and declines thereafter	Rapid introduction of new and more efficient technologies A1B: balanced across all sources A1F1: fossil intensive A1T: non-fossil energy sources	Convergence among regions, increased cultural and social interactions (mid-level GHG emissions scenario)
A2	Regionally oriented	Continuously increasing	Slower and more fragmented than Scenarios A1, B1, and B2	Self-reliance and preservation of local identities (high GHG emissions scenario)
B1	Rapid change toward service and information economy	Same as Scenario A1	Introduction of clean and resource-efficient technologies	Global solutions to economic, social, and environmental sustainability (low GHG emissions scenario)
B2	Intermediate levels of economic development	Continuously increasing, but not as fast as Scenario A2	Less rapid and more diverse changes than Scenarios A1 and B1	Local solutions to economic, social, and environmental sustainability

Source: IPCC, 2000, 2007.

GCMs project changes in temperature and precipitation for a given geographical area, from which changes in related climate parameters (such as lake water temperature, ice cover, lake

water levels, etc.) can then be derived through further mathematical computations. GCMs have relatively low spatial resolution, with model grid cell widths of 400 to 125 km. Downscaling methods can be used to obtain projections on more regional and local scales, such as for the Lake Superior region, and in some cases, to even finer scales, such as the downscaling that has been conducted for the different Ceded Territories located in the Great Lakes region (described further below in Section 4.2).

4.2 Climate Change Projections for the Lake Superior Region and the Reservation

A number of climate change-related changes have already been observed in the Great Lakes region, including increases in annual temperatures, increases in summer extreme heat events, increases in the duration of the growing season, shifts in the timing and intensity of precipitation events, and decreases in the amount and duration of snow cover and lake ice formation (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011). In the Lake Superior region, a number of climate changes are projected to occur over the course of the 21st century. Key expected changes include (Huff and Thomas, 2014):

> *A new study on global lake warming rates conducted by NASA and the National Science Foundation focused on 235 lakes on six continents, over 25 years. Four of the five Great Lakes were included in the study, and Lake Superior was found to be one of the fastest-warming lakes on the planet (O'Reilly et al., 2015).*

- Increase in annual average air temperatures
- Small increase in annual average precipitation
- Change in seasonal precipitation patterns – less precipitation in summer and more precipitation in winter
- Change in precipitation type – more precipitation falling as rain and less as snow, but little or no change in the frequency of lake effect snow events
- Change in precipitation amounts – storm events with 2"+ of rain are projected to be more frequent
- Increase in annual average lake water temperatures
- Increase in the length of the summer temperature stratification season
- Reduction in the extent and duration of ice cover on Lake Superior
- Increase in wind speeds over Lake Superior
- Increase in the rate of evaporation from Lake Superior, which could lower water levels

> ***Lake Superior example of the inter-dependence of climate change projections***
>
> *A study by Austin and Coleman (2008) showed that Lake Superior summer water temperatures have increased by roughly 3.5℃ over the last century, influenced not only by air temperatures, but also ice cover. The observed Lake Superior warming was greater than the observed regional changes over the same time period, by roughly a factor of two, which the authors concluded was related to Lake Superior winter ice cover decreasing from 23% to 12% over the last century.*

- Increase in the length of the growing season.

Table 2 provides a summary of climate change projections for a variety of climate parameters (air temperature, precipitation, water temperature, etc.). Many of the projected changes summarized in Table 2 are inter-dependent, and can further influence other physical and biological processes. For example, air temperatures affect a variety of key processes in the Lake Superior region, including the length of the growing season, the extent of the frost-free season, freeze/thaw cycles of water and soil, lake surface temperatures, rates of chemical reactions, biological activity, and the prevalence of pests and diseases (IJC, 2003; Huff and Thomas, 2014).

Table 2. Projected climate changes by the turn of the century for the Lake Superior region, as reported by Huff and Thomas (2014)

Climate change driver (parameter)	Projected change
Air temperature	Increase in annual average air temperatures of 3°C to 4.5°C (5°F to 8°F)
Precipitation	Increase in overall annual precipitation (5–15%) Seasonal shifts, decrease in summer precipitation and increase in winter precipitation More winter precipitation as rain, less as snow Increased frequency and intensity of storms in the Great Lakes region, but little is known specifically about Lake Superior
Water temperature	Increase in annual average surface water temperatures of 5°C to 7°C (8°F to 12°F), though this is based on a few projections (there are only a small number GCM projects of water temperatures for Lake Superior)
Ice cover	Decrease in ice cover; by 2090, the average February ice cover is projected to be only 11% of the lake surface for the western Lake Superior basins Decrease in duration of ice cover, by one to two months
Wind speeds	If air temperature and lake water temperatures continue to increase as projected, wind speeds over the lake are likely to increase concomitantly, due to destabilization of the atmospheric surface layer above the lake
Lake water levels	Due to competing impacts from variations in evapotranspiration and precipitation, difficult to predict changes May decrease slightly, from 0.1 m to 0.2 m (0.3 ft to 0.7 ft) Periodic increases in lake water levels are also possible
Onset and duration of seasons	Spring and summer will begin earlier Length of the frost-free season will increase by 4 to 8 weeks Date of the last spring frost will come 15 to 35 days earlier; the date of the first autumn frost will be delayed by up to 35 days

More detailed climate change projections are available for the Reservation from an ongoing climate study by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) for the Ceded Territories in the Great Lakes region. As a part of this study, GLIFWC has shared downscaled climate projections for the Reservation area with the Tribe, which GLIFWC obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). This downscaling provides more site-

specific projected changes for climate parameters for the Reservation. Figure 4 shows projected average summer air temperature increases by the end of the century for the modeled geographical area encompassing the Reservation (based on IPCC Scenario A2). The figure shows that air temperatures in the Reservation are projected to increase from 5.5°F to 6.8°F, according to the modeled scenario, which represents a future scenario with high GHG emissions (continuously increasing population and slower and more fragmented technology changes).

Table 3 provides end-of-century temperature and precipitation projections for the Reservation, across seasons, extracted from the downscaled modeling results provided by GLIFWC. The results project that temperatures will increase on the Reservation by 3.4°F to 5.5°F by the end of this century. Precipitation as rain in the winter is projected to increase by up to 1.3 inches on the Reservation, which is consistent with other climate change modeling that shows that precipitation as rain may increase in winter months. However, according to the downscaled modeling results, precipitation is also projected to increase in summer months by the same amount. This is contrary to most other research to date, which predicts decreased precipitation in summer months. These results in part serve to highlight some of the uncertainties in climate change modeling and projections (see Section 4.2.1 for more discussion of uncertainties).

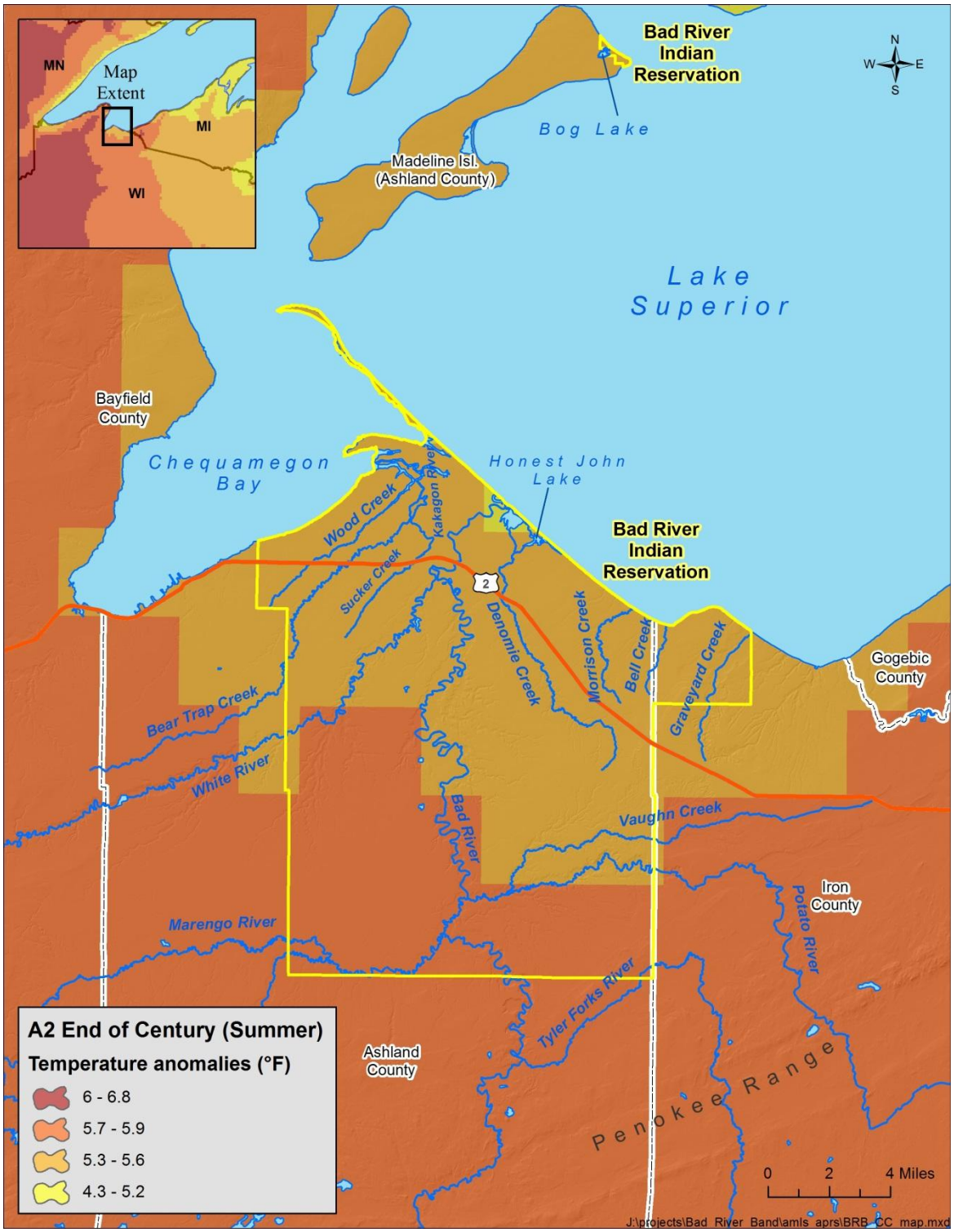


Figure 4. Projected average summer temperature changes for the end of the century (high GHG emissions, IPCC Scenario A2).

Table 3. Downscaled seasonal temperature and precipitation ranges for end-of-century projections on the Reservation, based on high GHG emissions (A2) and middle GHG emissions (A1B) scenarios. Data extracted from files received from GLIFWC.

	Temperature (°F)		Precipitation (inches)	
	Middle GHG emissions scenario (A1B)	High GHG emissions scenario (A2)	Middle GHG emissions scenario (A1B)	High GHG emissions scenario (A2)
Summer	3.1–3.4	5.2–5.7	0.9–1.1	1.1–1.3
Spring	2.7–3.1	4.2–4.7	1.4–1.6	1.0–1.1
Fall	3.5–3.7	5.1–5.4	0.6–0.7	0.9–1.1
Winter	4.1–4.4	5.8–6.2	0.7–0.7	1.2–1.3
Average temperature/total precipitation	3.4–3.6	5.1–5.5	3.7–4.0	4.3–4.7

4.2.1 Uncertainties and data gaps in climate change projections

There are a number of uncertainties and data gaps in the current state-of-the-science on climate change, and in the climate change projections that have been developed to date by climate scientists. For example, there is a relatively wide range in GCM projections that are used to anticipate changes in temperature and precipitation patterns, there is limited information on daily variations in temperature, and most of the information is on a seasonal scale.

In particular for the Lake Superior region, some of the uncertainties include implications of climate change on wind speeds. It is speculated that wind speeds could increase with increasing temperatures, but this has not been confirmed to date with modeling (see Table 2). A significant area of uncertainty for Lake Superior is in the projection of lake levels. There are currently conflicting data and uncertainty about how climate change will impact Lake Superior water levels. It is difficult to predict future changes in Lake Superior water levels due to competing impacts from variations in evapotranspiration and precipitation. The potential impacts of changes in ice cover and duration on wintertime evaporation from Lake Superior are also not definitively known.

Some GCM simulations suggest that Lake Superior water levels will decrease slightly, on the order of 0.10 m to 0.20 m (0.33 to 0.66 ft) by the end of the century. But others predict that periodic increases in lake water levels are also possible. The variation in results for different GCMs under different emissions scenarios suggests a high degree of uncertainty in possible future lake levels. A study (Lofgren et al., 2011) indicates that the magnitudes and possibly the sign of previous lake level projections based on hydrologic models are overestimated. Current research also suggests that the magnitude of any decreases in Lake Superior water levels will be less than for the other Great Lakes. The recent International Upper Great Lakes Study (IUGLS) Board report on Lake Superior Regulation (IUGLS, 2012) affirmed these conclusions and suggests that continued overall decreases in Lake Superior water levels are likely, although they will probably not be as large as previous studies have predicted, and periodic higher-than-average levels are possible.

These uncertainties, and sometimes conflicting results, make it challenging to plan and decide upon how to monitor for climate change. This is part of the reason why the Tribe is adopting a flexible approach to this Plan, allowing for future adjustments to be made to the Plan as needed.

4.3 Physical, Biological, Chemical, and Cultural Impacts of Climate Change on the Reservation

Because of the unique and inextricable relationships between Tribal members and their surrounding natural resources, the cultural fabric of the Tribe may be affected by climate change in profound and unique ways. Here we describe the impacts of climate change to natural resources found within the Reservation, including the cultural significance of these impacts to the Tribe. Climate change projections were described above in Section 4.2.

4.3.1 Physical, biological, and chemical impacts of climate change in the Lake Superior region

Changing lake levels may result in (WICCI, 2011; Huff and Thomas, 2014):

- The progression of coastal wetlands toward terrestrial ecosystems, with an associated loss of breeding and nursery areas for fish and wildlife, an inability of fish to reach spawning areas, a physical loss of habitat and food for migratory birds, a decline in aquatic wildlife populations, and potential loss of wild rice beds.
- Accelerated spread of non-endemic plants, such as purple loosestrife, narrow leaf cattail, and common reed (*Phragmites*), combined with warmer water temperatures.
- Dominance of native species that are better adapted to climate change, but are possibly less valued by the Tribe (e.g., other native vegetation may outcompete wild rice).
- Accelerated erosion of shoreline beaches (combined with higher winds), which may result in a loss of the endangered piping plover nesting habitat, as well as habitats for a number of other shorebirds.

Increased water temperatures may result in (WICCI, 2011; Huff and Thomas, 2014):

- A decrease in the abundance of coldwater and coolwater fish (e.g., brook trout, lake sturgeon, walleye), an increase in warmwater fish (e.g., common carp, bass), and a decrease in the threatened wood turtle's habitat (a coldwater species).
- An acceleration in the spread of warmwater, non-endemic species, such as carp, sea lamprey, zebra mussels, and quagga mussels.
- Adverse effects on the lifecycle of zooplankton – small organisms that are the base of the food chain for many predatory fish – and cascading adverse effects on fish populations.

- Changes in the coldwater stratification of Lake Superior.
- Increased frequency and extent of algal blooms, which could degrade water quality.
- Changes to the fish community composition, primarily increases in species diversity, in cold and coolwater systems.
- Changes to the timing of fish spawning seasons and reproductive success of some fish species. Timing changes could affect productivity if the available food supplies (zooplankton and benthos) for fry do not match the timing of need for fish.
- Increased habitat suitability for invasive species such as Asian carps (black, silver, and bighead).

More precipitation and greater intensity storms may result in (WICCI, 2011; Huff and Thomas, 2014):

- Increased runoff, flooding, and greater erosion rates.
- Adverse impacts to water quality, including increased turbidity and nutrient levels, which may in turn adversely affect vegetation, fish, wildlife, and human health.

Higher air temperature and changes in precipitation patterns may cause (WICCI, 2011; Huff and Thomas, 2014):

- A northward shift in forest habitat. Current forest species are expected to experience increased mortality, with tree species eventually being replaced by species from forests farther south (e.g., pine, spruce, maple, and birch species to be replaced with oak and hickory trees).
- An exacerbation of current stresses on trees, including drought, wild fires, and non-endemic pests (e.g., gypsy moth, tent caterpillar, emerald ash borer, spruce budworm).
- Declines in populations of small and medium sized northern mammal species (e.g., woodland deer mice, southern red-backed voles, woodland jumping mice, northern flying squirrels, least chipmunks, American Marten) and foraging animals (e.g., moose). Moose once did exist on the Reservation, and are important to the Tribe. They are still listed as a protected species, but are no longer resident species on the Reservation.
- A decline in suitable habitat for many bird species, including some warbler species and ruffed grouse, although habitat changes may benefit several year-round resident bird species (e.g., chickadees, woodpeckers, northern cardinals) and allow southern bird species to move into the Lake Superior region.
- Increase in mammalian pests and diseases. For instance winter tick, chronic wasting disease, etc.

4.3.2 Cultural impacts of climate change

The potential cultural impacts of these climate change projections are numerous, and include potential impacts to the Tribe's ability to successfully harvest wild rice, fish, collect maple syrup and gather balsam boughs, and other activities, such as harvest plants for medicinal and other uses.

Wild rice – As noted above, wild rice is of central cultural importance to the Tribe, and wild rice is vulnerable to the impacts of climate change. Wild rice is a shallow-water plant, generally growing well in water depths of 6 to 36 inches, with optimal depths of 13–45 inches observed in the Kakagon Sloughs (Fannucchi et al., 1986; Meeker, 1993). Rivers, estuaries, and lakes with inlets and outlets that allow for gentle flow, are ideal areas for growth. Wild rice needs both low and high water level years in order to out-compete other species. While some annual water fluctuation is good for wild rice, extreme water levels (both extreme highs and extreme lows) may have adverse impacts. This was the case in 2007, for example, when low Lake Superior water levels turned the beds into mudflats, and resulted in closure of the harvest in the Kakagon/Bad River Sloughs as Tribal members could not access the rice to harvest. Wind patterns, which have been increasing over Lake Superior over the past few decades (Desai et al., 2010), are also a key factor in the success of wild rice. This species is wind-pollinated, requiring mild summer winds. Long summer calms, or winds that are too strong, can interfere with pollination (Fannucchi et al., 1986).

Increased precipitation intensity can also adversely affect wild rice due to factors such as rapid changes in water levels over short time periods, or due to increased pollutant loading (e.g., phosphorus, sediments). Heavy precipitation can cause abrupt changes in water levels that can uproot the plants. Natural wild rice is particularly susceptible to uprooting, especially during its floating-leaf stage, which occurs in early summer. At this stage, any rapid increase in water levels can cause damage to natural stands (Ustipak, 1983; Fannucchi et al., 1986; MDNR, 2008). Moyle (1944) observed that wild rice was more successful when water level fluctuations throughout the growing season were less than 6 inches. In 2012, heavy precipitation that occurred toward the end of June resulted in rapid increases in water levels and uprooting of wild rice plants still in their floating-leaf stage. This large storm event contributed to the closure of the harvest in the Sloughs in 2012. Other factors that likely contributed to this closure include, but are not limited to, the unusually warmer water temperatures documented in the spring and early summer of that year (which may have affected rice germination) and the duration of lower water levels that occurred in the region in multiple consecutive years. These factors could have been associated with natural fluctuations and/or with climate change.

The accelerated spread of invasive species and disease (such as brown spot disease) due to increased temperatures and changes in precipitation can also have adverse impacts on wild rice. Carp is an invasive fish species with an increasing habitat range as water temperatures increase across the Great Lakes. This invasive species can disturb wild rice through its feeding habits. Carp feed on invertebrates, seeds, and young plant shoots, which results in them not only impacting the wild rice by eating the young shoots and seeds, but by dislodging the wild rice plants by their feeding actions (Johnson and Havranek, 2010). The feeding also suspends fine particles into the water column, and wild rice plants are unable to grow in this increased turbidity

(Johnson and Havranek, 2010). Invasive plant species that are better suited to changing climate conditions can directly out-compete wild rice for habitat and/or indirectly alter wetland habitats where wild rice grows; species that can cause these alterations include *Phragmites*, Eurasian water milfoil, invasive cattails, and purple loosestrife. For example, hybrid cattails compete directly with wild rice for shallow water habitat, aggressively forming thick mats of roots that can float as water levels fluctuate (Pillsbury and Bergey, 2000; MDNR, 2008, Meeker and Harris, 2009).

After completing several vegetation surveys over a period of 15 years, Dr. James Meeker was able to conclude that hybrid cattail is steadily increasing in the Kakagon/Bad River Sloughs system, an effect of which is thought to be the transition of wetland habitat types (Meeker and Johnson, 2013).

Wild rice may be vulnerable to temperature warming in the winter months, when it requires cold temperatures for dormancy. Studies have shown that the rate of seed germination is influenced by the length of dormancy in winter months. Seeds that lie dormant for longer in the winter have greater germination rates over a range of temperatures, than seeds that experience a shorter dormancy period (Atkins et al., 1987). Seed germination requires a dormancy period of three to four months of cold, nearly freezing water. Seeds are also unlikely to survive prolonged dry conditions (MDNR, 2008).

Fish – As noted above, fishery resources of the Reservation are some of the most highly valued resources to Tribal members for cultural, social, subsistence, and recreational purposes. Fishing is the most highly regarded recreational activity among Tribal members. Climate change may have adverse effects on fish populations on the Reservation, in particular, warming water temperatures. Warming water temperatures may cause shifts in species present in the Reservation's waters, in particular, a loss of coldwater (e.g., trout) and coolwater (e.g., walleye) species, and an increase in warmwater (e.g., carp and bass) species.

Brook trout. Source: WICCI, 2009.

As a part of the State of Wisconsin's development of climate change adaptation strategies (WICCI, 2011), the Coldwater Fish and Fisheries Working Group used watershed-scale models to predict the changes in fish habitat and distributions of fish under different climate scenarios. Scientists modeled the response of 50 species of stream fish, including the three coldwater species present in the state (brook trout, brown trout, and mottled sculpin), to three different climate change scenarios. In the worst-case of the three scenarios, the study predicted that 23 species (including all 3 coldwater species, all 16 coolwater species, and 4 warmwater species) will decline over the next century. In the worst-case scenario, a 7.2°F increase in water temperature (corresponding with a 9°F increase in air temperature) by mid-century resulted in a 72% loss of habitat for the coolwater northern pike species, a 88% loss of brown trout habitat, and a complete loss of brook trout habitat. Brook trout are very sensitive to changes in water temperature, and can survive only if temperatures remain below a certain threshold. Even in the best-case scenario, with an increase in air temperatures of 1.8°F and water of 1.4°F, 44% of brook trout

habitat will be lost. The study also predicted that the habitats of many warmwater species, including catfish, smallmouth bass, largemouth bass, and black crappie will increase (WICCI, 2011).

Trees – Tree species such as maples, black ash, birch, cedar, and balsams are culturally important to the Tribe. Maple trees are important for maple syrup production, and balsams for bough collection. The Tribe harvests cedar to make ricing sticks. Rising temperatures, shifting precipitation patterns, and extreme events, such as droughts, high winds, and flooding, will have direct and indirect effects on trees and forested ecosystems. Many of the native tree and plant species that are found on the Reservation and in Northern Wisconsin in general, are at the southern edge of their distribution range. If temperatures continue to rise, tree species currently growing in this northern part of the state – such as black spruce, balsam fir, and paper birch – may shift northward out of the state (WICCI, 2011; USDA, 2014). Some native tree species will benefit from warmer weather; for example, hardwoods – such as hickory, black oak and black walnut – might expand their range as temperatures rise (WICCI, 2011). Invasive tree species may also be well-adapted to grow in warmer temperatures and may colonize areas disturbed by tree mortality, floods, or droughts (WICCI, 2011; USDA, 2014).

USDA (2014) conducted a forest ecosystem vulnerability assessment for northern Wisconsin and western upper Michigan. Their assessment showed that for many boreal forest species, including balsam fir, suitable habitat and total biomass is expected to decline over the next century. USDA (2014) reports that the impacts of climate change to sugar maples are somewhat less clear, with some model results projecting decreased suitable habitat, and others not much change, and little change in biomass. However, these models do not explicitly take into account confounding factors, such as climate-associated spread of invasive species. In the case of sugar maples, the spread of exotic earthworms due to climate change may result in additional negative impacts. These earthworms reduce forest litter, alter nutrient and water cycling, alter soil conditions, can facilitate exotic plant species establishment, decrease regeneration suitability, and increase drought susceptibility for sugar maples. By reducing the duff layer, earthworms also degrade important habitat that is used by ground-nesting birds, small mammals, amphibians, reptiles, insects, spiders, and plants (USDA, 2014).

These are just but a few highlighted examples of the impacts of climate change on Tribal resources; there are additional impacts, such as to plants Tribal members gather for medicinal purposes, and to wildlife that Tribal members hunt.

4.3.3 Other environmental stressors

It is important to note that not all adverse effects observed in the environment are due to climate change, and the Tribe has taken this into consideration in developing this Plan.

Examples of other stressors include:

- Impacts of anthropogenic land use (e.g., timber harvesting, land development, farming)
- Contaminant releases

- Changes in water use/groundwater withdrawal for community or industrial purposes.

Alleviating environmental stressors that are not related to climate change can enhance ecosystem resilience and can be an adaptation strategy. The Tribe, through its Natural Resources Department, should continue implementing numerous projects focused on alleviating environmental stressors and expand, as appropriate. Examples of current efforts include invasive species management, the septic repair and replacement project, and implementing the IRMP and non-point source management plan.

5. Approach to Developing the Climate Change Monitoring Plan

The Tribe developed this Plan and prioritized resources to be monitored in a consensus-based approach, with input from an expert working group who provided guidance on the process.

> ***Prioritizing which resources to monitor for climate change impacts***
>
> *All natural resources on the Reservation are important to the Tribe. However, because financial resources are finite, the Tribe needed to prioritize the resources to be monitored for climate change impacts. The Tribe prioritized resources for monitoring using a consensus-based approach informed by the best available science and expert knowledge; relied on judgment of the Tribe's resource managers; and considered input from an expert working group.*

5.1 Convening an Expert Working Group

The Tribe convened an expert working group to provide guidance and input on the development of this Plan. The working group consisted of Tribal members and elders with intimate knowledge of the Tribe's natural resources, the uses and cultural importance of the resources, and local resource managers primarily from nongovernmental organizations (NGOs) and federal and Tribal government agencies with expertise on climate change impacts and adaptation (Table 4). The Tribe held a kick-off meeting in November 2014; resource managers from the BRNRD presented an overview of natural resources on the Reservation to the expert working group and described existing monitoring programs and data for these resources. The group discussed some of the challenges involved with monitoring for climate change impacts and how to decide which resources should be included for monitoring in the Plan. A key recommendation of the expert working group was to focus monitoring on those resources that are of greatest importance to the Tribe.

Following the recommendations of the expert working group, the Tribe developed a preliminary list of monitoring objectives that they believed might be important to track resource concerns; these objectives were based on (1) the importance of the resource to the Tribe (ecologically and culturally), and (2) their likelihood of being impacted by climate change. For each resource concern and corresponding monitoring objective(s), the Tribe identified anticipated climate change impacts, information on current monitoring, proposed monitoring parameters for climate change impacts, and potential resource management decisions (e.g., adaptation strategies) that the Tribe could implement to address the impacts.

Table 4. Expert working group members

Name	Agency	Expertise or title
Aurora Conley	Bad River Tribal Member	Tribal member
Katherine Baerg	Bad River Tribal Member	Tribal member
James Mayotte	Bad River Tribal Member	Tribal member
Joe Rose Sr.	Bad River Tribal Member	Tribal Elder
Henry Quinlan	USFWS	Fisheries
Peggy Burkman	Apostle Island National Lakeshore NPS	Wildlife and GIS
Peter David	GLIFWC	Wildlife and wild rice
Matt Dallman	The Nature Conservancy	Director of Conservation
Esteban Chiriboga	GLIFWC	Environmental issues, GIS, and modeling
Stephen Handler	U.S. Forest Service	Climate Change Specialist
Eric Oliphant	Bureau of Indian Affairs	Forestry
Mark Fedora	U.S. Forest Service	Hydrologist
Peter Jackson	EPA	Water Quality
Cathy Techtmann	University of Wisconsin Extension	Environmental Outreach Specialist/ meeting moderator
Kim Stone	GLIFWC	Climate change

GIS: geographic information system.
GLIFWC: Great Lakes Indian Fish and Wildlife Commission.
NPS: National Park Service.
USFWS: U.S. Fish and Wildlife Service.

5.2 Prioritizing Resources for Climate Change Monitoring

The working group held a second meeting in November 2015 to review and prioritize monitoring with the expert working group. The working group ranked the monitoring objectives corresponding to resource concerns based on priority and the cost of the identified monitoring parameters. Ranking was accomplished on a consensus-basis, through group discussion, drawing upon the Tribe's in-house knowledge and expertise, as well as with input from other members of the expert working group with expertise on climate change effects and environmental monitoring. The Tribe then decided to take an ecosystem-based approach to monitoring, and thereby grouped resource concerns into the habitat types found on the Reservation (see text box).

The Tribe took an ecosystem-based approach to climate monitoring and organized the monitoring priorities by habitat types found on the Reservation:

- *Coastal aquatic habitats*
  - *Coastal wetlands/estuaries*
  - *Beaches*
- *Inland aquatic habitats*
  - *Rivers/creeks*
  - *Wetlands/lakes/ponds*
- *Upland habitats*
  - *Forested land*
  - *Agricultural land*

The outcome of this exercise is summarized in Appendix B. The appendix describes the resource concerns upon which monitoring objectives were based, monitoring parameters, associated management decisions (and potential adaptation approaches), relevant ecosystem habitats, and individual prioritizations (low, medium, or high), with explanations for the ranking. Monitoring objectives with medium to high prioritization and medium to high cost-effectiveness are currently the priorities for monitoring under this Plan. Monitoring objectives with high prioritization but low cost-effectiveness will also be considered over parameters with low prioritization and low cost-effectiveness, but after those ranked high/medium in either category. Tables 5 and 6 below summarize monitoring objectives that the Tribe is currently focusing on. It is important to note that all of the resource concerns and corresponding monitoring objectives listed in Appendix B are important to the Tribe. The ranking in Appendix B is based on the currently identified monitoring parameters, and these may change over time as parameters are refined and/or new parameters are identified. Any such changes would be reflected in future iterations of the Plan.

5.2.1 Interweaving cultural practices into monitoring priorities

As a part of implementing this adaptive, living Plan, the Tribe may also further prioritize monitoring objectives, and refine monitoring designs (e.g., sites, parameters, frequency of monitoring) to ensure it adequately addresses culturally important resources. For example, the Tribe will adapt the Plan as needed to ensure that monitoring priorities are aligned with cultural practices and uses of natural resources, such as the Tribes' four sacred foods.

Table 5. Coastal habitats monitoring objectives, and monitoring parameters

Resource	Monitoring objectives	Parameters to be monitored to meet objectives
Coastal wetlands/estuaries (and inland aquatic habitats)		
Wild rice	Monitor for decreased wild rice viability due to changes in hydrology (flow and water levels of major tributaries to wild rice areas)	▸ Flow rates and water levels of major tributaries to and within wild rice areas ▸ Presence/absence and density of wild rice
	Monitor for decreased wild rice viability due to increased precipitation (frequency and intensity), increased air and water temperatures	▸ Precipitation data (frequency of events and amount of rain per event) ▸ Air and water temperature ▸ Presence/absence of wild rice ▸ Increased incidence of brown spot disease (this fungal disease is associated with warmer air temperatures and increased precipitation)
	Monitor for decreased wild rice viability due to increased wind speeds, which drive seiches and associated changes in water levels (seiche-driven water level changes)	▸ Wind speed ▸ Presence/absence of wild rice

Table 5. Coastal habitats monitoring objectives, and monitoring parameters

Resource	Monitoring objectives	Parameters to be monitored to meet objectives
	Monitor for decreased wild rice viability (physical destruction of rice stands) due to increased carp populations associated with warmer water temperatures	▸ Carp population ▸ Water temperatures ▸ Presence/absence of wild rice
Species Diversity (Invasive species)	Monitor for the accelerated spread of non-native species, such as purple loosestrife, narrow leaf/hybridized cattail, Eurasian water milfoil, *Phragmites*, and other species, as a result of increased temperature and changes in precipitation patterns, and corresponding pollutant loadings	▸ Density and/or presence/absence of invasive species
Benthic invertebrates	Monitor for changes in aquatic life (benthic invertebrate) community composition due to increased water temperatures, and changes in precipitation patterns and corresponding pollutant loadings	▸ Benthic invertebrate abundance and diversity ▸ Habitat parameters (e.g., substrate type)
Fish	Monitor for changes in fish populations, including decreased coldwater fish (e.g., brook trout and salmon), and increased warmwater fish (bass and common carp, as well as sea lamprey), due to water temperature increases, decreased ice cover, and changes in lake stratification	▸ Fish population abundance and diversity ▸ Sea lamprey population levels (which are monitored in open lakes and streams) ▸ Water temperature
Fish (sea lamprey)	Monitor for increased wounding rates on native fish, due to warmer water temperatures	▸ Native fish wounding rates
Water quality	Monitor pollutant (e.g., sediments, nutrients, mercury) concentrations and loadings in surface waters	▸ Pollutant concentrations ▸ Flow rates and water levels
Wetland birds and amphibians	Monitor for loss of avian and amphibian wetland habitat due to lowering lake water levels, warmer temperatures	▸ Water levels ▸ Population levels (through acoustic monitoring of birds and amphibians in wetland locations) ▸ Plant community structure/species
Beaches		
Species diversity	Monitor for accelerated spread of invasive species, such as winged pigweed, as a result of increased temperature and changes in precipitation	▸ Density and/or presence/absence of invasive species ▸ Endangered piping plover and its habitat ▸ Eagle productivity surveys
Water quality	Monitor for increased fecal contamination due to warmer water temperatures and changes in precipitation patterns and corresponding pollutant loadings.	▸ Water quality parameters (e.g., E. coli, temperature) in recreational waters ▸ Harmful algal blooms

Table 5. Coastal habitats monitoring objectives, and monitoring parameters

Resource	Monitoring objectives	Parameters to be monitored to meet objectives
Loss of habitat	Monitor for increases in shoreline erosion and shoreline damage due to water level changes and wave action changes	Erosion/accretion measurements

5.2.2 Prioritized resource concerns and corresponding monitoring objectives in coastal aquatic habitats

Coastal aquatic habitats include coastal wetlands/estuaries and beaches. In coastal wetlands and estuaries, the resources prioritized by the Tribe for monitoring include wild rice beds, the spread of invasive species, benthic invertebrates, birds, amphibians, and fish. For beaches, the prioritizations for monitoring include species diversity, water quality, and habitat loss (accelerated erosion). Table 5 summarizes the Tribe's prioritized monitoring objectives (which were prioritized based on ranked monitoring parameters), and the identified parameters to monitor for each. Furthermore, the Tribe may want to monitor the effectiveness of selected adaptation projects that may be implemented in coastal aquatic habitats.

5.2.3 Prioritized resource concerns and corresponding monitoring objectives in inland aquatic habitats

Inland aquatic habits include rivers and streams, lakes, ponds, and wetlands that are not adjacent to the Lake Superior shoreline. The Tribe has prioritized monitoring objectives, based on ranked monitoring parameters within these habitats. In inland aquatic habitats, these include:

- ***Wild rice*** – decreased viability because of changes in hydrology and precipitation
- ***Wetland vegetation diversity*** (invasive species) – accelerated spread of invasive species because of warmer air temperature and changing precipitation patterns
- ***Benthic invertebrates*** – changes in population abundance and diversity because of water temperature increases
- ***Wetland birds and amphibians*** – changes in population and diversity because of increased air temperature and decreased water levels
- ***Fish*** – changes in fish community and species composition because of water temperature changes, and the spread of sea lamprey.
- ***Water quality*** – changes in pollutant concentrations and loadings because of changes in precipitation patterns.

The monitoring parameters for these resources are the same as described above for coastal habitats (see Table 5). Furthermore, the Tribe may want to monitor the effectiveness of selected adaptation projects that may be implemented in inland aquatic habitats.

5.2.4 Prioritized resource concerns and corresponding monitoring objectives in upland habitats

Upland habitats include forested and agricultural lands. The resource concerns prioritized by the Tribe for climate monitoring (based on ranked monitoring parameters) include the loss of species diversity through the accelerated spread of non-endemic species, as well as concerns for specific tree species that are of cultural importance to the Tribe – maple syrup and balsam trees – and tree growth in general. Additional resource concerns the Tribe may consider including for monitoring in the future include impacts of climate change on the collection of black ash branches and bark from birch trees. For agricultural lands, the main concern is the potential accelerated spread of non-endemic or invasive species. Table 6 summarizes the Tribe's specific monitoring objectives that correspond to these resource concerns, and monitoring parameters for each concern. Furthermore, the Tribe may want to monitor the effectiveness of selected adaptation projects that may be implemented in upland habitats.

Table 6. Upland habitats monitoring objectives and monitoring parameters

Resource	Monitoring objectives	Parameters to meet monitoring objectives
Forested lands		
Species diversity	Monitor for the accelerated spread of non-native plant species (such as garlic mustard, honeysuckle, reed canary grass, etc.) and insects/pests (such as emerald ash borer, etc.) due to increased air temperature and changes in precipitation patterns	Density and/or incidence of invasive species Presence/abundance of tree seedling species (forest regeneration)
Trees	Monitor for shortening of the maple syrup season and shifts or losses of suitable habitat for maple syrup trees, due to warmer temperatures and shorter winter season	Duration of maple sap collection season
	Monitor for shortening of the balsam bough gathering season and shifts or losses of suitable habitat for balsam trees, due to increases in temperature	Balsam bough gathering season duration Timing of first frost/onset of cold weather; and timing of last frost in the spring
	Monitor for changes in native tree growth rates and shifts in habitat suitability due to temperature increases and precipitation changes	Tree age measurements (coring)
Agricultural lands		
Species diversity	Monitor for the accelerated spread of pests and other invasive species, as a result of increased temperature and changes in precipitation	Density and/or incidence of invasive species

6. Monitoring Approach – Detecting the Adverse Effects of Climate Change

The Tribe's approach to monitoring for any potential adverse effects of climate change is shown in Figure 5. After prioritizing resources and identifying monitoring parameters, the Tribe will establish baseline conditions for the prioritized resources. The Tribe will then monitor the resources, and the data will be compared to baseline conditions at established benchmark intervals. If a deviation from baseline is observed, the Tribe will evaluate the reason for the deviation, and the need to implement and/or modify adaptation measures. In addition, if during the course of regular monitoring, a sudden change (e.g., an invasive species outbreak), or a climate threshold is crossed (e.g., exceedance of threshold temperatures for coldwater fish in a river or creek), the Tribe will react appropriately at that time, possibly through fish trapping and relocation.

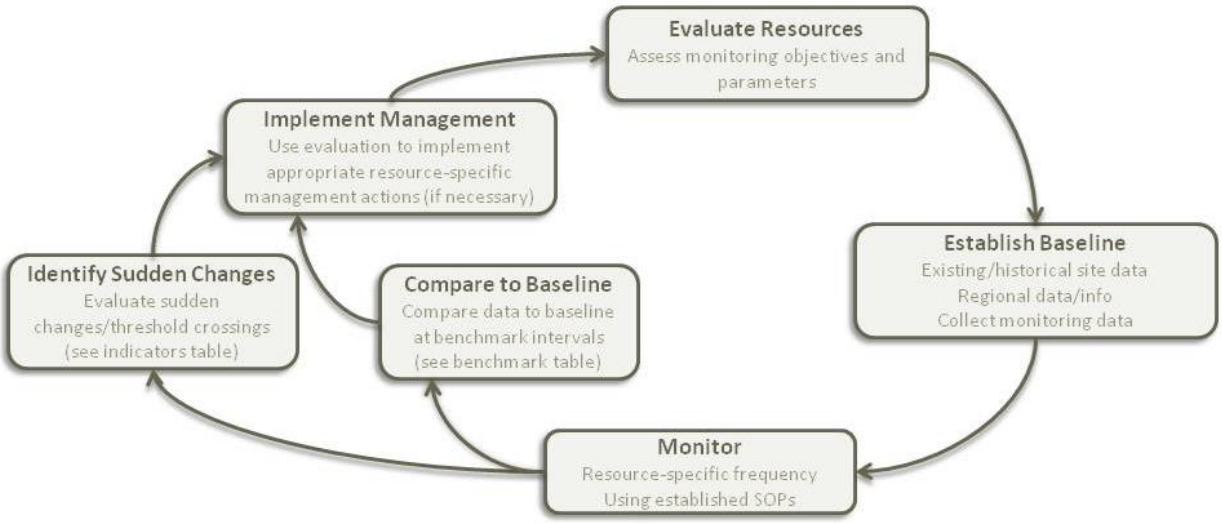


Figure 5. Climate change monitoring process.

As shown in Figure 5, this Plan also allows the Tribe the flexibility to initiate adaptation measures without delay, for resources that are known or suspected to be particularly vulnerable to the effects of climate change. The Tribe may choose to conduct formal vulnerability assessments to identify resources susceptible to climate change effects, or they may proceed based on their current knowledge. For example, the Tribe may proactively implement measures to forestall crossing of temperature thresholds in coldwater streams by implementing restoration to maintain colder temperatures that support the current fish populations, before critical temperature thresholds are crossed. These restoration measures could include deepening channels that have become shallow from excessive sediment load, or planting of overhanging vegetation to create shade and cooler temperatures along stream edges (Huff and Thomas, 2014).

Finally, Figure 5 emphasizes the living nature of this Plan. The process outlined in Figure 5 recognizes that this Plan will be in place for the next seven generations. During that time span,

conditions may change, unforeseen events may occur, and the state of the science on climate change may advance. As such, the Tribe may modify the Plan at any time to respond to changing conditions, and the Tribe will also undertake a re-evaluation of prioritized resources, monitoring approaches, and benchmark intervals approximately every 15–20 years.

6.1 Establishing Baseline

As a part of implementing this Plan, the Tribe intends to gather and compile existing data collected on the Reservation for the prioritized resources. The data will be organized into a format so that it can be used to compare to future monitoring data, for the purpose of detecting adverse, climate-induced changes. For example, the Tribe may generate data tables, graphical plots and maps showing past spatial and temporal trends for the prioritized parameters identified in this Plan.

Traditional ecological knowledge (TEK) may assist with developing an understanding of historical baseline conditions for prioritized resources. TEK may also be helpful in developing adaptation strategies – Tribal Elders may know of ways that the Tribe adapted to environmental changes in the past which could be applicable to conditions experience today and in the future.

The Tribe has already begun the process of compiling the existing data. For example, resource managers have begun to compile information on vegetation and other biological surveys that have been conducted on the Reservation to date – information such as the area surveyed, date of survey, and results (e.g., biological diversity and abundance values). The Tribe is also compiling information on aquatic sampling – locations, frequency of sampling, sampling dates, and the parameters that were monitored (temperature, flow rates, water quality, and biological parameters). Compiling baseline data is an important step in the process, and will require an extensive effort, as the Tribe has collected a large amount of environmental data over the past several decades.

Water level monitoring in the Kakagon River.
Source: BRNRD

Specific examples of environmental data that are available to establish baseline conditions include:

- Long-term flow rate data are available from a USGS station on the Bad River at Elm Hoist bridge that has operated on the Reservation since 1914. More recently, the Tribe established water flow and elevation monitoring locations at multiple stream sites across the Reservation, and the USGS installed a gage on Bear Trap Creek in 2007.

- Meteorological data are available from a meteorological station that has operated on the Reservation since 2003. The station collects temperature, humidity, corrected barometric pressure, solar radiation, wind direction, wind speed, and precipitation data. Collection of meteorological data will be important in monitoring long-term climate trends (30 + years) on the Reservation. In addition, there are nearby (off-Reservation) meteorological stations with longer-term data.

- Vegetation surveys, non-endemic (or invasive) species surveys, and biological surveys (e.g., benthic invertebrate surveys) have been conducted in the Sloughs, inland wetlands, rivers, and other locations across the Reservation.

- Songbird and amphibian acoustic monitoring is occurring in wetland habitats.

BRNRD Intern, Adam Oja, assisting with wood turtle monitoring on the Bad River. Source: BRNRD

- Sediment and soil cores have been collected in the Sloughs complex, and are being analyzed to provide information on historical wild rice locations and densities, in addition to other information.

- Tree species inventory data are available for the upland forests.

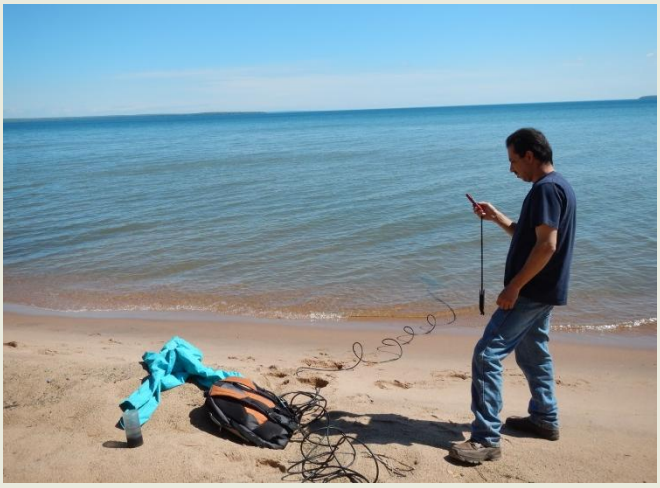
- Water quality data are collected at numerous sites across the Reservation, along rivers, streams, beaches, and in the sloughs. Parameters include dissolved oxygen, pH, specific conductance, dissolved organic carbon, turbidity, dissolved solids, phosphate, nitrate, chloride, E. coli, and fecal coliform.

- Fish and sea lamprey monitoring data have been collected over decades, by the Tribe, and in conjunction with the USFWS. For example, USFWS has collected sturgeon survey data for nearly two decades from the Bad and White Rivers; these data are shared with the Tribe. In addition, USFWS and BRNRD have more recently begun monitoring brook trout work in Graveyard Creek, where survey stations have been established, with standardized brook trout data collection.

- Historical aerial photographs could help to map the historical spatial extent of the Sloughs complex and wild rice beds over time. They may also help with assessing the rate of beach and stream erosion over time.

These existing datasets may also be supplemented with TEK, as appropriate, through discussions with elders and other Tribal members. In addition, the Tribe may further supplement the available baseline data with regional datasets collected by state and/or federal agencies and researchers, if appropriate. For example, the Tribe may incorporate historical climate data (precipitation and temperature) from the Midwestern Regional Climate Center (MRCC, 2016).

6.2 Monitoring Implementation through Existing Plans, Standard Operating Procedures, Quality Assurance Project Plans and Regional Monitoring Networks



Water quality sampling at a beach site on Madeline Island. Source: BRNRD

This Plan is programmatic in the sense that it sets forth the Tribe's long-term priorities for climate monitoring and establishes the resources and parameters that the Tribe intends to monitor over the next seven generations. The actual implementation of the monitoring will largely occur through the Tribe's existing environmental monitoring programs. The Tribe has established numerous monitoring protocols, Quality Assurance Project Plans (QAPPs), and Standard Operating Procedures (SOPs), and these will be the main guiding vehicles through which monitoring will occur. Additional QAPPs and SOPs may need to be developed, and/or existing protocols may need to be refined, to implement monitoring priorities identified in this Plan. Table 7 provides a summary of the Tribe's existing environmental monitoring documents. In addition, the Tribe may draw upon other plans and guides, as appropriate, such as the USGS's "*Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities*" (Rosen and St. Amand, 2015).

If a monitoring plan/protocol for a particular monitoring parameter does not currently exist, it may be developed as a part of enacting this Plan. This approach is cost-effective for the Tribe, as it draws upon existing protocols/SOPs/QAPPs as much as possible, rather than re-inventing them.

Networks - Climate change is complex, and monitoring at different scales (e.g., Reservation, regional, etc.) may be needed to better understand changes and impacts to the ecosystem. The Tribe is participating or planning to participate in multiple regional monitoring networks. For example, the Tribe is participating in a new regional monitoring network (RMN) for wadeable streams being coordinated through U.S. EPA Region 5. The RMN will enable tribes and states to collect biological, thermal, and hydrologic data from wadeable streams in a consistent manner. This information will be used to help track long-term, climate-related trends in water quality and quantity on a regional scale and will also enable the Tribe to benefit from a larger data collection effort in the region. The RMN will rely upon continuous data collection for water temperature and flow which will enhance the ability to determine impacts from climate change. RMN sampling will also include habitat and chemistry sampling; details on these elements are under development.

Table 7. Table of existing environmental monitoring plans, protocols, QAPPs, and SOPs that the Tribe will draw upon to implement climate monitoring. Note that the year listed is the year of the most recent document approval.

Document name	Year	Document type	Resource	Description
Bad River Reservation, Invasive Species Management Plan For Aquatic and Terrestrial Plants	2015	Resource Management Plan	Invasive species management	The BRNRD created this Plan to document and support the implementation of the management strategy used to address invasive species within the Reservation of the Bad River Bank of Lake Superior Tribe of Chippewa Indians. In this Plan, the Tribe proposes management goals, objectives, and actions for addressing invasive species and summarizes information on invasive species of concern within the Reservation, including previous control, monitoring efforts, known locations, treatment options, and identification information. This Plan seeks to use the best available science to maintain ecosystem integrity on the Reservation by protecting natural resources though invasive species management.
Bad River Band of the Lake Superior Tribe of Chippewa Indians: Water Quality Standards	2011	Resource Management Plan	Water quality standards	The Bad River Band promulgated water quality standards to protect the Tribe's political integrity, economic security, and health and welfare. These water quality standards apply to the surface waters located within the exterior boundaries of the Bad River Reservation and fulfill the minimum requirements of water quality standards described under the Clean Water Act (CWA).
Bad River Ambient Air Monitoring QAPP	2011	QAPP	Air quality and meteorological monitoring	The Band's ambient air monitoring site is part of the Wisconsin Primary Quality Assurance Organization (PQAO), a monitoring network of state and Tribal agencies. This QAPP covers the Band's ambient air quality and meteorological monitoring, how the Band's monitoring differs from the other PQAO agencies, how the Band's monitoring follows the Wisconsin network's Quality Management Plan (QMP), and all the relevant SOPs across the Wisconsin network to provide data that meet EPA and World Meteorological Organization (WMO) requirements.
Bad River Band of Lake Superior Chippewa Indians: Continuous Forest Inventory	2010	SOP	Field Manual for Continuous Forest Inventory (CFI) systems	This manual is a field guide for forest inventory crews to measure specific CFI systems in the Midwest Region. The purpose of a CFI system is to determine forest growth and yield capacity and to measure forest trend toward desired objectives; this information is essential in developing a Forest Management Plan. The procedures in this manual provide for the basic measurements needed to evaluate land productivity, determine timber volume, describe stand conditions, access trends and gauge forest growth. The procedures in this manual have been developed to assure uniformity among field crews in collecting data and define certain inventory terms for consistent understanding.

Table 7. Table of existing environmental monitoring plans, protocols, QAPPs, and SOPs that the Tribe will draw upon to implement climate monitoring. Note that the year listed is the year of the most recent document approval.

Document name	Year	Document type	Resource	Description
Surface Water Monitoring QAPP	2014	QAPP	Water quality monitoring at surface water sites	This QAPP covers the majority of the Tribe's water chemistry data collection, flow measurements, and operation of continuous sensors (Aquistar and Eurekas) at selected sites in coastal wetlands/estuaries and inland aquatic habitats.
Macroinvertebrate Sampling and Biomonitoring QAPP	2013	QAPP	Biological monitoring at surface water sites	This QAPP covers the Tribe's biological monitoring, such as macroinvertebrate sampling, wild rice density counts, and macrophyte surveys at selected sites in coastal wetlands/estuaries and inland aquatic habitats.
Background Inorganics Investigation QAPP	2015	QAPP	Water sampling at surface water sites	This QAPP covers the Tribe's stream bed sediment sampling, sulfate, and other sampling at selected sites, including wild rice waters. This QAPP also covers the trace metal water sampling conducted by USGS and Tribal staff. Sampling under this QAPP occurs at coastal wetlands/estuaries and inland aquatic sites.
Beach Monitoring and Assessment QAPP	2013	QAPP	Sanitary surveys at coastal beaches	This QAPP covers the Tribe's routine and annual sanitary surveys at Lake Superior beach sites (including E. coli water sampling). As part of the annual sanitary surveys, beach width and erosion/accretion measurements occur at the coastal beaches sites.
Bad River Reservation, Integrated Resources Management Plan	2001	Resource Management Plan	IRMP	The federal government requires tribes with forested reservation land to develop a Forest Management Plan or a more extensive IRMP. The Tribe adopted a Tribal resolution to develop an IRMP in 1990. The goal of the IRMP is to maintain and improve the health of ecosystems within the Bad River Reservation for at least the next seven generations, while providing resources at a sustainable level of harvest. The IRMP is focused on the following resources: soils, minerals, water, air, transportation, recreation, cultural, wetlands, timber, fish, wildlife, and threatened and endangered species. This document describes the current condition of each of these resources, lists a set of known issues or problems relating to each resource, and outlines a series of goals and objectives designed to address these issues. By examining resources use in an integrated manner, the Tribe has attempted to ensure that the sustainable use of any one resource does not negatively affect any other resource.

Table 7. Table of existing environmental monitoring plans, protocols, QAPPs, and SOPs that the Tribe will draw upon to implement climate monitoring. Note that the year listed is the year of the most recent document approval.

Document name	Year	Document type	Resource	Description
Sampling and Reporting Protocols for the Juvenile Lake Sturgeon Index Survey for Lake Superior, Draft	2011	SOP	Sampling protocol for juvenile Lake Sturgeon	The Juvenile Lake Sturgeon Index Survey for Lake Superior aims to (1) describe the current lake-wide status of juvenile lake sturgeon in Lake Superior (ages ~ 4–15), (2) establish an index of relative abundance for juveniles to monitor recruitment, year class strength, and population trends over time, and (3) describe and compare the biological characteristics of juveniles within and among locations throughout Lake Superior and over time.
Bad (and White River) River Lake Sturgeon Spawning Run Assessment	No date	SOP	Sampling protocol for Lake Sturgeon at spawning grounds	This document describes the protocol to capture, tag, and release Lake Sturgeon from spawning grounds of the Bad and White Rivers.

6.3 Evaluating Monitoring Data to Detect Climate Change Impacts

Sampling in the Kakagon/Bad River Sloughs. Source: BRNRD

As a part of implementing this Plan, the Tribe will analyze the collected monitoring data, with the objective of identifying trends that signal climate change impacts. This will involve comparing the collected monitoring data to the baseline data that the Tribe has compiled, looking for any deviations that are beyond the normal variability in the measured parameters, and evaluating whether any such detected changes also correlate with changes in climate change drivers (such as temperature, precipitation changes, etc.). As a part of this effort, the Tribe may analyze spatial and temporal trends in the data (e.g., generating graphs of water temperature in the Bad River over time, across the Reservation from upstream to downstream; creating time-series maps showing changing distributions of plant communities over time), to compare collected data to baseline.

There are several challenges in interpreting environmental data for climate change impacts. For example:

- It may be difficult to distinguish climate change impacts from natural fluctuations in the data (e.g., natural seasonal and inter-annual variations in water temperatures).
- Other environmental stressors can complicate and confound the interpretation of the data (e.g., a decrease in water quality may be associated with an increase or change in farming practices, as opposed to an impact of climate change).
- The record length and quality of historical data (e.g., detection limits, reliability of older measurements, changing sampling locations/techniques over time) can make it difficult to establish a robust baseline from which to compare present and future data.
- “Bright line” thresholds/indicators may not exist for all resources and all types of impacts. Consequently, associating climate change impacts with particular resources can be challenging, requiring careful review of multiple sources of data, and use of best professional judgment.
- The time and resources required to analyze the data can be significant.

In light of these challenges, the Tribe intends to employ multiple strategies in interpreting monitoring data for indications of climate change. To the extent possible and feasible, the Tribe intends to analyze more than one data type for prioritized resources, as multiple parameters all trending in the same direction can provide a greater weight of evidence that climate change impacts are occurring. The Tribe also intends to carefully monitor for those climate change

thresholds that do exist, and to react quickly if sudden changes and/or thresholds are crossed (such as water temperature transitions for coldwater and warmwater fish, and invasive species outbreaks).

As reflected in Figure 5, and noted above, The Tribe may also choose to act sooner rather than later in implementing adaptation measures, particularly for those resources that have a high likelihood of being adversely affected by climate change and that are of importance to the Tribe. Many adaptation measures need time to take effect (e.g., restoration of riparian buffer zones and implementing best management practices to minimize runoff may take time to result in measurable improvements in water quality), and thus the Tribe may choose to proactively implement these measures in anticipation of offsetting adverse effects in the years to come.

6.3.1 Benchmark dates for evaluation of prioritized resources

Detecting signs of climate change impacts for a given resource requires establishing that a detected change is greater than natural fluctuations expected for that resource (baseline conditions), and then correlating the change to observed trends in climate driver(s), such as temperature, precipitation, or water level changes, etc.

Therefore, when setting benchmark dates (time intervals) for the evaluation of prioritized resources, the Tribe took into consideration:

- The magnitude and duration of natural variability in resource populations (species life histories, population dynamics)
- The frequency that monitoring data are collected.

All of the prioritized resources – wild rice viability; biological diversity in wetlands, beaches, and upland forests; population health (benthic invertebrates, fish, birds, amphibians); beach water quality and erosion – exhibit natural variability over time. These changes occur in response to normal ecological processes (e.g., predator/prey relationships, variation in plant communities due to changes in herbivore populations). For example, there is natural variability in the size of wild rice beds in the Sloughs that has historically occurred within roughly a 7–8 year cycle (Bad River Band, 2001), and in other wild rice regions, is reported to be 4–5 years (MDNR, 2008). The Tribe set the benchmark interval for evaluation of wild rice beds taking this variability into account. The Tribe also took into consideration that in general, population changes in shorter-lived species may be detectable over shorter timeframes, and thus may warrant shorter benchmark intervals than those needed for longer-lived species.

The frequency of sample collections will also determine the shortest time interval between benchmarks. Evaluating trends in the data can only occur at timescales that are the same as, or longer than the minimum sampling frequency.

Given these considerations, the working group developed suggested benchmark intervals for the different prioritized resources. These are summarized in Table 8. The timeframes are

"suggested" because, as noted above, this Plan is a living document, and there may be a need to adjust benchmark dates in the future. In addition to adjusting to future changes in environmental conditions, and advances in the state of climate change science, the Tribe may also refine benchmark dates based on further analysis of available baseline data. Further, the amount of time and effort the Tribe can invest in evaluating monitoring data may need to be adjusted from time to time, depending upon practical constraints, such as the available financial resources.

Table 8. Benchmark intervals (timeframes) for evaluation of monitoring data to assess deviations from baseline

Resource concern	Benchmark intervals for evaluation of monitoring data	Notes/assumptions
Coastal wetland/estuaries and inland aquatic habitat		
Wild rice	6 years	▸ The midpoint in reported natural variability in wild rice beds.
Wetland and estuary vegetation diversity	6 years	▸ This timeframe is tied to the wild rice assessment (combine vegetation diversity assessment with wild rice assessment). ▸ The Tribe will also monitor for invasive species outbreaks, and will take action without delay to control outbreaks (see Table 9).
Benthic invertebrate aquatic communities	3–5 years	▸ Monitor invertebrates for community composition shifts that are associated with temperature/flow-changes. ▸ Given the short lifespan of most benthic invertebrates, deviations from baseline should be detectable within three to five years, assuming annual sampling.
Wetland birds and amphibians	3–5 years	▸ Average lifespan of most wetland song birds and amphibians is less than five years. ▸ This timeframe assumes continuous seasonal acoustic sampling, and annual water level sampling.
Fish Sea lamprey	Life history-dependent (e.g., 4–5 years for trout species)	▸ The Tribe will monitor fish species age class distribution to evaluate population age trends. ▸ The Tribe will also monitor temperature and coldwater fish (trout) in coldwater streams for any sudden temperature increases and population declines, and will take action without delay if adverse effects are observed (see Table 9). ▸ The Tribe will also monitor for invasive species outbreaks, and will take action without delay to control outbreaks.
Beach habitat		
Beach species diversity	5 years	▸ It is assumed this should be a sufficient interval to detect deviations from baseline, if sampling occurs annually, but the Tribe may refine this interval once baseline data have been compiled and analyzed. ▸ The Tribe will monitor for invasive species outbreaks, and will take action without delay to control outbreaks (see Table 9).
Water quality (fecal contamination)	5 years	▸ It is assumed this should be a sufficient interval to detect deviations from baseline, if sampling occurs annually, but the Tribe may refine this interval once baseline data have

Table 8. Benchmark intervals (timeframes) for evaluation of monitoring data to assess deviations from baseline

Resource concern	Benchmark intervals for evaluation of monitoring data	Notes/assumptions
		been compiled and analyzed. ▸ In addition, if water quality standards exceed safe levels for humans, the Tribe will act immediately (see Table 9).
Loss of habitat (erosion)	5 years	▸ It is assumed this should be a sufficient interval to detect deviations from baseline, if sampling occurs annually, but the Tribe may refine this interval once baseline data have been compiled and analyzed. ▸ In addition, the Tribe may monitor for high energy events (e.g., storms, big waves or winds) that result in a sudden land loss, and may respond quickly (see Table 9).
Water quality (pollutant loading)	Pollutant dependent	▸ Intervals for evaluation will be established based on pollutant type and site specific considerations. ▸ In addition, if water quality standards are exceeded, the Tribe will act immediately.
Upland habitat		
Forest species diversity	Overstory/understory-dependent	▸ The Tribe will evaluate trends in overstory (tree) composition every 10 years, based on forest regeneration. ▸ The diversity of the understory plant community will be evaluated every five years, assuming data are collected annually. ▸ The Tribe will monitor for invasive species outbreaks, and will take action without delay to control outbreaks (see Table 9).
Maple trees – syrup season	5–10 years	▸ It is assumed this should be a sufficient time interval establish a baseline and to detect any decline in the amount of syrup harvested.
Balsam trees – bough collection	5–10 years	▸ It is assumed this should be a sufficient time interval establish a baseline and to detect any decline in the number of balsam trees, and/or the shortening of bough collection season.
Tree growth	Species-dependent	▸ Coring will provide long term information on growth rates, and thus does not need to occur frequently. The intervals between coring events will be set based on species lifespans.

6.3.2 Identifying sudden events and threshold crossings attributable to climate change

While many climate change impacts may only be detected by gathering data over a sufficient timeframe to detect subtle changes from baseline conditions, other impacts may be sudden and

large. Therefore, in addition to monitoring trends over time for deviations in monitoring data from baseline, the Tribe will also monitor for sudden changes and/or climate change-related threshold crossings, as noted in Table 8. In the event that such sudden changes/threshold-crossings are observed, the Tribe will respond quickly, by implementing adaptation measures, as appropriate. Table 9 provides a summary of potential sudden changes and/or threshold crossings and corresponding responses the Tribe may consider undertaking.

Table 9. Sudden change/threshold crossings and potential responses

Resource	Sudden change/threshold	Potential responses
Biological diversity (in all habitat types)	▸ Sudden invasive species outbreak – appearance of new, or rapid spread of existing invasive species	▸ For trees – harvest the infected area before the pest/disease can spread ▸ Implement new control measures/ramp up current control measures (e.g., more aggressive implementation of sea lamprey control measures; more aggressive removal of invasive plants)
Coldwater fish	▸ Stream temperature rises above coldwater threshold ▸ Shift from coldwater to cool/warmwater benthic communities ▸ Disappearance of coldwater fish species (e.g., trout)	▸ Re-stock, once temperatures lower again (e.g., later in the season) ▸ Translocate fish from coldwater refugia (locations where temperatures remain cold enough for coldwater fish to survive)
Beach habitat	▸ Sudden, large erosional loss, corresponding to storm/high wave event	▸ Construct erosion barriers, limit foot/boat/ATV traffic in the affected area
Beach water quality	▸ E. coli concentrations exceeding water quality standards	▸ Post advisory at applicable beaches to protect human health, and take other actions as appropriate

Additional, sudden/threshold-crossing impacts may also occur in the future that are currently unpredicted. It is challenging to plan for the unknown, but the Tribe intends to coordinate with other Tribal, state, and federal natural resource agencies to stay abreast and share information on emerging climate-related impacts.

7. Adaptation Strategies

The Tribe will consider implementing different types of adaptation strategies in response to climate change impacts. This might include taking long-term conservation measures to protect and/or conserve the resource, taking action to alleviate the direct impact of the climate driver(s), and/or alleviating other stressors on the resource in hopes of maximizing its resiliency to climate change impacts. For example, in the case of wild rice, conservation measures might include collecting wild rice seeds and storing them in a long term seedbank

> "*Vulnerability to climate change is exacerbated by other stresses such as pollution, habitat fragmentation, and poverty. Adaptation to multiple stresses requires assessment of the composite threats as well as tradeoffs among costs, benefits, and risks of available options.*"
>
> From: The Third National Climate Assessment. Chapter 28: Adaptation (Bierbaum et al., 2014).

so that the Tribe has a reserve source for re-seeding if needed in the future. Examples of measures that could be implemented to directly alleviate the impacts of climate change include implementing best management practices to reduce stream flow during storm events (e.g., creating settling ponds, establishing riparian buffer zones, reconnecting rivers to their floodplains). Examples of alleviating other stressors on wild rice to maximize its resiliency to climate change might include implementing best management practices to improve water quality – if the wild rice isn't already stressed by poor water quality, it might have greater resiliency to withstand climate change-induced water level fluctuations.

Table 10 provides a summary of potential adaptation strategies by resource concern. Some of these measures may be implemented as a part of long-term resource management on the Reservation. Many of these concepts are already captured as resource management strategies and best management practices in some of the Tribe's existing resource management plans, such as the 2001 IRMP, and the Tribe's Invasive Species Management Plan. As discussed above, others may be implemented rapidly in response to a sudden climate-induced change, such as an invasive species outbreak, or a sudden rise in water temperatures in a coldwater stream. Table 10 provides representative examples of approaches the Tribe is currently considering, and may be further refined and developed in subsequent adaptation plans that the Tribe may develop.

Members of the BRNRD Invasive Species Crew hand-remove hybrid and narrow-leaf cattail encroaching on the emergent native species within the Kakagon Sloughs. Source: BRNRD

Table 10. Potential adaptation strategies in coastal and inland aquatic habitats and upland habitats. The adaptation strategies represent potential approaches the Tribe is considering, and may more fully develop in future plan(s).

Resource concern	Potential adaptation strategies
Wild rice	▸ Implement best management practices such as improving riparian buffer zones and communication with the floodplain to manage runoff and minimize flashiness in rivers and creeks discharging to wild rice beds ▸ Implement carp population control strategies, and other measures to protect wild rice from carp, such as placing protective fencing around wild rice beds ▸ Strategically plant wind/storm-resistant vegetation to protect wild rice beds from wind; limit boat action (wake-creation) near wild rice beds ▸ Minimize other stressors – for example, improve water quality in wetlands and streams discharging into wild rice beds (see water quality best management practices listed for benthic invertebrates and fish) ▸ Collect seeds for long term seed-bank storage, for possible re-seeding use in the future

Table 10. Potential adaptation strategies in coastal and inland aquatic habitats and upland habitats. The adaptation strategies represent potential approaches the Tribe is considering, and may more fully develop in future plan(s).

Resource concern	Potential adaptation strategies
Wetland and estuary vegetation diversity	▸ Maintain an inventory of plant species, focusing on high quality habitat, where rare community types are most likely to be found ▸ Undertake invasive species control measures – consider prioritizing the protection of high quality habitat areas ▸ Consider starting an herbarium so that there is a permanent record of plant species found in wetlands and estuaries (and possibly other habitats on the Reservation) ▸ Minimize other stressors – for example, improve water quality in streams discharging into wetlands and estuaries (see water quality best management practices listed for benthic invertebrates and fish)
Benthic invertebrate aquatic communities	▸ Minimize other stressors, such as water quality by implementing best management practices. Examples include: creating riparian buffer zones along stream edges; minimizing runoff and sediment loading from developed areas (road, towns) and agricultural/timber harvesting areas; resizing wastewater facilities if needed to accommodate increased storm flows; resizing and/or installing storm sewers to accommodate increased storm flows, etc. (these actions could also benefit other aquatic biota, including fish) ▸ Maintain cold/coolwater temperatures by deepening channels that have become shallow due to excessive sediment loading; plant overhanging (shade-creating) vegetation along stream (these actions could also benefit other aquatic biota, including fish)
Wetland birds and amphibians	▸ Minimize other stressors – for example, improve water quality in streams discharging into wetlands (see water quality best management practices listed for benthic invertebrates and fish) ▸ Maintain and protect natural corridors (possibly in coordination with resource coordinators outside the Reservation) to enable species to move along migration corridors in response to climate changes
Fish	▸ Minimize other stressors, such as water quality by implementing best management practices. Examples include: creating riparian buffer zones along stream edges; minimizing runoff and sediment loading from developed areas (road, towns) and agricultural/timber harvesting areas; resizing wastewater facilities if needed to accommodate increased storm flows; resizing and/or installing storm sewers to accommodate increased storm flows, etc. ▸ Maintain cold/coolwater temperatures by deepening channels that have become shallow due to excessive sediment loading; plant overhanging (shade-creating) vegetation along stream ▸ Re-stock streams in the event of a temperature-induced fish kill
Fish (sea lamprey)	▸ Continue to participate in USFWS sea lamprey monitoring and control program ▸ Identify strategies to limit sea lamprey populations and decrease wounding mortality; such as participating in USFWS's temperature-dependent control measures (when temperatures reach 10°F for multiple continuous days, USFWS intensifies lamprey control measures – Huff and Thomas, 2014)
Species diversity	▸ Maintain an inventory of plant species found in beach habitat ▸ Undertake invasive species control measures – consider prioritizing the protection of higher quality habitat areas ▸ Consider starting an herbarium so that there is a permanent record of plant species found on beaches (and possibly other habitats on the Reservation)

Table 10. Potential adaptation strategies in coastal and inland aquatic habitats and upland habitats. The adaptation strategies represent potential approaches the Tribe is considering, and may more fully develop in future plan(s).

Resource concern	Potential adaptation strategies
Water quality (fecal contamination)	▸ Manage recreational uses of beaches for public health ▸ Address other sources that may be contributing to decreased water quality and algal blooms – for example, improve water quality in streams discharging into coastal beach habitat (see water quality best management practices listed for benthic invertebrates and fish)
Loss of habitat (erosion)	▸ Identify potential erosion mitigation options that could be implemented, such as planting vegetation, or constructing erosion barriers minimizing other anthropogenic activities that can accelerate erosion, such as boating (generation of wakes), and construction of structures (such as docks) ▸ Consider coordinating with the U.S. NPS Apostle National Shoreline and share adaptation strategies
Forest species diversity	▸ Identify strategies to control non-native species (e.g., controlling invasive pests by minimizing traffic of trees and other forest vegetation onto the Reservation, and by quickly harvesting trees when outbreaks are discovered) ▸ Consider deer management programs – high populations of deer may have a negative impact on the reproduction of some plants, such as hemlock, Canada yew, white pine, white cedar, lilies, and orchards (Bad River Band, 2001) ▸ Manage aspen stands, as aspen stands in turn attract and contribute to deer population (Bad River Band, 2001)
Maple trees	▸ Identify strategies to compensate for decreased maple sap collection, such as tree planting or permit collection limits
Balsam trees	▸ Identify strategies to adapt to a shorter season (e.g., refrigerated storage of boughs)
Tree growth	▸ Determine if changes in management strategies are warranted to manage the forests on the Reservation, and identify potential adaptation strategies (e.g., by minimizing other stressors, such as controlling pests, and understory invasive species such as spotted knapweed and garlic mustard that may limit regeneration by competing with native tree saplings)

8. Summary

Because of the unique and inextricable relationships between Tribal members and their surrounding natural resources and ecosystems, the cultural fabric of the Tribe may be affected by climate change in profound and unique ways.

This Seven Generation Climate Change Monitoring Plan was accordingly developed to guide the Tribe in detecting adverse climate change impacts to the ecosystems and natural resources found on the Reservation. The Plan summarizes projected climate changes and probable physical and cultural impacts, and outlines a monitoring approach to identify anticipated adverse effects. In order to enable the Tribe to proactively address and adapt, the Plan incorporates monitoring for early warning signs of negative impacts of climate change, as well as benchmark dates for assessing potential climate change impacts over the long-term. The Plan was developed through

a careful, thoughtful process, which included convening an expert working group comprised of Tribal members and elders, and climate change experts from various state and federal agencies, and NGOs. Decisions about which resources to monitor and monitoring approaches were made on a consensus-basis, through a series of workshops held at the Reservation.

Importantly, the Tribe has designed the Plan to be a living, flexible guide to climate monitoring. This flexibility will allow the Tribe to make changes to the Plan as needed to adapt to new conditions, unforeseen events, and any advances in the state of the science on climate change that may occur over its seven generation lifespan.

9. Future Needs

Upon completion of this plan we determined that a gap analysis is needed to identity which monitoring activities already meet the needs of establishing a baseline and where we may need to dedicate more time and resources to assure that a baseline is established. As mentioned early this plan is meant to be a flexible guide for our natural resources department and updates and revisions will be completed as needed.

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Appendix A. Threatened and Endangered Species

Type	Common name	Scientific name	*Ojibwe name	Federally threatened	State threatened	Federally endangered	State endangered	Tribally protected
Bird	Cerulean Warbler	*Setophaga cerulea*			X			X
	Spruce Grouse	*Falcipennis canadensis*	Mashkodese		X			X
	Yellow Rail	*Coturnicops noveboracensis*			X			X
	Black Tern	*Chlidonias niger*					X	X
	Caspian Tern	*Hydroprogne caspia*					X	X
	Common Tern	*Sterna hirundo*					X	X
	Loggerhead Shrike	*Lanius ludovicianus*					X	X
	Peregrine Falcon	*Falco peregrinus*					X	X
	Piping Plover	*Charadrius melodus*				X	X	X
Insect	Beach Dune Tiger Beetle	*Cicindela hirticollis rhodensis*					X	X
	Warpaint Emerald	*Somatochlora incurvata*	Oboodashkwaanishiinh				X	X
Mammal	Big Brown Bat	*Eptesicus fuscus*	Apakwaanaajiinh		X			X
	Little Brown Bat	*Myotis lucifugus*	Apakwaanaajiinh		X			X
	Northern Long-Eared Bat	*Myotis septentrionalis*	Apakwaanaajiinh	X	X			X
	American Martin	*Martes americana*	Waabizheshi				X	X
	Gray Wolf	*Canis lupus*	Ma'iingan			X	X	X
	Lynx	*Lynx canadensis*	Bizhiw	X				X
	Moose	*Alces alces*	Mooz					X
Mussel	Purple Wartyback	*Cyclonaias tuberculata*					X	X
Plant	Beautiful Sedge	*Carex concinna*			X			X
	Braun's Holly-Fern	*Polystichum braunii*			X			X
	Broad-Leaved Twayblade	*Listera convallarioides*			X			X
	Canada Gooseberry	*Ribes oxyacanthoides*	Zhaaboomin		X			X
	Coast Sedge	*Carex exilis*			X			X
	English Sundew	*Drosera anglica*			X			X
	Fairy Slipper	*Calypso bulbosa*			X			X

Type	Common name	Scientific name	*Ojibwe name	Federally threatened	State threatened	Federally endangered	State endangered	Tribally protected
	Large Water-Starwort	*Callitriche heterophylla*			X			X
	Marsh Grass-of-Parnassus	*Parnassia palustris*			X			X
	Michaux's Sedge	*Carex michauxiana*			X			X
	Narrow False Oats	*Trisetum spicatum*			X			X
	Pale Green Orchid	*Platanthera flava var. herbiola*			X			X
	Plains Ragwort	*Packera indecora*			X			X
	Ram's-Head Lady's-Slipper	*Cypripedium arietinum*			X			X
	Shore Sedge	*Carex lenticularis*			X			X
	Slenderleaf Sundew	*Drosera linearis*			X			X
	Tea-Leaved Willow	*Salix planifolia*	Oziisigobiminzh		X			X
	Common Butterwort	*Pinguicula vulgaris*					X	X
	Goblin Fern	*Botrychium mormo*					X	X
	Large-Leaved Sandwort	*Moehringia macrophylla*						X
	Moonwort Grape-Fern	*Botrychium lunaria*					X	X
	Mountain Cranberry	*Vaccinium vitis-idaea ssp. minus*	Mashkiigimin				X	X
	Sand Dune Willow	*Salix cordata*					X	X
	Satiny Willow	*Salix pellita*	Oziisigobiminzh				X	X
	Small Yellow Water Crowfoot	*Ranunculus gmelinii*					X	X
	Smith's Melic Grass	*Melica smithii*					X	X
Reptile	Wood Turtle	*Glyptemys insculpta*	Miskwaadesi		X			X

*Just because a name is not listed does not mean it does not exist. This list is also subject to change. Please check with BRNRD Wildlife Program for the most recent version.

Appendix B. Prioritization of Natural Resource Concerns and Monitoring Objectives for Climate Change Monitoring

The table below summarizes the resource concerns upon which the Tribe's monitoring priorities are based. For each, the table lists currently identified monitoring parameters and potential management decisions that may be needed. It also lists the relevant ecosystem types for each concern, and then provides the Tribe's priority and cost-effectiveness ranking, and explanations of the ranking as needed. The ranking was based on the identified monitoring parameters, which may change in the future, for example, if new parameters are identified. In Section 5 of the Plan, the resource concerns are organized by ecosystem type, but they are not ordered here.

Monitoring parameters	Resource concern that drives monitoring objectives	Management decisions	Ecosystem types	Priority rank	Cost-effectiveness rank	Rank explanation
Density and/or presence/absence of invasive species populations (e.g., purple loosestrife, Eurasian water milfoil) over time	Non-native species population increases (species diversity)	Identify strategies to control non-native species	Beaches Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands Forested land Agricultural land	High	High	Importance of controlling non-native species because of impact on native biodiversity; relatively low cost for vegetation surveys
Benthic invertebrate surveys	Changes in aquatic life (benthic invertebrate) community composition	Determine if changes in management strategies are warranted and identify potential adaptation strategies	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	High	High	High value of data that is indicator of overall water quality; relatively low cost, though time consuming
Wild rice metrics (e.g. presence/absence, density, incidence of brown spot disease) at sites with a range of hydrological conditions	Decrease in wild rice	Identify strategies to increase resiliency of wild rice ecosystem (e.g., water control structures, reseeding efforts)	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	High	High	Importance of wild rice to Band and of continuing current monitoring; monitoring relatively expensive
Water temperature compared to thresholds for coldwater species (e.g., trout and salmon), warmwater species (e.g., bass and carp); sea lamprey populations	Changes in fish populations	Identify strategies to support coldwater fishery, transition to coolwater or warmwater fishery; control sea lamprey populations	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	High	High	Importance of maintaining current monitoring; costs may be controlled by partnering with USFWS
Water quality (e.g., E. coli, temperature) in recreational waters	Changes in frequency and extent of algal blooms	Manage recreational uses of beaches for public health	Beaches	High	High	Importance of maintaining current beach monitoring for human health concerns

Monitoring parameters	Resource concern that drives monitoring objectives	Management decisions	Ecosystem types	Priority rank	Cost-effectiveness rank	Rank explanation
Wounding rates	Increased wounding rates on native fish	Identify strategies to control sea lamprey populations and decrease wounding mortality	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	High	High	Sea lamprey are a concern for native fish populations
Maple sap collection season duration	Loss of maple trees and declining sap production	Identify strategies to compensate for decreased maple sap collection, such as tree planting or permit collection limits	Forested land	High	Medium	Importance to Tribal members; challenges in acquiring human use data
Tree age measurements (coring)	Native tree growth rate changes	Determine if changes in management strategies are warranted and identify potential adaptation strategies	Forested land	High	Medium	Importance to continue current record of tree aging; somewhat time consuming and costly
Various metrics	Adaptation project effectiveness	Identify appropriate metrics for adaptation projects and evaluate success over time	Coastal wetlands/ estuaries Beaches Rivers/streams Lakes/ponds/wetlands Forested land Agricultural land	High	Medium	Importance of understanding effectiveness of projects; costs unknown at this time
Small mammal surveys, browse surveys, deer harvest survey	Small and foraging mammal population decreases and deer population increases associated with decrease in snow cover	Identify strategies to increase resiliency of small and foraging mammal populations and limit increases in deer populations	Forested land Agricultural land	High	Low	Importance of these resources to the Band; monitoring could be expensive and funding difficult to come by; current deer pellet counts are not accurate for assessing population; member harvest data difficult to collect

Monitoring parameters	Resource concern that drives monitoring objectives	Management decisions	Ecosystem types	Priority rank	Cost-effectiveness rank	Rank explanation
Firewood collection volumes	Firewood collection	Warmer winters may result in less firewood gathering, which could affect how the resource needs to be managed; Determine if changes in management strategies are warranted and identify potential adaptation strategies	Forested land	High	Low	Importance to Tribal members; challenges in acquiring human use data
Population metrics for a range of species (e.g., mussels, rare plants, piping plovers, wolves, and bats)	Threatened and endangered species populations	Determine if changes in management strategies are warranted and identify potential adaptation strategies	Coastal wetlands/ estuaries Beaches Rivers/streams Lakes/ponds/wetlands Forested land Agricultural land	High	Low	Importance of these resources to the Band and continuing current monitoring (e.g., mussels, piping plovers, wolves, bats); monitoring somewhat expensive and funding difficult to come by
Concentrations of pollutants (e.g. sediments, nutrients, mercury methylation, E. coli) in water	Changes in pollutant concentrations and loadings	Evaluate whether water quality standards are being met and inform non-point source management decisions	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	High	Low	Importance of maintaining current monitoring; can focus on existing sites to limit analytical costs

Monitoring parameters	Resource concern that drives monitoring objectives	Management decisions	Ecosystem types	Priority rank	Cost-effectiveness rank	Rank explanation
Water levels, acoustic monitoring of birds and amphibians in wetland locations, and plant community metrics	Reductions in coastal wetland habitat availability for birds and amphibians	Identify strategies to protect or increase resiliency of wetlands	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	Medium	High	Importance of maintaining current monitoring; initial investment in acoustic recording devices already made and maintenance is inexpensive; currently monitoring in inland wetlands, intend to expand to coastal wetlands.
Balsam bough gathering season duration Timing of first frost/onset of cold weather and timing of last frost	Loss of balsam trees; ability to gather balsam boughs	Identify strategies to adapt to shorter season (e.g., refrigerated storage of boughs)	Forested land	Medium	Medium	Importance to Tribal members; challenges in acquiring human use data
Winter logging season duration	Shortening of winter logging season	Identify strategies to maintain adequate production, such as smaller units sold to greater number of loggers	Forested land	Medium	Medium	Importance to Tribal members; challenges in acquiring human use data
Hydrology (flow and water levels) of major tributaries to wild rice areas Presence/absence, density of wild rice	Decrease in wild rice viability	Implement “slow the flow” management strategy to manage runoff and minimize flashiness	Coastal wetlands/ estuaries Rivers/streams	Medium	Medium	Concern about drought and flooding events and impacts on wild rice; costs may be controlled by analyzing USGS data where available

Monitoring parameters	Resource concern that drives monitoring objectives	Management decisions	Ecosystem types	Priority rank	Cost-effectiveness rank	Rank explanation
Carp population metrics Water temperatures Presence/absence of wild rice	Changes in fish populations (carp) adversely affecting wild rice	Identify strategies to control carp and protect wild rice from carp	Coastal wetlands/ estuaries	Medium	Medium	Concern about carp in wild rice beds – currently removed but population levels are not monitored; some funding currently available for a mark-recapture study
Wind speed and water level	Wild rice viability	Evaluate whether water seiche-controlled water levels are affected. If so, review data on wild rice populations (from #5) to evaluate whether these changes affect wild rice, and identify strategies to increase resiliency.	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	Medium	Medium	Importance of wild rice to Band and of continuing current monitoring; cost to monitor wind speeds at a resolution that is meaningful for the seiche could be prohibitive
Benthic algal community metrics (particularly diatoms)	Benthic algae population increases	Evaluate whether water quality standards are being met and inform non-point source management decisions	Coastal wetlands/ estuaries Rivers/streams Lakes/ponds/wetlands	Medium	Low	Value in continuing limited current monitoring; high expense to analyze samples
Erosion/accretion measurements	Increases in shoreline erosion and damage	Determine if erosion control measures are necessary	Beaches	Low	High	While current monitoring is relatively low cost and should be maintained, it is challenging to analyze the significance of the erosion/accretion data; may reassess priority at a later date.

Monitoring parameters	Resource concern that drives monitoring objectives	Management decisions	Ecosystem types	Priority rank	Cost-effectiveness rank	Rank explanation
Shoreline mapping using aerial photography, correlated with data from NOAA buoys	Increases in shoreline erosion and damage	Determine if erosion control measures are necessary	Beaches	Low	Low	Data not that valuable and may be able to use available sources of imagery (like Google); high expense for planes

Appendix C. List of Acronyms and Abbreviations

BIA – Bureau of Indian Affairs
BRNRD – Bad River Natural Resources Department (see NRD)
BRWS – Bad River Watershed
CWA – Clean Water Act
EPA – Environmental Protection Agency (see USEPA)
GIS – Geographic Information System
GLIFWC – Great Lakes Indian Fish and Wildlife Agency
IPCC – Intergovernmental Panel on Climate Change
IRMP – Integrated Resources Management Plan
NPS – National Park Service
NRD – Natural Resources Department (see BRNRD)
PQAO – Primary Quality Assurance Organization
QAPP – Quality Assurance Project Plan
QMP – Quality Management Plan
SOP – Standard Operating Procedure
TEK – Traditional Ecological Knowledge
TWG – Tribal Wildlife Grant
USDOI – United States Department of the Interior
USEPA – United States Environmental Protection Agency (see EPA)
USFWS – United States Fish and Wildlife Service
USGS – United States Geological Survey
WDNR – Wisconsin Department of Natural Resources
WICCI – Wisconsin Initiative on Climate Change Impacts
WQS – water quality standards

BAD RIVER BAND OF LAKE SUPERIOR TRIBE OF CHIPPEWA INDIANS

CHIEF BLACKBIRD CENTER P.O.Box 39 • Odanah, Wisconsin 54861

Resolution No. 6-21-16-632

Authorization of the Bad River Seventh Generation Climate Change Monitoring Plan

WHEREAS: the Bad River Band of Lake Superior Tribe of Chippewa Indians is a federally recognized Indian tribe with a Constitution enacted pursuant to the Indian Reorganization Act of 1934, 25 U.S.C. Section 476; and

WHEREAS: Article VI, Section 1(a) of the Constitution authorizes the Tribal Council to negotiate with Federal, State, and local Government on behalf of the Band; and

WHEREAS: Article VI, Section 1(n) of the Constitution directs the Tribal Council to encourage and foster the arts, crafts, traditions, culture, wildlife, and natural resources of the Band; and

WHEREAS: the Bad River Integrated Resource Management Plan (IRMP) is utilized as the guiding document for the conservation, preservation, and sustainable use of the natural resources of the Bad River Reservation.

NOW THEREFORE BE IT RESOLVED, that the Bad River Tribal Council hereby approves the attached *Seventh Generation Climate Change Monitoring Plan*;

AND BE IT FURTHER RESOLVED, that this resolution is effective beginning on this date and continuing until the Resolution is rescinded.

CERTIFICATION

I, the undersigned, as Secretary of the Bad River Band of the Lake Superior Tribe of Chippewa Indians, an Indian Tribe organized under Section 16 of the Indian Reorganization Act, hereby certify that the Tribal Council is composed of seven members, of whom 6 members, constituting a quorum, were present at a meeting hereof duly called, noticed, convened, and held on the 21 day of June, 2016; that the foregoing resolution was duly adopted at said meeting by an affirmative vote of 5 members; 0 against and 0 abstaining, and that said resolution has not been rescinded or amended.

Rae Ann Maday, Secretary
Bad River Tribal Council