GREAT LAKES INDIAN FISH & WILDLIFE COMMISSION
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• MEMBER TRIBES •

MICHIGAN	WISCONSIN		MINNESOTA
Bay Mills Community	Bad River Band	Red Cliff Band	Fond du Lac Band
Keweenaw Bay Community	Lac Courte Oreilles Band	St. Croix Chippewa	Mille Lacs Band
Lac Vieux Desert Band	Lac du Flambeau Band	Sokaogon Chippewa	

May 26, 2016

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Environmental Review Manager
Minnesota Department of Commerce
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Ms. MacAlister,

Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is an intertribal agency exercising delegated authority from 11 federally recognized Ojibwe (or Chippewa) tribes in Wisconsin, Michigan and Minnesota.[1] Those tribes have reserved hunting, fishing and gathering rights in territories ceded in the 1836, 1837, 1842, and 1854 treaties with the United States (Map 1). GLIFWC's mission is to assist its member tribes in the conservation and management of natural resources and to protect habitats and ecosystems that support those resources.

Enclosed are GLIFWC staff comments on the Draft Scoping Decision (DSD) documents for the Line 3 Replacement Pipeline Project and the Sandpiper Pipeline Project proposed by Enbridge Energy. At this stage of the Environmental Impact Statement (EIS), GLIFWC comments are general in nature. As the process moves forward, we expect that additional comment and interaction with the Minnesota Department of Commerce will occur. GLIFWC submits these comments from an off-reservation Ceded Territory perspective and an individual tribe may choose to submit comments from its own perspective.

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[1] GLIFWC member tribes are: in Wisconsin -- the Bad River Band of the Lake Superior Tribe of Chippewa Indians, Lac du Flambeau Band of Lake Superior Chippewa Indians, Lac Courte Oreilles Band of Lake Superior Chippewa Indians, St. Croix Chippewa Indians of Wisconsin, Sokaogon Chippewa Community of the Mole Lake Band, and Red Cliff Band of Lake Superior Chippewa Indians; in Minnesota -- Fond du Lac Band of Lake Superior Chippewa, and Mille Lacs Band of Chippewa Indians; and in Michigan -- Bay Mills Indian Community, Keweenaw Bay Indian Community, and Lac Vieux Desert Band of Lake Superior Chippewa Indians.

General Scoping Comments

Analysis of Impacts to Cultural Resources

The DSD Documents indicate that impacts to cultural and natural resources will be analyzed. However, it is important to note that for tribal members, natural resources *are* cultural resources. The Ojibwe have historically used and continue to use their natural resources within the Ceded Territories for spiritual, cultural, subsistence, medicinal and economic purposes. Tribal members harvest and consume freshwater fish, wild rice, and many other natural resources as part of their bimaadiziwin, or traditional lifeway, which incorporates culture, spirituality, language and traditions, including the harvest and consumption of traditional foods. The resources that tribal members depend on have been degraded over time through a combination of loss of access and environmental degradation. Pipelines are one of many constructed features that drastically alter the landscape and can diminish the resources tribes depend on.

The EIS, in its analysis of natural resources (surface and groundwater, wetlands, habitat, etc.) should recognize the importance of a healthy environment to tribes and describe the cultural ties of tribes to the potentially impacted areas of the proposed pipeline projects.

Spatial Extent of Analysis

The Sandpiper line is intended to transport Bakken shale oil from North Dakota to Superior, Wisconsin. Line 3 transports tar sands oil from Alberta Canada to Superior Wisconsin. Therefore, these projects are regional in scope and the impacts of these projects should be described at local and regional scales. We suggest that impacts of all existing pipelines in Minnesota should be done to define existing conditions for these projects. From GLIFWC's perspective, the impacts of pipeline projects on the 1837, 1842, 1836 and 1854 ceded territories should also be conducted (Map 1) with the Ceded Territories used as distinct geographic study areas.

Additionally, on a broader scale, the EIS should also use information developed for other pipeline environmental impact assessments in Wisconsin and North Dakota, and any pertinent information developed for other multi-jurisdictional pipeline projects, such as the Keystone XL project, because these proposals present similar permitting and environmental challenges as the Sandpiper project.

History of Pipeline Safety and History of Enbridge Energy

Enbridge Inc. has a questionable environmental record. From 1999 to 2010, Enbridge pipelines spilled over 7 million gallons of crude oil in over 800 different incidents across the United States and Canada (National Wildlife Federation, 2012). The

combined environmental effect of these incidents to wetlands and surface and ground waters has not been quantified. The most notorious spill involves a ruptured pipeline that spilled over a million gallons of heavy crude oil into the Kalamazoo River in the lower peninsula of Michigan in July of 2010. Thirty-five river miles downstream of the spill were closed by the EPA. Cleanup activities at this site continued until 2014 with costs exceeding 675 million dollars. Cleanup efforts were complicated by the heavy crude oil that, when spilled, sank to the bottom of the river and into the sediment. Line 3 replacement pipeline could transport this type of oil and the proposed Sandpiper pipeline could, potentially, transport heavy crude as well. Because of this, traditional oil cleanup techniques that involve surface skimming of affected waters could be ineffective and costlier dredging of substrates must be performed.

Given this history, the EIS must provide a complete accounting of all spills from pipelines. While it is important that Enbridge's historical operations record is identified, the information should include all companies operating in the region. Spills from local feeder lines should also be detailed. With each pipeline and feeder line operating in the region, the likelihood of spills increases and any cumulative impact of successive spills impacting the region is also potentially greater. This must be acknowledged by the EIS.

Surface and Groundwater Quality

The potential for these pipelines to rupture and cause an oil spill is a major concern. The EIS should document the environmental effects of past oil spills and scientifically assess the effects of a spill in the water rich regions of the Upper Midwest and Lake Superior regions. A systematic assessment of remediation and cleanup techniques must be provided for light and heavy crude oil along with a detailed review of the effectiveness of each technique. The EIS should also quantitatively assess the possible changes to surface and groundwater that may result from a spill.

The water quality assessment should pay special attention to potential impacts to Lake Superior. This analysis should be done in the context of the Great Lakes Water Quality Agreement, the bi-national Water Quality Agreement between Canada and the United States.

A cumulative assessment of all existing impacts from pipeline construction and pipeline spills on surface and groundwater should be conducted.

Wetland Impacts and Wetland Mitigation

Construction and expansion of pipelines involve wetland fill and hydrologic alteration that will affect wetland functions and values. Mitigation for wetland impacts that cannot be avoided will be required. However, the effectiveness of wetland mitigation, both through the use of wetland banks or rehabilitation of drained wetlands, is

questionable. The EIS should describe the effectiveness of wetland mitigation measures and assess whether all functions and values of lost wetlands are likely to be replaced.

Climate Change

Increased oil transportation capacity will contribute to existing CO2 emissions into the atmosphere and exacerbate global climate change. Potential impacts of climate change have been documented for the Ceded Territories through work of the Wisconsin Initiative on Climate Change Impacts (WICCI) and GLIFWC (Attachment 1). Potential impacts on the Lake Superior Basin have been described through the work of the Lake Superior Workgroup. Furthermore, the impacts on forest ecosystems have been described by the Northern Institute of Applied Climate Science (NIACS) of the USDA. The EIS should examine the effects that this project will have on carbon emissions as well as the effect on the climate change adaptation strategies that have been suggested for Minnesota and the Lake Superior region.

The DSD documents for both projects indicate that regional economic analysis of the effects of the projects will be conducted. These economic analyses should include information on the economic effects of climate change on the region and account for the contribution of the pipeline projects to these impacts.

The economic analysis should also describe treaty guaranteed usufructury rights of Tribes in the region and assess how the proposed pipeline projects would impact the ability of tribes to continue to exercise their rights.

Financial Assurance

As previously discussed, GLIFWC staff believe that spills of oil transported through these pipelines are likely. Cleanup and remediation are costly and require long periods of time to complete. The EIS should describe, in detail, the types of financial assurance that Enbridge will be required to provide to ensure that the public is not burdened with cleanup and remediation costs. Furthermore, financial assurance is needed to cover the costs of maintaining structural integrity of the abandoned Line 3 as well as the costs of ultimately removing pipelines from the right of way whenever that becomes feasible.

No Action Alternative

The no action alternative for the proposed Sandpiper project assumes that Bakken oil will continue to be shipped by other means. The assumption that oil extraction at current levels will continue to be necessary is not supported. The United States has decided against approving the Keystone XL pipeline. There are many reasons for this, but concerns over increased carbon emissions and their contribution to global climate change as well as concerns over accidental releases of oil are two of the most important reasons.

This same rationale applies to the proposed new Sandpiper line. The analysis in the EIS should acknowledge that the need for oil transported by the Sandpiper line and Line 3 is speculative and that this oil may not be needed nor desired, given the commitments the United States has made on climate change mitigation.

Cumulative Impact Analysis

In general, the description of cumulative impact analysis is appropriate. However, there are some points that should be clarified.

Page 13 of the Line 3 Replacement DSD document states:

> "Each project will have its own EIS, and the cumulative impacts of each project will be addressed in both EISs."

Page 15 of the Sandpiper Pipeline DSD Document states:

> "The Sandpiper EIS will analyze the potential impacts of the L3R Project as part of the EIS's cumulative impacts discussion. In addition, other projects throughout the Sandpiper corridor that may cause cumulative impacts will also be discussed at a local, county and larger regional levels."

Cumulative effects analysis must not be confined to the corridor of the pipeline projects. The analysis of cumulative effects should be broad enough to account for regional impacts such as habitat fragmentation and wetland fragmentation. Additional clarity on the spatial extent of the cumulative impact assessment is needed.

The EPA, in cooperation with Region 5 tribes, has developed a protocol for assessing cumulative effects on tribal resources. This guidance should be used in the EIS for the proposed pipeline projects.

Impacts of Routine Construction and Operation

The DSD documents for Sandpiper and Line 3 projects discuss the impacts of routine construction and operation activities. However, additional detail is needed to clarify the scope of the analysis. The EIS must describe the impacts of all activities related to pipeline maintenance into the future. This includes impacts from permanent and temporary access roads and activities needed to maintain cathodic protections in pipelines abandoned in place. The EIS must anticipate, based on past experience, all permits that the applicant will need over the lifetime of the pipelines and describe them in detail.

We look forward to working with the Minnesota Department of Commerce as the EIS process moves forward. Please contact me at 608-263-2873 with any questions.

Sincerely,

Esteban Chiriboga

Esteban Chiriboga
GLIFWC Environmental Specialist

cc. Jonathan Gilbert, GLIFWC Biological Services Director (Acting)
Ann McCammon Soltis, GLIFWC Director of Intergovernmental Affairs
John Coleman, GLIFWC Environmental Section Leader
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Sources Cited

National Wildlife Federation, 2012, "The Anatomy of Enbridge's Once and Future Oil Spills, www.nwf.org.

Great Lakes Indian Fish & Wildlife Commission (GLIFWC)

Preliminary Climate Change Vulnerability Assessment for the Ceded Territories

Introduction

Sound conservation practices and management decisions are vital to GLIFWC's core mission of protecting and enhancing natural resources in the ceded territories. Climate data have shown that average temperature and precipitation in the ceded territories have been changing since the mid-1950's at least. These changes are due to increased greenhouse forcing in the atmosphere associated with the burning of fossil fuels. These rapid climate changes are, at best, another stressor on the ecosystems that tribes depend upon to exercise their treaty rights. At worst, these climate changes are a direct threat to the continued existence of treaty-protected natural resources that tribal members depend upon. GLIFWC has begun the process of assessing the predicted effects of climate changes on ceded territory ecosystems with the ultimate goal of developing a climate change adaptation strategy. This strategy will outline the conservation and management practices that can be implemented to protect traditional resources. It is important to note that climate change adaptation is a temporary measure that may reduce some of the impacts of climate change. The only permanent solution is to reduce the emissions of fossil fuels to the atmosphere.

This vulnerability assessment is the first step in developing an adaptation. It characterizes the potential climate changes expected within the Ceded Territory (e.g. temperature, precipitation, snow cover, etc.). It is important to note that this analysis treats the ceded territories as a distinct geographic unit and it is this ceded territory unit that is the focus of the study. The potential effects of climate change on a subset of species that GLIFWC member tribes harvest is also provided to add context to changes that the ceded territory is likely to experience. Finally, recommendations for additional, more detailed, risk assessment analyses are presented.

Predicted Climate Changes to the Ceded Territory

Temperature and precipitation are the driving variables in regional climate change research and are the basis of this vulnerability assessment. From those 2 variables, other factors that affect the ceded territory ecosystems like snow (quantity and timing), soil moisture, growing degree days, can be computed. This report relies on 2 datasets to examine the vulnerability of the ceded territory to predicted climate changes -- the National Center for Atmospheric Research (NCAR) and the Wisconsin Initiative on Climate Change Impacts (WICCI) downscaled climate change databases. Both the NCAR and WICCI datasets are computed by statistically downscaling the output of global climate change models (GCM). The underlying models used in the downscaling procedure are different for NCAR and WICCI, but at a ceded territory scale, the results are very similar. This dataset cross-check increases the confidence that the downscaling procedure is valid.

It is important to note that the downscaled climate change predictions that are the basis of this report are not without uncertainty. There are general conclusions that can be made with a great deal of scientific confidence. First, the climate of the Ceded Territories has changed and will continue to change in the future. Second, these changes are the result of enhanced greenhouse effect in the atmosphere that is caused by human emissions of carbon. Third, these climate changes, will have profound effects on plants and animals because these changes are occurring faster than ecosystems can change. What is uncertain, is the precise changes that will occur and the exact consequences that climatic changes will bring. Research in these areas is ongoing. For example, downscaled models of temperature and the associated vegetation shift have a greater degree of confidence that downscaled models of precipitation and lake levels. This report presents the best available information for the Ceded Territories in order to provide a preliminary assessment of changes and stresses to the ecosystems of the region.

This vulnerability assessment looks at predicted changes to ceded territory climate variable under two different global climate change scenarios -- A1 and A1B. These two scenarios were selected because, based on current carbon emission trends, they appear to be likely to occur in the future. The scenarios are defined by the Intergovernmental Panel on Climate Change (IPCC) as:

- A2. The IPCC A2 scenario describes a future world of intense fossil fuel use, rapid economic growth, global population that reaches 10 billion by mid-century, and the slow introduction of new and more efficient technologies. Major underlying themes are regional economic development and a lack of international cooperation. It can be considered a high emissions scenario.
- A1B. The IPCC SRES A1B scenario is marked by a balance in the use of fossil fuels and renewable energy sources. It is often thought of a mid-level scenario. It assumes very high economic growth and relatively low population growth . A convergence of global living standards results in a high per-capita demand for food, fiber, and energy. As a result, there is an increase in the human footprint on the landscape, with a decline in natural land covers such as grassland, forest, and wetland.

Changes to temperature and Precipitation are analyzed for the end of the 21st century (2099). While annual averages of temperature and precipitation are important in defining the scale of changes, considerable attention is given to the expected changes in climate during winter (monthly averages of December, January, February), Spring (monthly averages of March, April, May), Summer (monthly averages of June, July, August), and Fall (monthly averages of September, October, November). These seasonal changes are important in characterizing effects on the many seasonal activities in which tribal members engage.

Predicted Temperature Changes

Temperatures are expected to increase throughout the ceded territory. By the end of the century, average annual temperatures are predicted to increase on average across the Ceded Territories by approximately 4°F under the A1B scenario (Map 1) and 5°F to 6 ^{o}F under the A2 scenario (Map 2).

There are no significant seasonal differences in the magnitude of warming at a ceded territory scale The data indicate that greater warming is associated with the high emissions scenario.

Table 1: Predicted Seasonal Temperature Changes in the Ceded Territories by the End of the Century:

Emissions Scenario	Winter	Fall	Summer	Spring
A1B	2.7°F to 3.5°F	3.1°F to 4.1°F	2.7°F to 4.2°F	2.3°F to 3.4°F
A2	5.1°F to 6.9°F	4.8°F to 6.3°F	4.3°F to 6.8°F	3.4°F to 5.1°F

Interesting spatial patterns can be detected from the seasonal temperature data. During winter, the 1837 ceded territory is predicted to warm less than other ceded territories. This pattern is evident for both emission scenarios (Map 3 and 4). Maps for the Fall (Map 5 and 6) and Summer seasons (Map 7 and 8) indicate that the 1854 and 1837 ceded territories are predicted to warm more than the 1842 and 1836 ceded territories. This pattern is likely the result of Lakes Superior and Michigan moderating temperatures. The lakeshore areas and areas downgradient of the prevailing wind patterns are predicted to warm less than the areas upgradient of the lakes. Model predictions for the Spring season (Map 9 and 10) show different spatial patterns for the A1B and A2 scenarios. While springs are expected to be warmer, greater warming is expected in the western half of the ceded territories under the A1B scenario. The opposite prediction is evident during the A2 scenario. Spring is a notoriously difficult season to model because of the rapid changes that occur in the transition from snow and ice cover conditions to a dynamic growing season. The predictions are also complicated by the fact that there will be fewer days of snow and ice cover over the winter. Additional data are needed to provide greater clarity to spring season predictions.

Predicted Precipitation Changes

Precipitation is expected to increase throughout the ceded territories by the end of the century under both the A1B and A2 modeling scenarios (Map 11 and 12). The annual average increases are relatively small and the spatial pattern is the same for both emission scenarios. The modest increases in precipitation combined with the expected temperature increases suggest that the ceded territories are predicted to become drier as the evaporation potential created by the increased temperatures exceeds the additional precipitation.

Table 2: Predicted Seasonal Precipitation Changes in the Ceded Territories by the End of the Century

Emissions Scenario	Winter	Fall	Summer	Spring
A1B	0.3" to 0.9"	0.1" to 1.1"	0.2" to 1.8"	0.5" to 2.4"
A2	0.7" to 1.8"	0.5" to 1.5"	0.4" to 2.2"	0.5" to 1.6"

Downscaled model predictions of winter (Map 13 and 14) and fall (Map 15 and 16) precipitation indicate small increases and the predicted changes do not constitute significant deviations from existing

conditions at a ceded territory scale. At more detailed scales, topography and microclimates, including seasonal wind patterns, could have dramatic effects on precipitation patterns and their changes. Additional work in this area is needed. Summer precipitation is predicted to increase for both the A1B and A2 scenarios (Map 17 and 18). Under both scenarios, the models indicate that precipitation increases, if any, would be the smallest in the northern half of the ceded territory and increase to the south of Lake Superior. Large storm events are predicted to increase so the increased precipitation may come in the form of large storm events with drier periods in between. When combined with the temperature predictions it is reasonable to assume that conditions by the end of the century may be drier overall. Spring precipitation is also predicted to increase (Map 19 and 20) but As described in the temperature section, Spring is a difficult season to model because of the rapid changes that occur in the transition from snow and ice cover conditions to a dynamic growing season. Additional research is needed to provide greater clarity to spring season predictions.

Predicted Snowfall Changes

New research and downscaled modeling indicates that annual mean snowfall is expected to decline throughout the ceded territories. In addition, the beginning of the snow season is expected to occur later in the year and snowmelt is expected to occur earlier in the year. Thus, the duration of snow cover will decrease throughout the region. Individual snowstorms are predicted to become less common but more intense. Map 21 illustrates the predicted reduction in snow depth by comparing the average winter snow depth for the present, mid-21st century and late 21st century time periods. The location of the modeled 15 centimeter snow depth contour retreats to the north over time. By the end of the 21st century, the 15 centimeter contour is located almost entirely outside the ceded territory.

Predicted Change in the Frequency of Extreme Precipitation Events

Extreme precipitation events are expected to become more frequent. This is particularly important for the long term stability of existing infrastructure and of large-scale projects like metallic mines. Mines leave behind large tailings basins and waste rock stockpiles that become permanent features of the landscape. These facilities were designed and constructed with tolerances for climate extremes that will not exist in the future. New mines must incorporate additional safety and structural tolerances to account for increased climatic stresses. Extreme events will also likely impact natural ecosystems through increased flooding events, droughts, erosion, etc. Additional work is needed to characterize the effect these events may have on natural resources in the ceded territory.

Climate Change and Manoomin (Wild Rice)

Manoomin is highly important to the traditional lifeway and has a key role in Ojibwe history. The Sokaogon Chippewa Community established the location of their reservation because of the importance of Rice Lake to the band. The annual harvest of rice is a major event in the tribal year. Because of its unique characteristics, wild rice may be particularly vulnerable to climate change-related impacts.

Manoomin (Wild rice*)* Life Cycle (information from Peter David, GLIFWC Manoomin Biologist)

- Wild rice is an annual, cross-pollinated species.
- It generally grows in muddy shallow areas of lakes and streams.
- Wild rice requires about 2600 growing degree days (4.4° C base).
- Grows effectively in depths ranging from 6 to 36 inches (ranges are approximate) and site-specific hydrology is very important.
- Natural stands are found in water with <10 ppm of sulfate.
- Wild rice requires a certain amount of water flow,

Germination – Germination begins in late April to early May when the soil/water reach 5.6° C. During the seedling stage the leaves are submerged.

Some factors affecting plant growth:

- Turbidity/light penetration.
- Water Temperature
- Plant Competition and Shading
- Water Depth

Floating Leaf Stage – In May and early June, the next set of leaves that appear after the submerged seedling stage float on the surface of the water. All subsequent leaves are aerial.

Some factors affecting wild rice at this stage:

- Large storm/wave events can uproot the plant.
- Increased water level can drown the floating leaves.
- Herbivory by muskrat, deer, geese and swans.

Emergent Leaf Stage – In late June to early July additional aerial leaves and the main stem appear. This stage occurs earliest in shallow waters and later with increasing depth.

Some Factors affecting wild rice at this stage:

- Herbivory by muskrat, deer, geese and swans.
- Possible hail damage.

Flowering Stage – Flowering occurs in July. Pollen viability appears to be negatively correlated with temperature and positively correlated with humidity. In late July and August tillers begin to emerge and their maturity lags roughly 7 to 14 days behind the growth of the main stem. During August the grain is at an early stage of development.

Some factors affecting wild rice at this stage:

- Hot dry calm days at time of pollen release may hinder fertilization success and reduce seed set.
- Rice worm infestation (noctuid moth larva) can reduce seed yield by 10% per larva.
- Wind storms can knock the plant over or tissue can be damaged by hail.
- Drought can leave plants on exposed soil, stressing the plant in several ways.

Maturation Stage – Seeds mature and drop from the plant from late August through mid to late September. After dropping, the grains sink and are generally deposited in the sediment near the parent plant. Seeds will not germinate for at least 3 months after dropping and require a dormant period in water at or near freezing (<=35). The seed lies dormant in the sediment until the following spring when roughly 50% of the seed will germinate. Approximately 10% of the seed can remain dormant for up to 5 years, possibly longer.

Some factors affecting wild rice at this stage:

- Excessive sedimentation. Seed buried under >8 centimeters results in no emergence.
- Mild winters may contribute to poor rice season because the dormant period is too warm and because of the possibility of increased rice worm infestation.
- Over-winter drought conditions might lead to seed desiccation.

Other Concerns

- Climate change may alter wild rice's ability to compete with various species, including invasives.
- Brown spot (formerly called *Helminthosporium* brown spot) is the most serious disease affecting wild rice. This disease is caused by *Bipolaris oryzae* Luttrell (*Helminthosporium oryzae* B. de Haan) and *B. sorokiniana* Luttrell (*H. sativum* P.K. and B.). These fungi are considered to cause brown spot since both are found on infected plants and cause similar symptoms in wild rice plants. Every variety of wild rice, at each stage of development, is susceptible to brown spot. This disease is most severe when day temperatures range from 77 to 95° F and nights are 68° F or warmer. High relative humidity (greater than 89%), and the continuous presence of free water on leaf surfaces for 11 to 16 hours, can also favor infection. All parts of the plant are susceptible to infection.

Climate Change Parameters Important in Detailed Vulnerability Assessment:

GLIFWC staff developed an initial list of parameters that may be used in a detailed climate change vulnerability assessment for wild rice. The parameters are listed below.

Brown Spot Disease:

- Change in frequency of 77 to 90+ degree days.
- Change in frequency of night temp of 68 F or warmer.
- Change in frequency of relative humidity (>89%)

Risk of Uprooting:

- Change in frequency of 20 year flood events

Germination Success:

- Changes in winter temperature (more mild winters)
- Increased regional drought leading to lower water levels

Changes in Plant Competition

- Increase in number of growing degree days favor southern species

Risk of Pollination Failure -

- Increase in frequency of dry weather in July/August?

Map 22 indicates that by the end of the century summers in the western half of the ceded territory are predicted to be 5.9^{o}F to 6.8^{o}F warmer than current conditions under the A2 emissions scenario. Map 23 indicates that summers are predicted to warm between 2.7^{o}F to 4.2^{o} across the ceded territory, with the eastern half of the ceded territory predicted to warm somewhat less than the western half. All wild rice waters depicted in the map could be affected, but some areas may more severely impacted. As outlined above, brown spot disease is likely to become more common as the climate warms. The increase in extreme precipitation events will contribute to uprooting of plants during the floating leaf stage. At the same time, an overall drier climate may reduce pollination success. Additional work is needed to assess the effects on individual rice waters and the effect of the various climatic factors on the plant in increased spatial detail. The overall conclusion is that wild rice is vulnerable throughout the ceded territories with increased vulnerability on the western half of the region. It is possible that wild rice beds along the coast of Lake Superior may be sheltered from temperature-related impacts but the effects of Lake Superior level changes should be characterized.

Climate Change and Cold Water Ogaa (Walleye) Fishery

Coldwater habitats are defined by their maximum seasonal water temperatures (17 degrees Celsius during June and August). In general, rising air temperatures will be associated with rising lake and stream temperatures as well. Increasing temperatures have the potential to change coldwater habitats to cool water or even warm water habitats, subsequently affecting the ecology and species composition in lakes or rivers.

The spring walleye spearing season begins immediately after ice-out in inland lakes. Predicted spring temperature changes are likely to cause earlier ice out. Maps 24 and Map 25 indicate that the temperature of the air above many of the inland walleye lakes that are open for tribal spearing is predicted to warm between 2.3^{o}F and 5.1^{o}F during the spring season depending on the emissions scenario. Maps 26 and 27 characterize summer impacts to trout streams. Brook trout are among the most vulnerable species to water temperature increases because their habitat consists of shallow cold streams, which are highly affected by changes in air temperature. The maps indicate that some streams in the ceded territory are more vulnerable than others. Under both scenarios, the western end of the ceded territories is predicted to have greater impacts on coldwater habitats than the eastern side. However, the future water temperature in the individual walleye lake and trout stream will depend on many other factors, such as the health and quality of riparian environments and the amount of groundwater in the water budget for each individual waterbody.

Research conducted by the coldwater fisheries working group of WICCI indicated that brook trout, walleye and northern pike habitat is expected to decline throughout the ceded territory. However, at a ceded territory scale it is not possible to assess lake-specific vulnerability because lake temperatures in many cases are moderated by groundwater inflow, differences in lake morphology, and the characteristics of riparian zones. For example, deep natural lakes will warm less than shallow ones. Also, the degree of dependence of a lake on groundwater, its shape and depth, and the character of shorelines and riparian habitat will ultimately determine the water temperature increase and the viability of coldwater fish species. Trout streams with abundant shade trees will warm less than exposed stream banks. Generally, cold and cool water fish species are vulnerable to climate change, and vulnerability is greater in rivers, streams and shallow lakes. Additional work is needed to characterize vulnerability on a lake by lake basis because of the implications that climate change has on the different tribal activities that occur in the ceded territories. For example, it is known that lakes in the western side of the ceded territories are the first to thaw in the spring and therefore, tribal walleye spearing activities occur there and moves eastward as those lakes lose ice cover. If the eastern ceded territory warms at a faster rate, this pattern may change.

Climate Change and Mooz (Moose)

Moose habitat includes boreal forests and subarctic mixed forests. The southern limit of moose range coincides with the northern limit of the ceded territories for GLIFWC member tribes in Wisconsin and Michigan and have populations in northern MN and upper MI. Moose have specific temperature tolerances and prefer areas where the average summer temperature does not exceed 60°F and winter temperatures that do not exceed 41°F. Because of this, moose are easily heat stressed, and the effects of climate change upon moose are likely to be greatest in the southern limits of their range where temperatures and exposure to white-tailed deer parasites and ticks are greatest. Moose populations in Minnesota have declined substantially in recent years, and this decline has been correlated with increasing temperatures. In the Upper Peninsula of Michigan, recent population estimates suggest the growth rate of this re-introduced population may have slowed in recent years. The decline in moose populations are attributed to summer heat stress, increased mortality from parasites (more ticks survive in mild winters), and brain parasites carried by white tail deer. Maps 28 and 29 indicate that current moose ranges are in areas that are predicted to warm the most in the future for both emission scenarios. This suggests that winter stress from ticks will only increase. Maps 30 and 31 suggest summer indicating that summer heat stress will continue to be a problem throughout the ceded territories regardless of emission scenario. However, the moose range in the 1854 ceded territory is predicted to be more severely impacted than the moose ranges in the Upper Peninsula of Michigan. Regardless of the emissions scenario, the future of moose in the Ceded Territories seems uncertain.

Climate Change and Makwa (Black Bear)

Black bear habitat is found throughout North America in areas without significant urbanization. Because of their large range it is unclear how climate change may affect this species. Bears hibernate during the winter months when food is scarce; in the ceded territories, changes in temperature and shortening of the winter season are likely to change the timing of winter hibernation. Additionally, bears typically leave the den when ambient temperature is above 50°F and snow is melting; this melting condition is predicted to occur earlier in the year, which may cause bears to emerge from hibernation before food is available. Map 32 and 33 depict the location of selected hibernacula and bear management zones where GLIFWC issues permits. The map indicates that spring temperatures are predicted to increase for both emission scenarios across the range of black bears in the ceded territories. It is therefore expected that bears will emerge from hibernation earlier in the year across all management zones. Additional research is needed to determine if this change in timing of hibernation is harmful to bear health, or if climate change will affect black bears in any other ways, such as impacts on food sources, access to water, etc.

Climate Change and Waabezheshi (American Marten) and Ochig (Fisher)

American Marten and Fisher are found in suitable habitats throughout the ceded territories. In the Wisconsin and Michigan ceded territories the Marten and Fisher are at the south fringe of their ranges and both species are sensitive to warm temperatures. The southern extent of the fisher range is determined by temperature. Aside from heat stress, a changing climate may provide fishers a competitive advantage over martens, because fishers appear to use a larger variety of forest cover types than martens. However, deep fluffy snow may give pine martens a competitive edge over fishers as well as thermal protection over the winter; the small rodents on which martens feed also need fluffy snow cover. The predicted reduction in winter snow cover (map 21) may allow fishers to outcompete martens throughout the ceded territory. Additional research is needed to fully characterize the effect that warmer temperatures and reduction of snow cover may have on these two species as well as the competitive relationship between them. In addition, both species have preferences for specific types of forest cover. The effect of climate change on those ecosystems should be assessed in greater detail.

Climate Change Parameters Important in Detailed Vulnerability Assessment:

- Change in temperature for summer and winter
- Change in snow depth
- Change in snow density
- Change in seasonal duration of snowpack
- Increased variability of spring temperature and precipitation. (Creates thawing and refreezing of snow which increase density.

Climate Change and Forest Species

Climate change is expected to affect the suitable habitat of tree species impacts to northern tree species are expected to lead to a conversion to other types of forests that are more common in southern parts of the country. This conversion is detailed in work conducted by the US Forest Service Northern Research Station. Three species are listed in this vulnerability assessment because of their importance to GLIFWC member tribes. The information is taken from the USDA tree atlas at http://www.fs.fed.us/nrs/atlas/. Additional information for other tree species is available at this site.

Wiigwaas (Paper Birch)

The historic range of paper birch encompasses the entire Ceded Territories (Map 34). Recently, a decline has been noted in populations of paper birch, potentially due to changes in climate. “Higher soil temperatures, windstorms and the arrival of new forest pests such as mountain pine beetles would impact almost every tree species found in the north woods today. Paper birch and Aspen would decline from increased drought. White cedar and white pine regeneration would be impacted by deer herds that expand thanks to milder winters”.

Paper birch is expected to decline in the ceded territories by between 58 and 87 percent depending on the emissions scenario (Maps 35 and 36). Paper birch are known to be fairly drought-intolerant, sensitive to higher temperatures, and dependent on productive soils. This is one of the species most severely impacted in the models.

Aninaatig (Sugar Maple)

Sugar maple is an important species for tribal members and is found throughout the Ceded Territory (Map 37). Warmer years can mean the sugar maple -tapping season can get shorter and shorter. Warmer weather can also lead to problems with pests such as the Asian longhorn beetle. An Environmental Protection Agency Climate Action Report from 2002 notes that "climate change is likely to cause long-term shifts in forest species, such as sugar maples moving north out of the Ceded Territories." This can mean that the migration of sugar maple northwards may be unavoidable and ultimately threaten this aspect of Ojibwe sustenance living.

Sugar maple is expected to decline in the ceded territories by between 38 and 69 percent depending on the emission scenario (Maps 38 and 39). It is not expected to be completely eliminated from the CT but this species is vulnerable throughout the ceded territories.

Giizhik (Northern White Cedar)

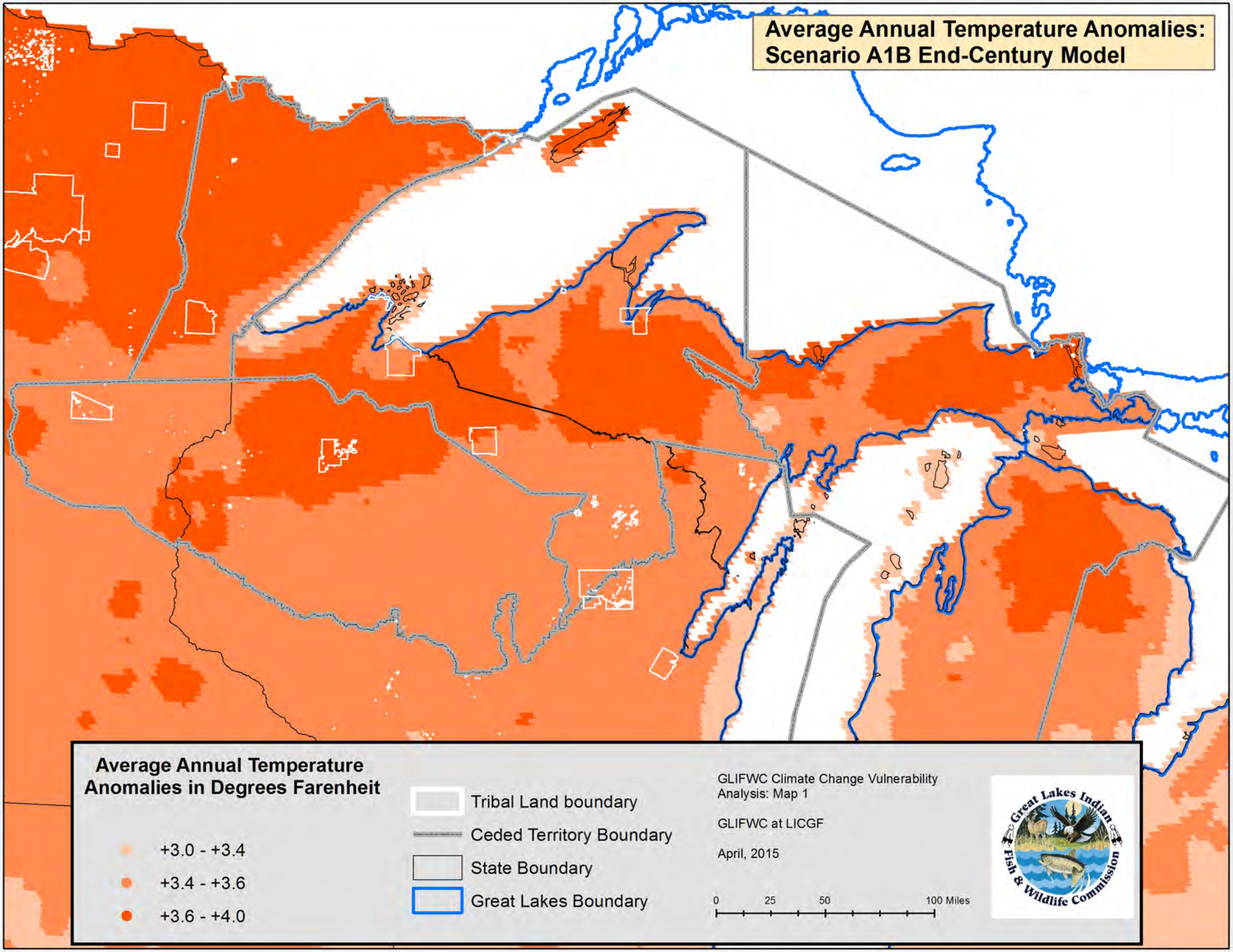
The current range encompasses the ceded territories but ends at the southernmost boundary, leaving it susceptible to northward migration, potentially eventually out of the ceded territories. In this area the warmer climates and longer growing seasons can have a “cumulative negative impact of all drivers of change. Storms, fires, invasive insects, and unsuitable climate will remove mature forests from the landscape, increasing deer populations will prevent reproduction of several species that would otherwise be resistant to the impacts of a warmer climate, including white pine, northern red oak, yellow birch, and northern white cedar”.

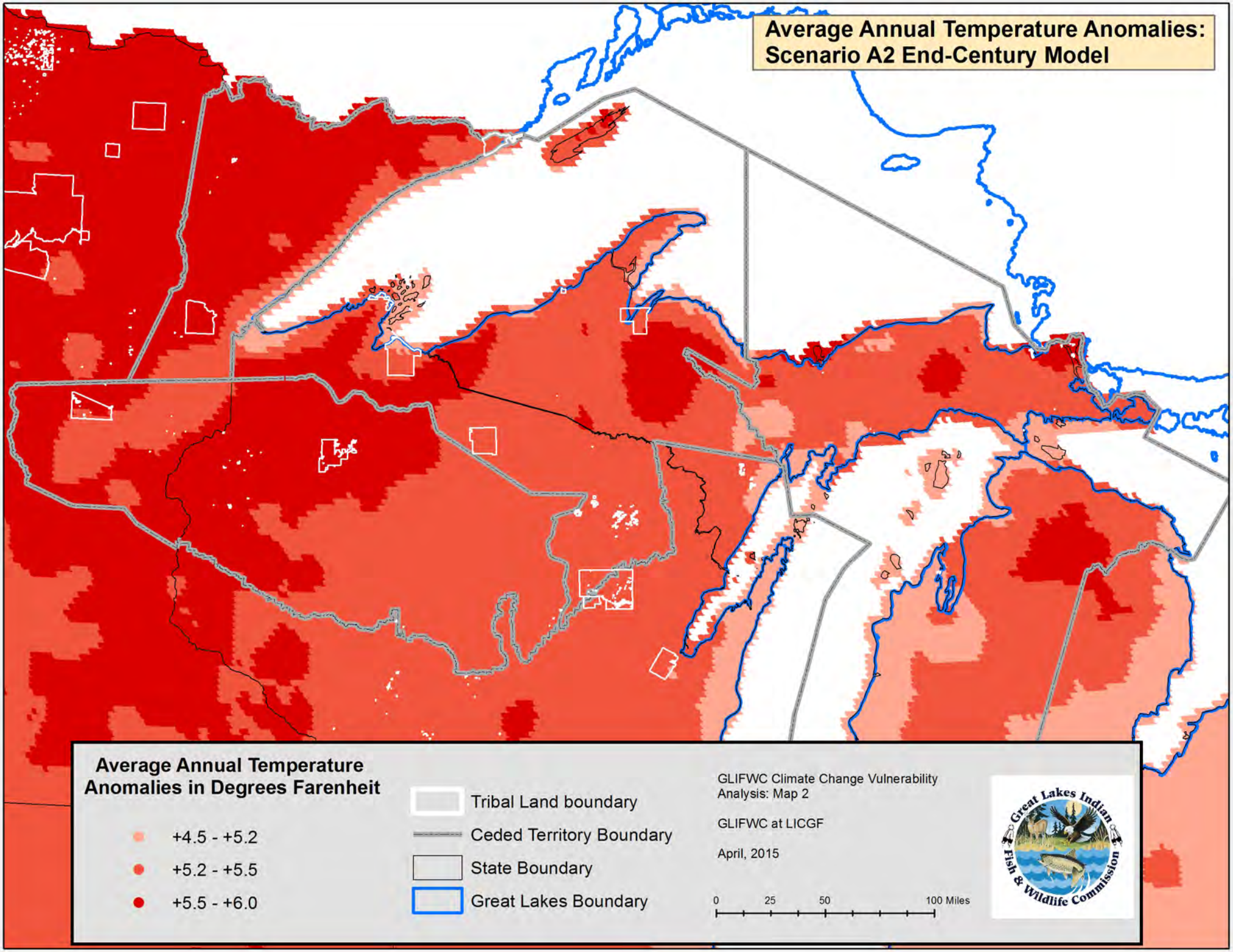
Discussion on Invasive Species

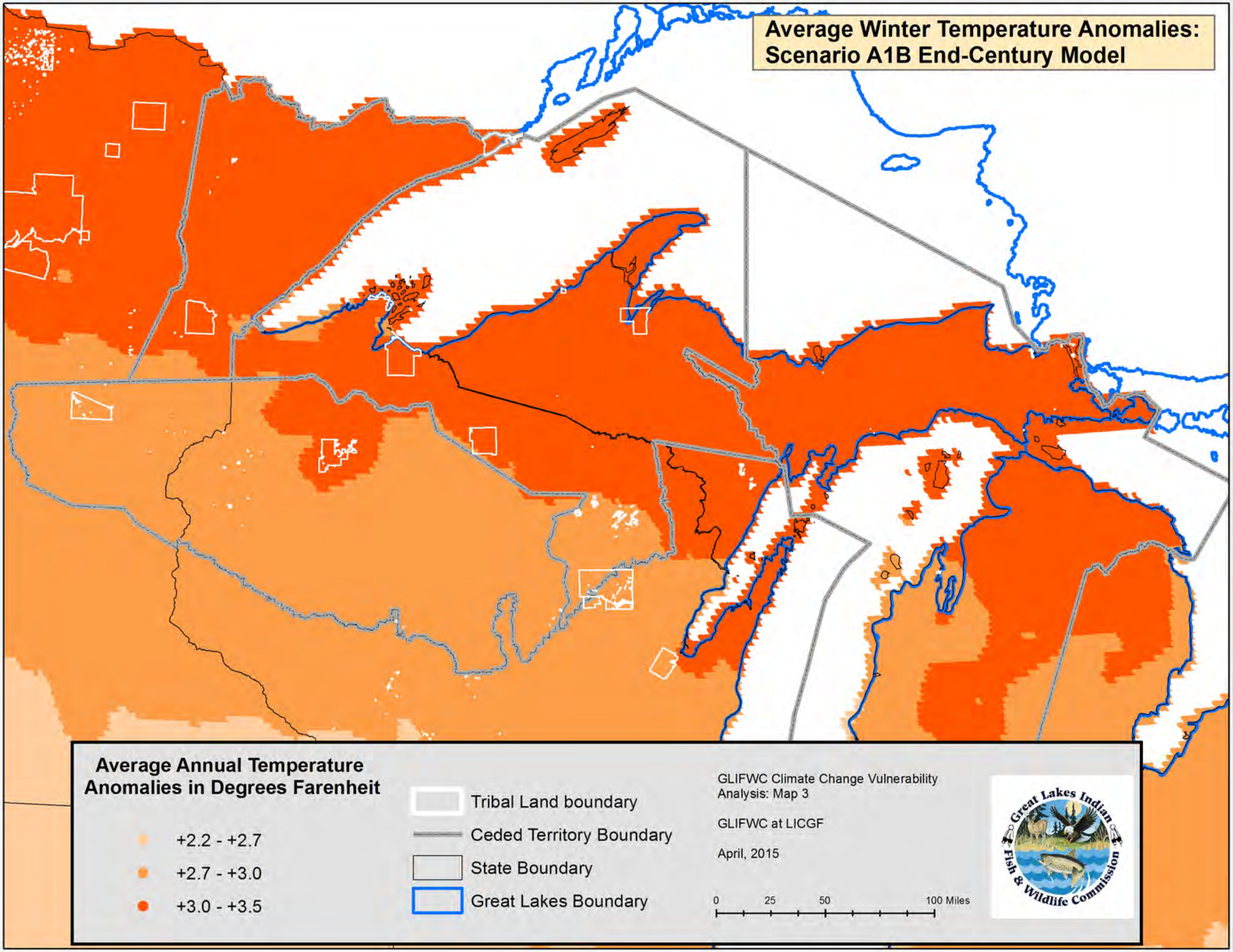
Invasive species are a non-climate stressor impacting habitats and species in the ceded territory. For example, emerald ash borer will have impacts on ash trees before the mid- and late century timeframes used in this assessment. Invasive species could create a positive feedback loop in which impacts from existing invasive species are expected to continue as climates change, and native habitats that have been degraded by invasive species become more vulnerable as climate changes. Future climates may then increase the likelihood of new infestations. For example, currently, the gypsy moth and asian carp cannot easily colonize areas of the ceded territory because they are limited by air and water temperatures. As both of these air and water temperatures rise, they may be able to invade areas farther north. This vulnerability assessment does not address invasive species in detail and additional research is needed to thoroughly assess each species and determine the potential impacts it may have on ecosystems throughout the Ceded Territories as climate change progresses.

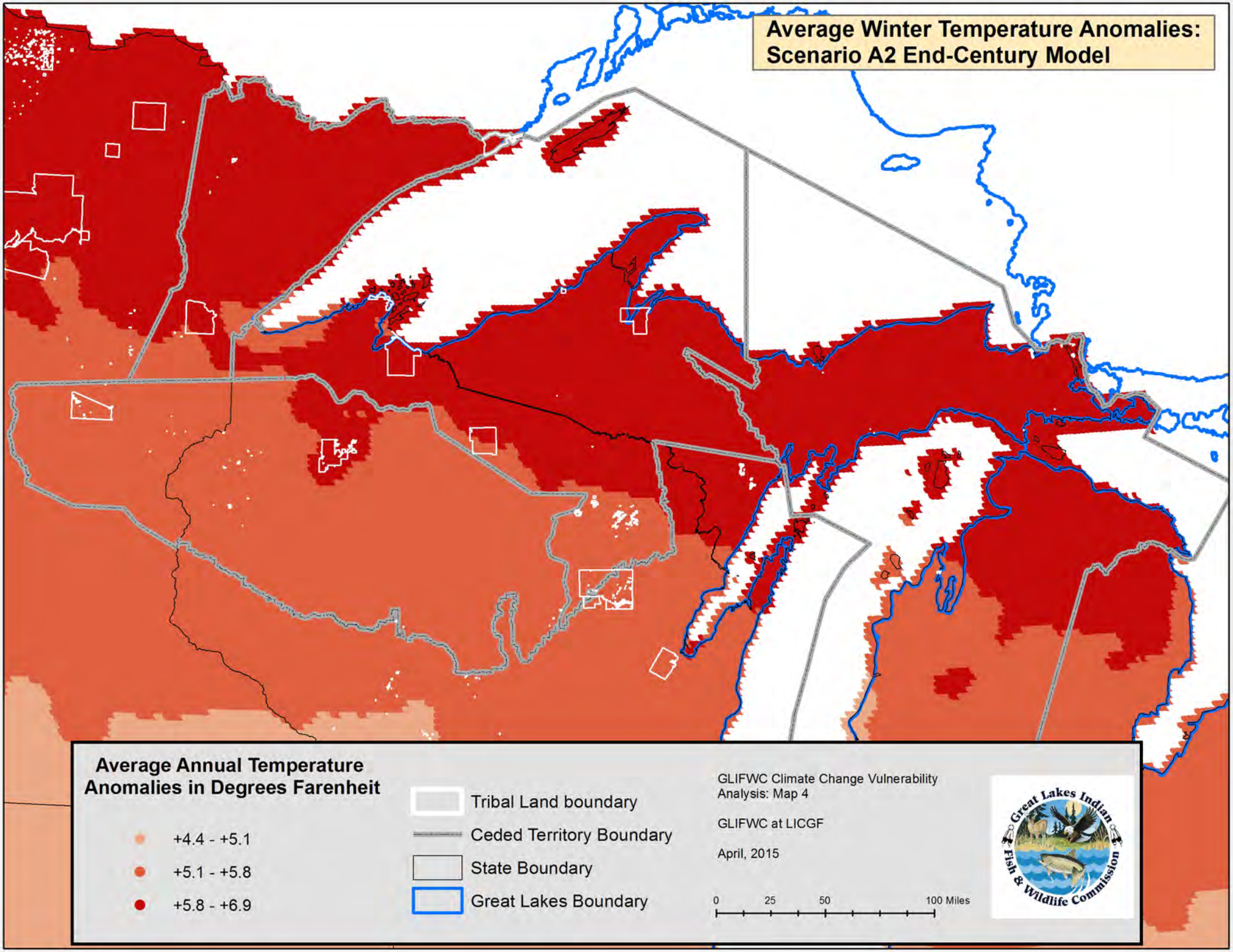
Acknowledgements

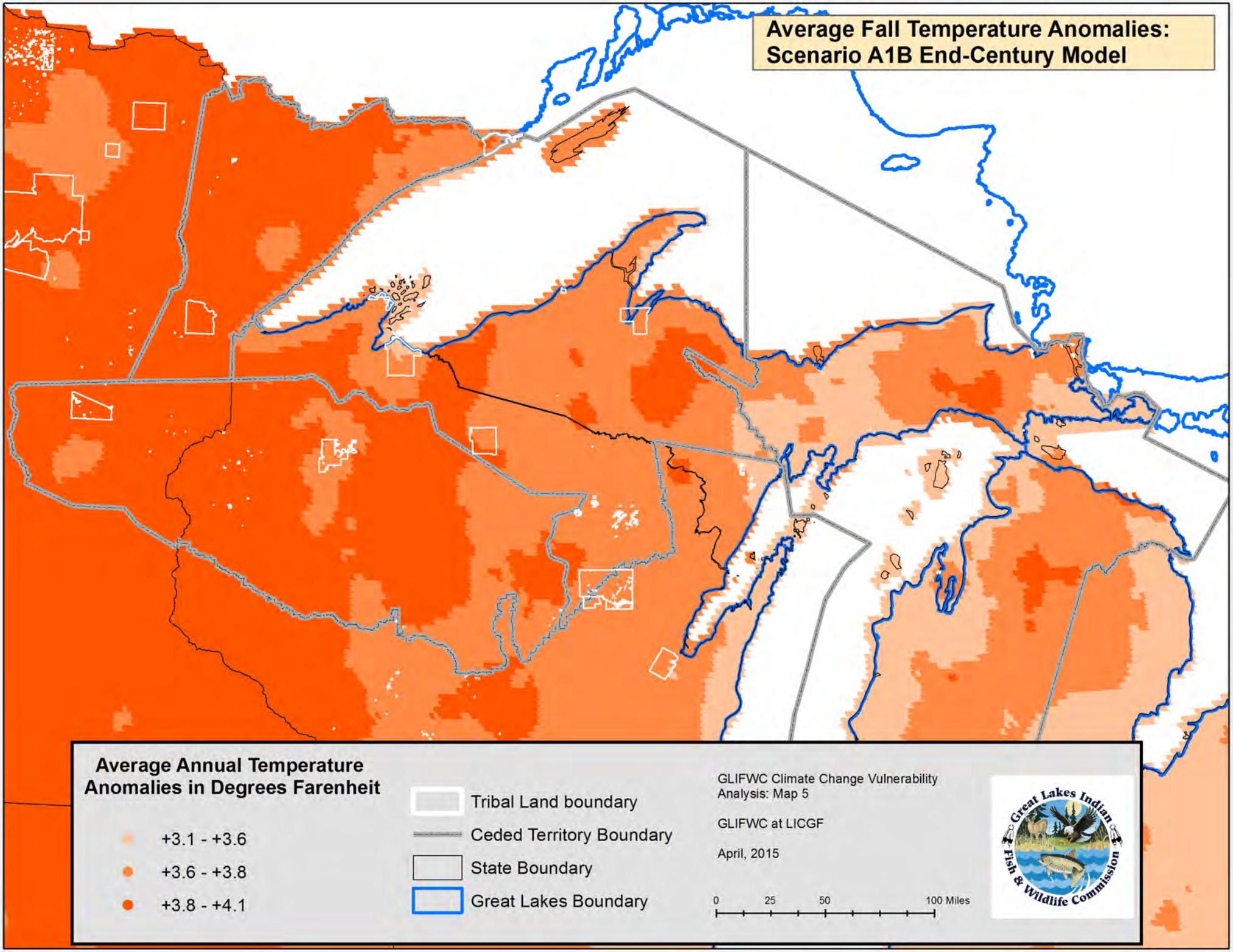
Downscaled climate change data were developed by University of Wisconsin-Madison researchers through the Wisconsin Initiative on Climate Change Impacts. Downscaled climate change data developed by the National Center for Atmospheric Research (NCAR) was also used to provide context to WICCI data. The biologic information (e.g. species range, habitat descriptions, etc) are based on the expertise of the GLIFWC wildlife section biologists.

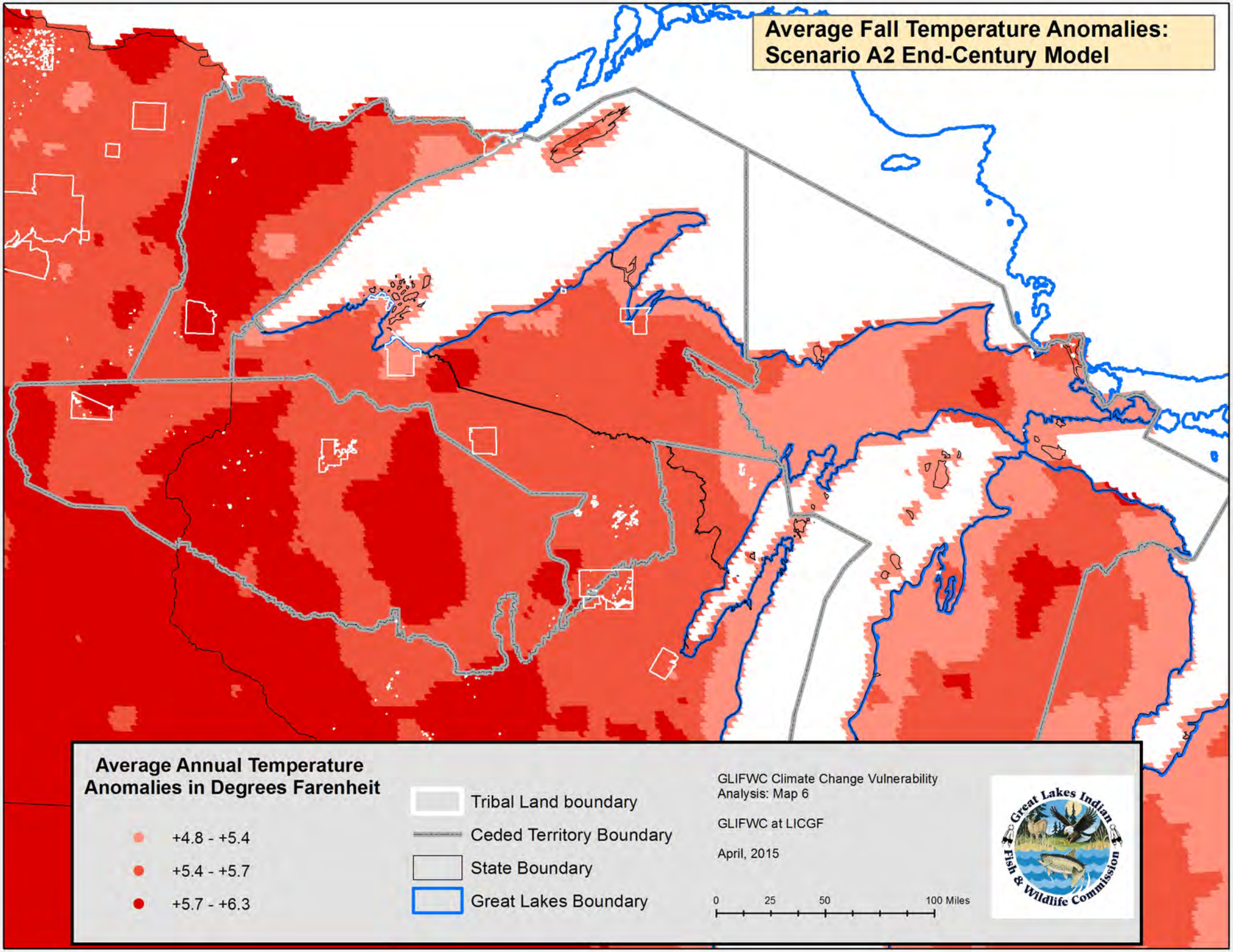

Average Annual Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+3.0 - +3.4
+3.4 - +3.6
+3.6 - +4.0
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 1
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

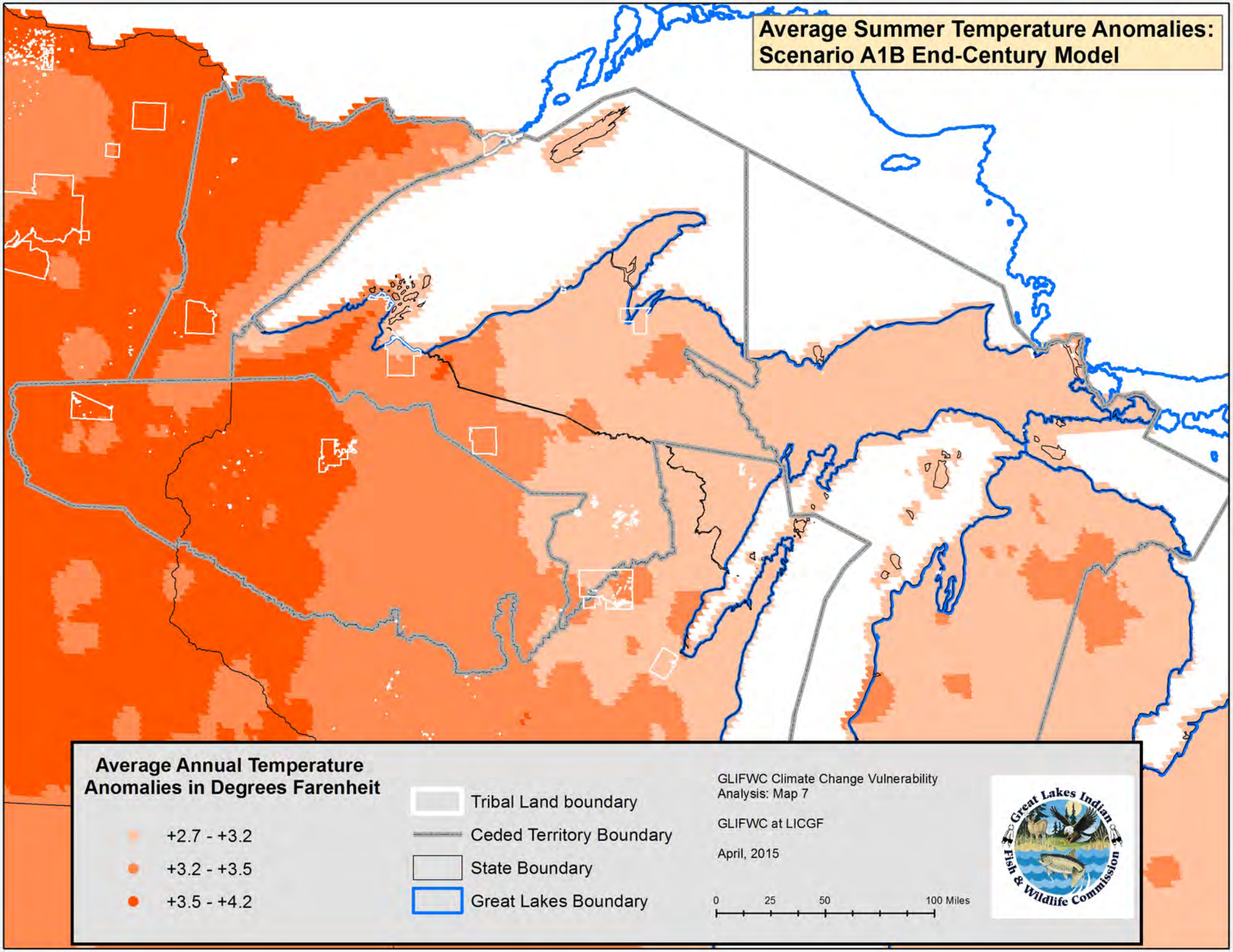

Average Annual Temperature Anomalies: Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.5 - +5.2
+5.2 - +5.5
+5.5 - +6.0
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 2
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

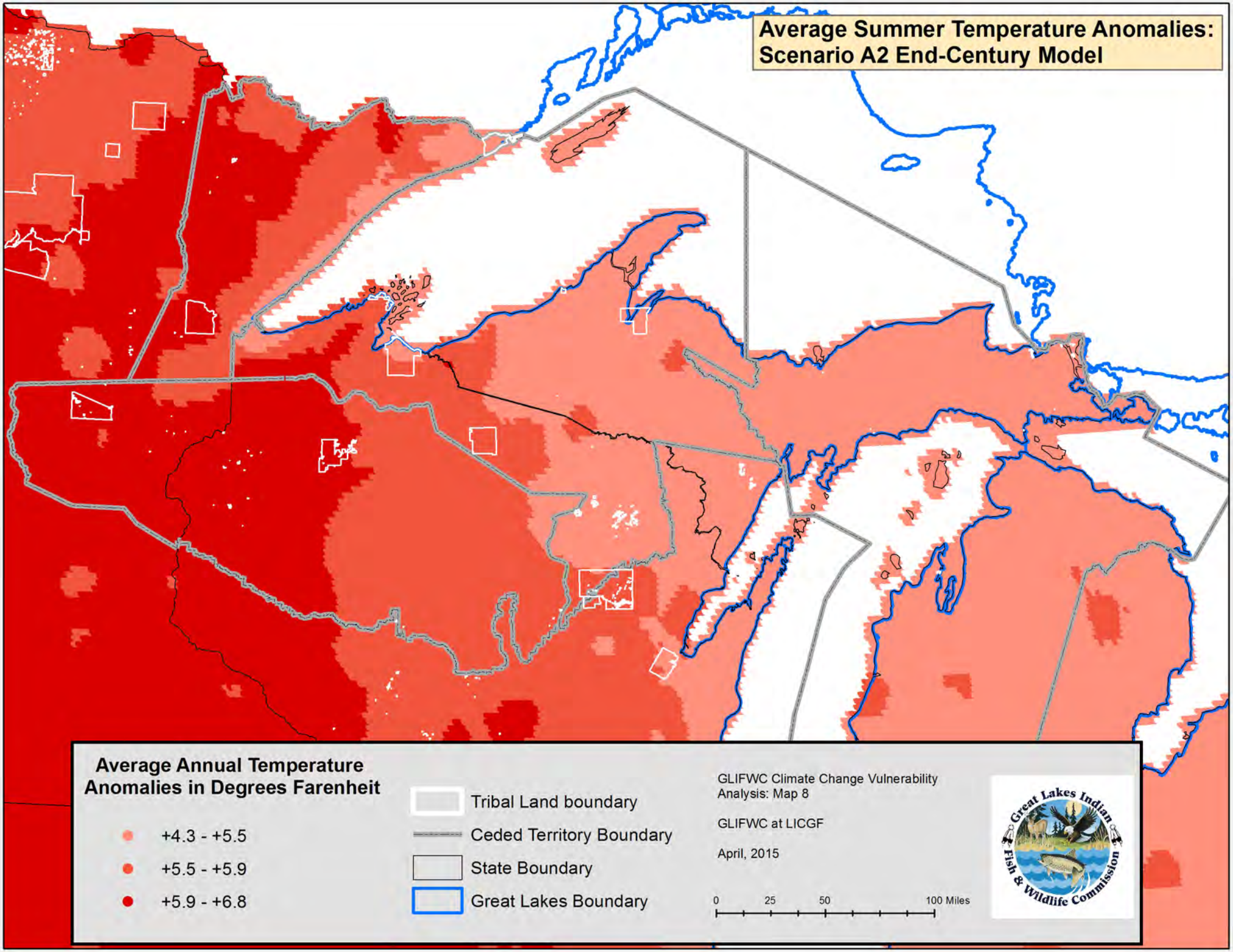

Average Winter Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature
Anomalies in Degrees Farenheit
+2.2 - +2.7
+2.7 - +3.0
+3.0 - +3.5
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability
Analysis: Map 3
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian
Fish & Wildlife Commission

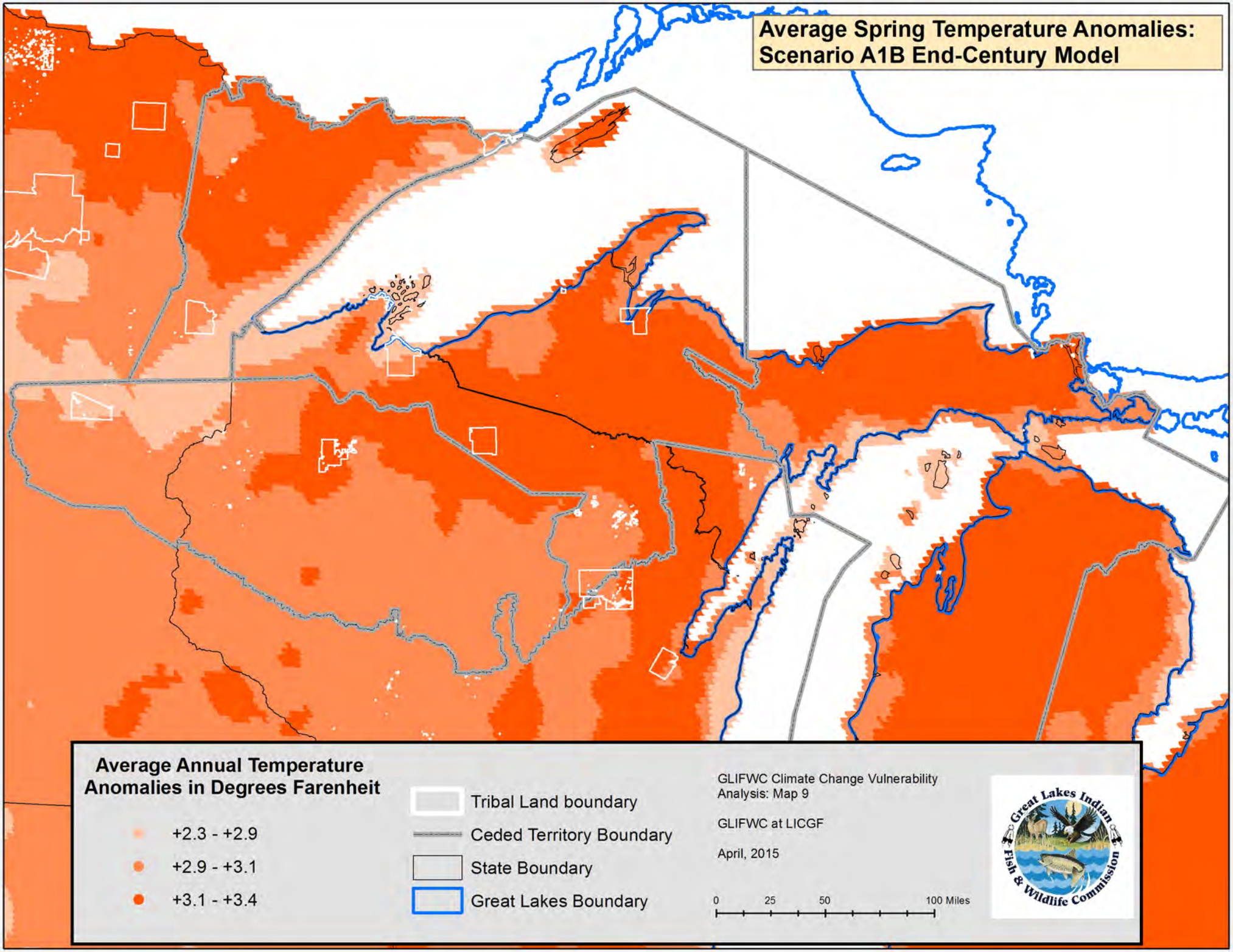

Average Winter Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.4 - +5.1
+5.1 - +5.8
+5.8 - +6.9
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 4
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

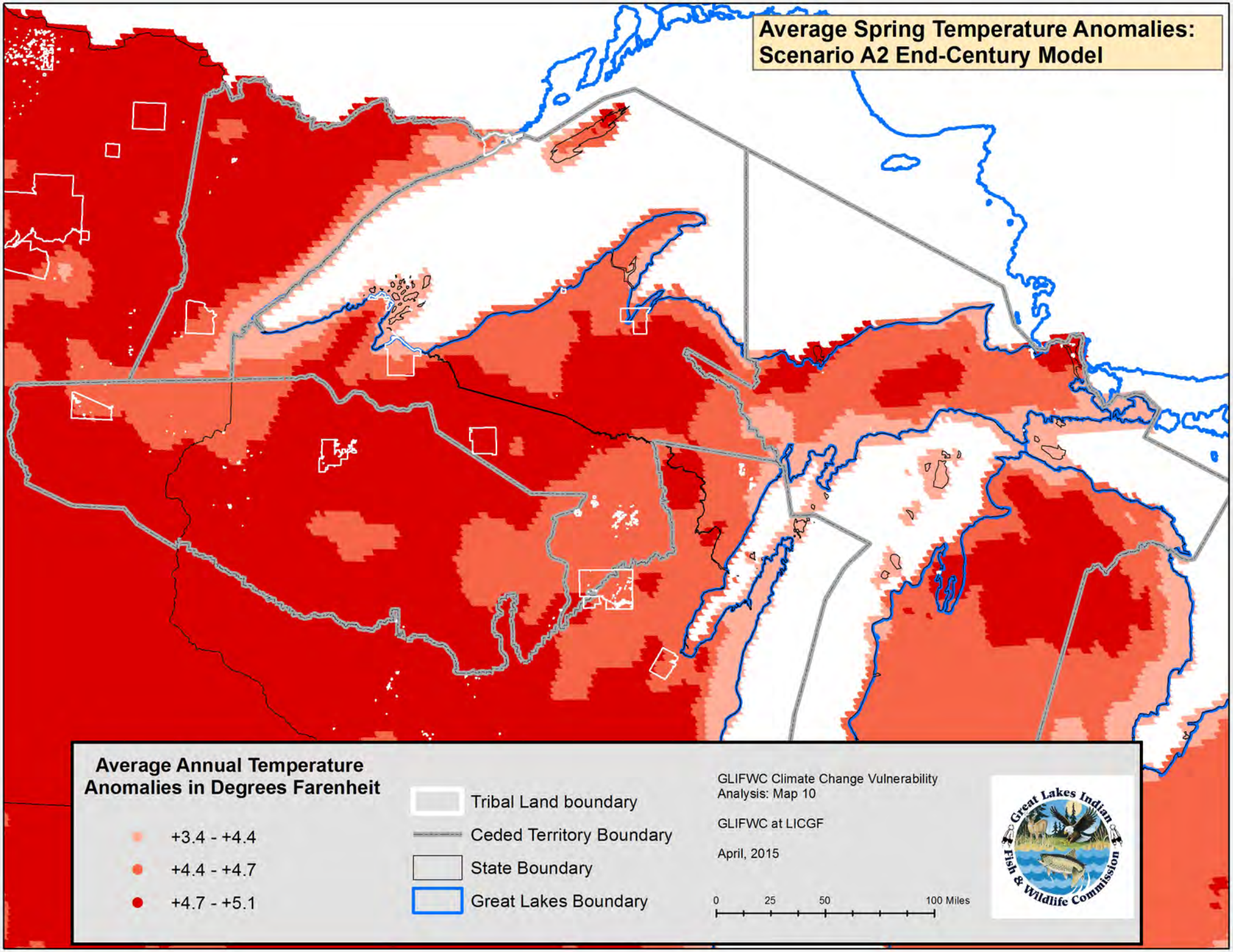

Average Fall Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+3.1 - +3.6
+3.6 - +3.8
+3.8 - +4.1
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 5
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

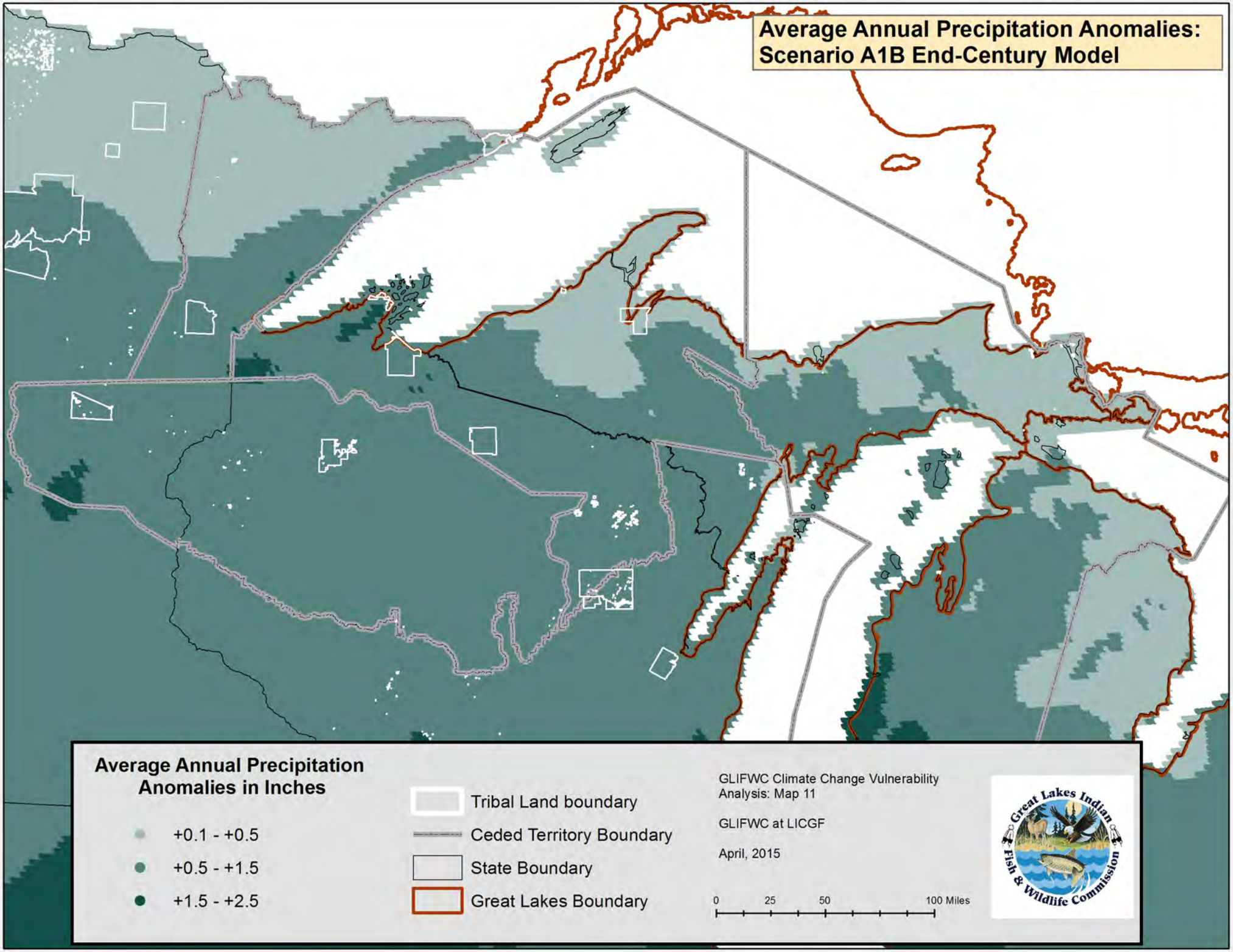

Average Fall Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.8 - +5.4
+5.4 - +5.7
+5.7 - +6.3
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 6
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

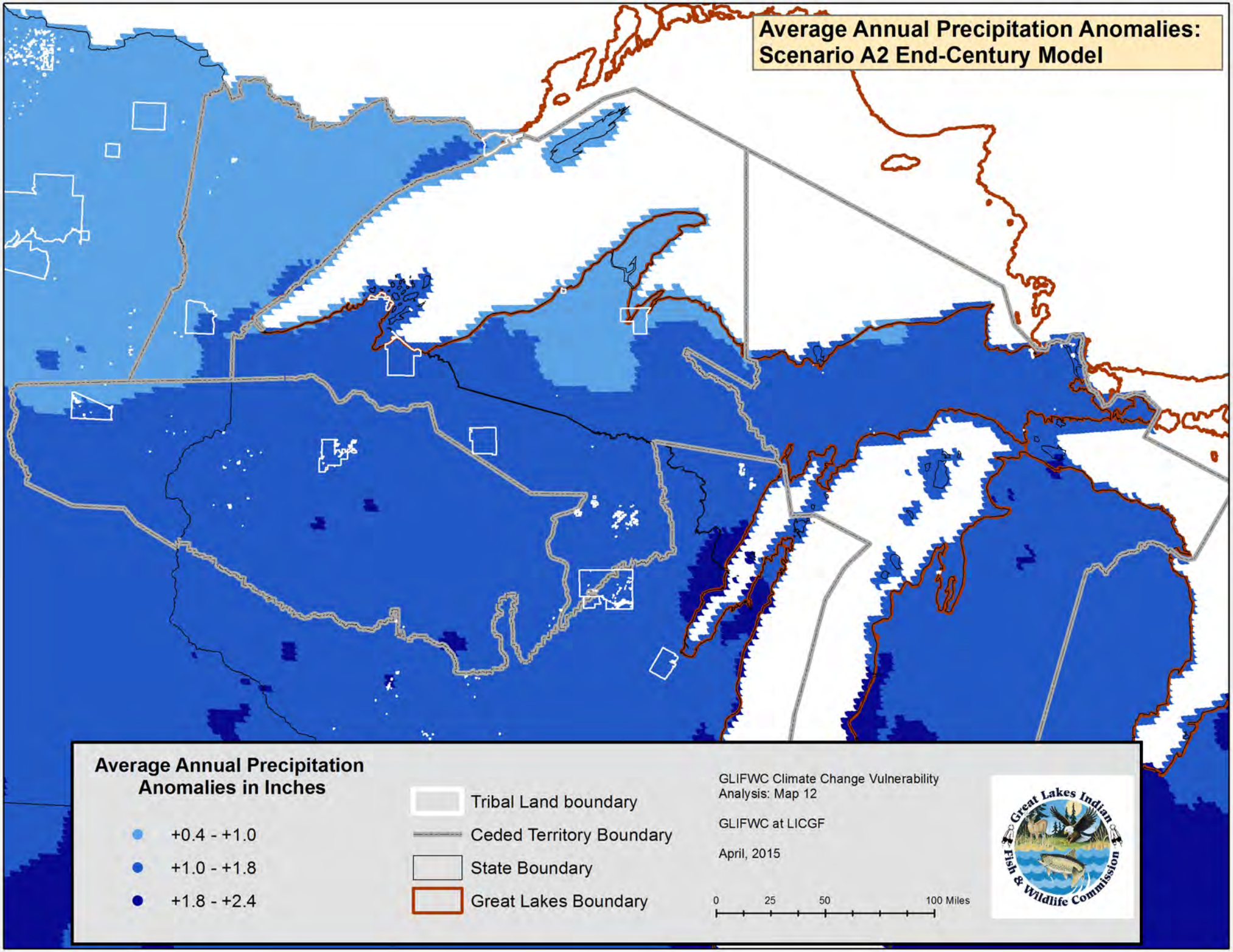

Average Summer Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature
Anomalies in Degrees Farenheit
+2.7 - +3.2
+3.2 - +3.5
+3.5 - +4.2
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability
Analysis: Map 7
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian
Fish & Wildlife Commission

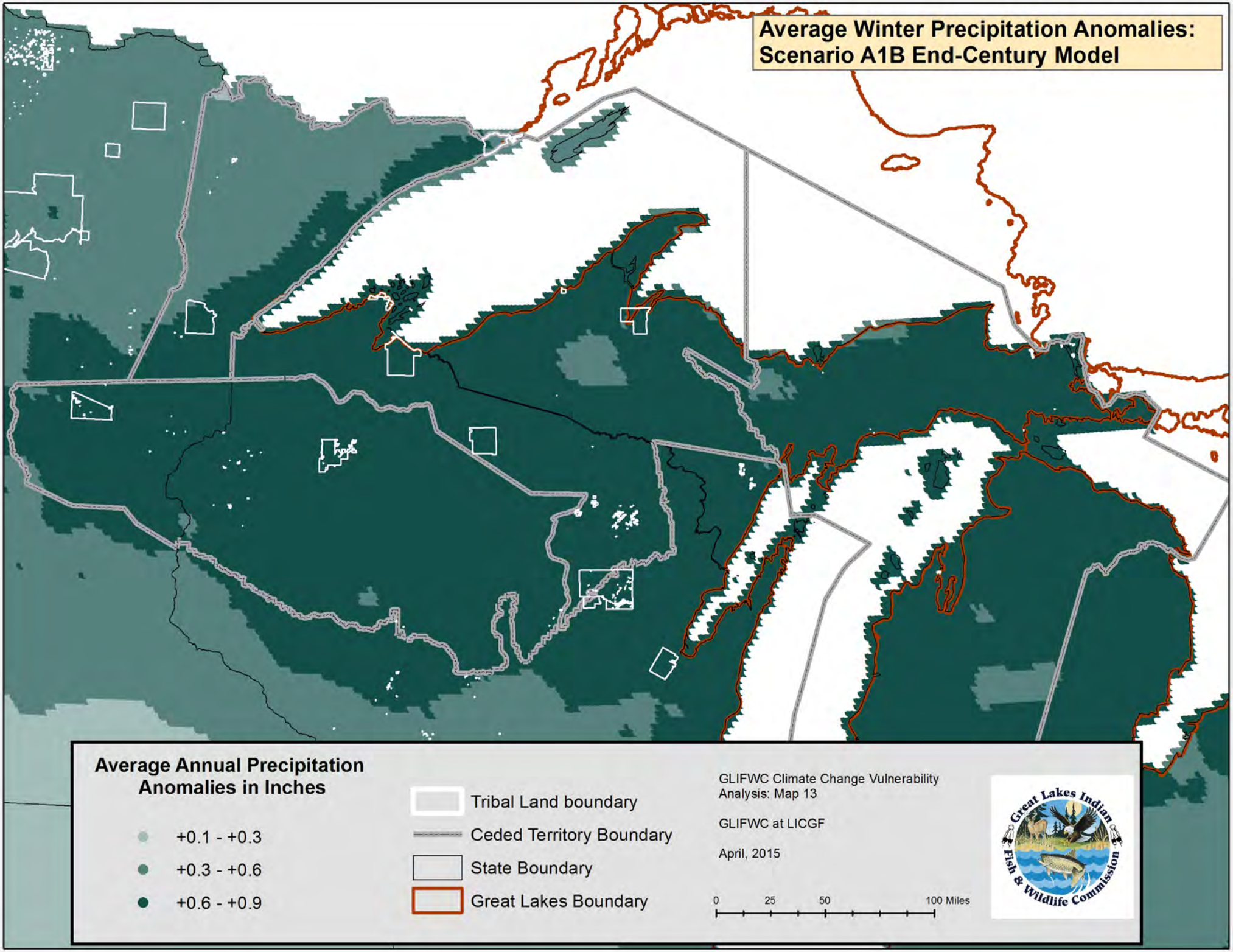

Average Summer Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.3 - +5.5
+5.5 - +5.9
+5.9 - +6.8
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 8
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

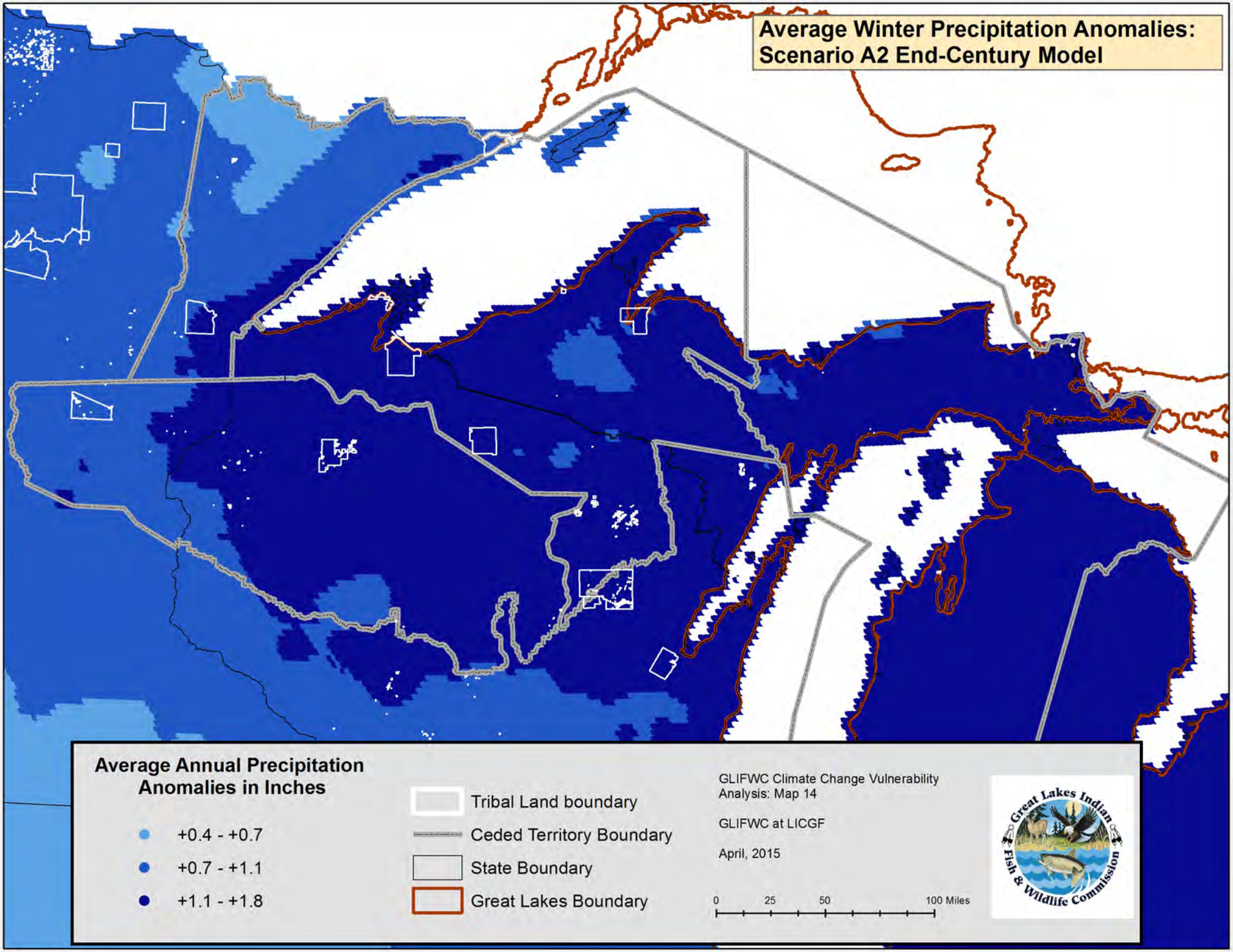

Average Spring Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature
Anomalies in Degrees Farenheit
+2.3 - +2.9
+2.9 - +3.1
+3.1 - +3.4
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability
Analysis: Map 9
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian
Fish & Wildlife Commission

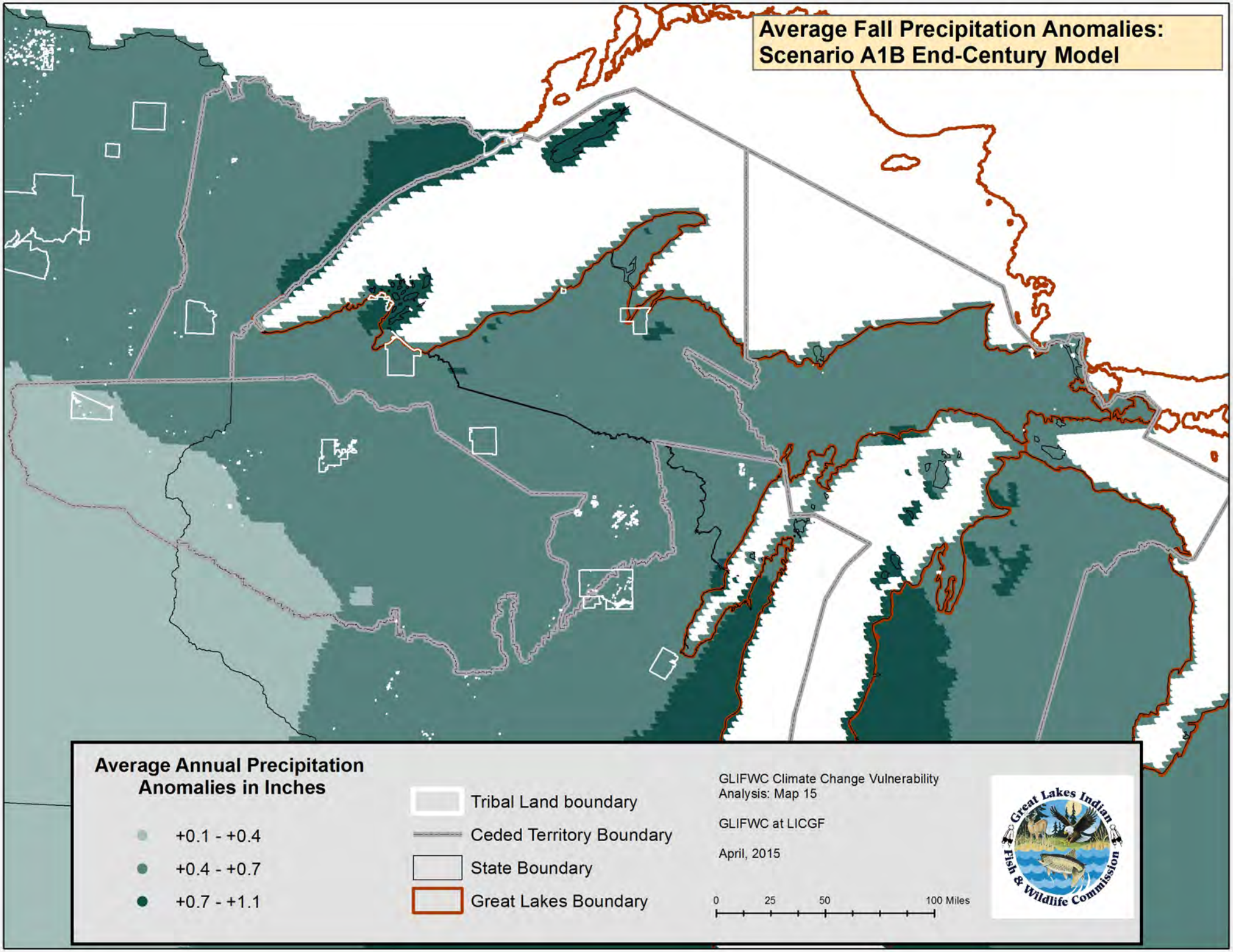

Average Spring Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature
Anomalies in Degrees Farenheit
+3.4 - +4.4
+4.4 - +4.7
+4.7 - +5.1
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability
Analysis: Map 10
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian
Fish & Wildlife Commission

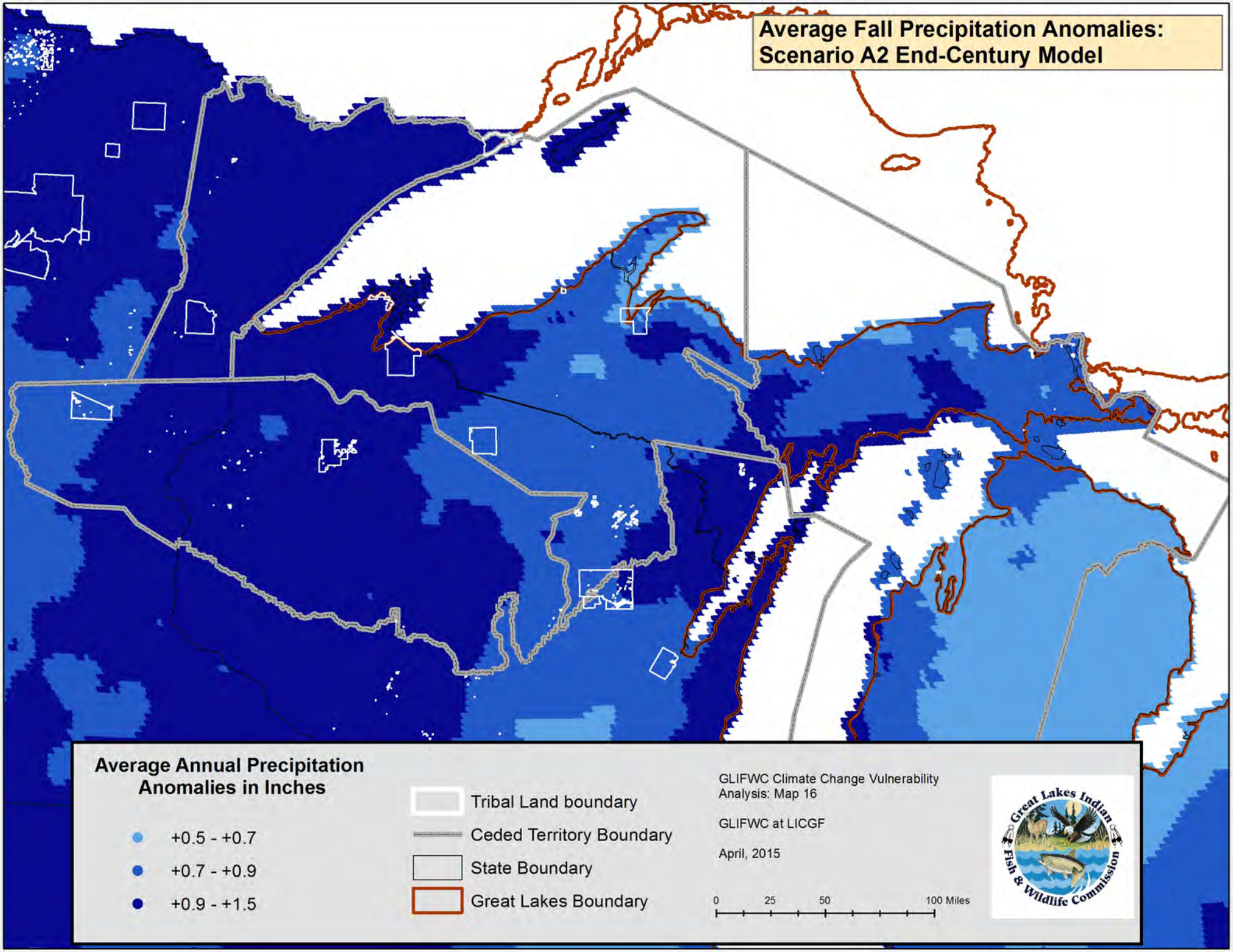

Average Annual Precipitation Anomalies: Scenario A1B End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.1 - +0.5
+0.5 - +1.5
+1.5 - +2.5
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 11
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

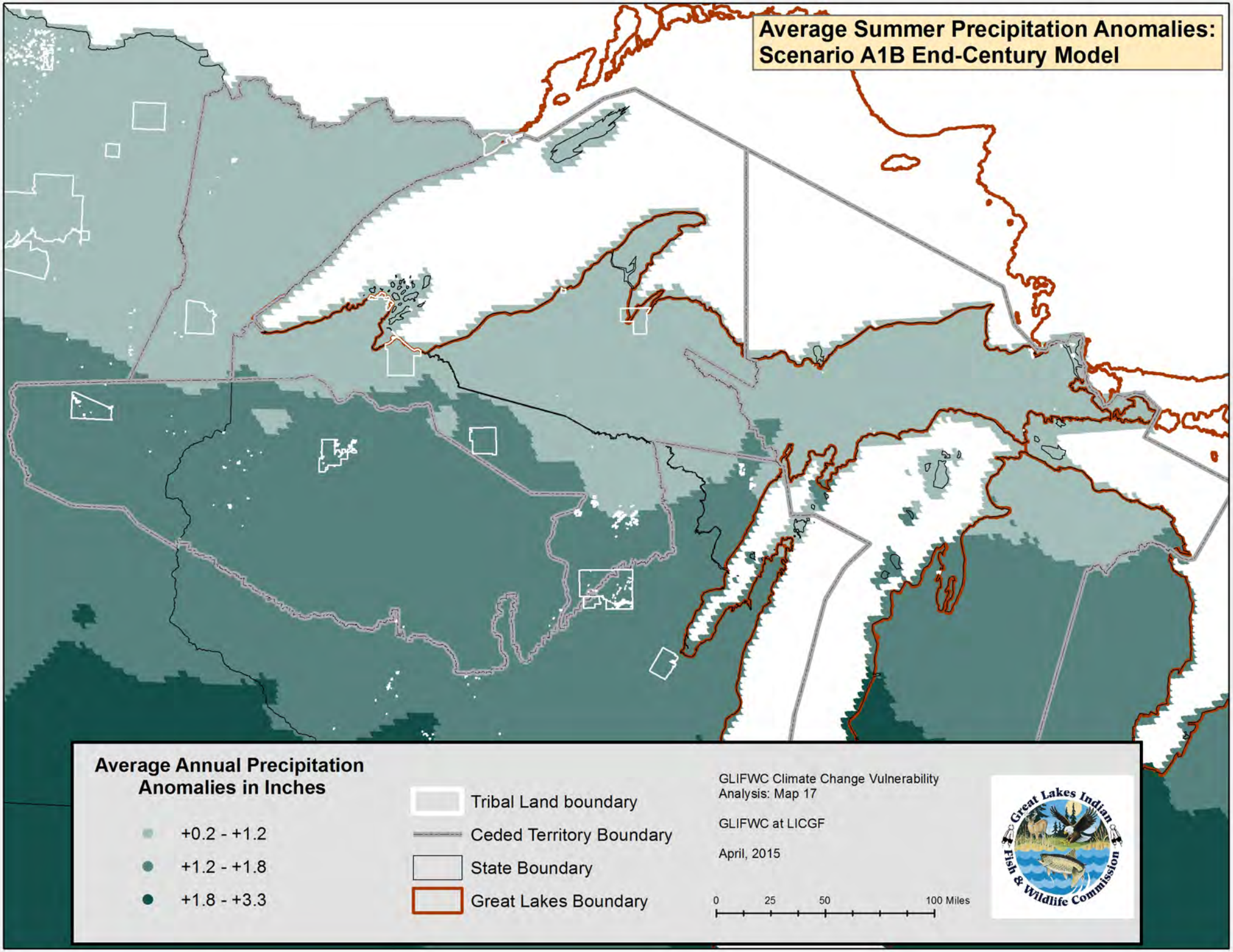

Average Annual Precipitation Anomalies: Scenario A2 End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.4 - +1.0
+1.0 - +1.8
+1.8 - +2.4
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 12
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

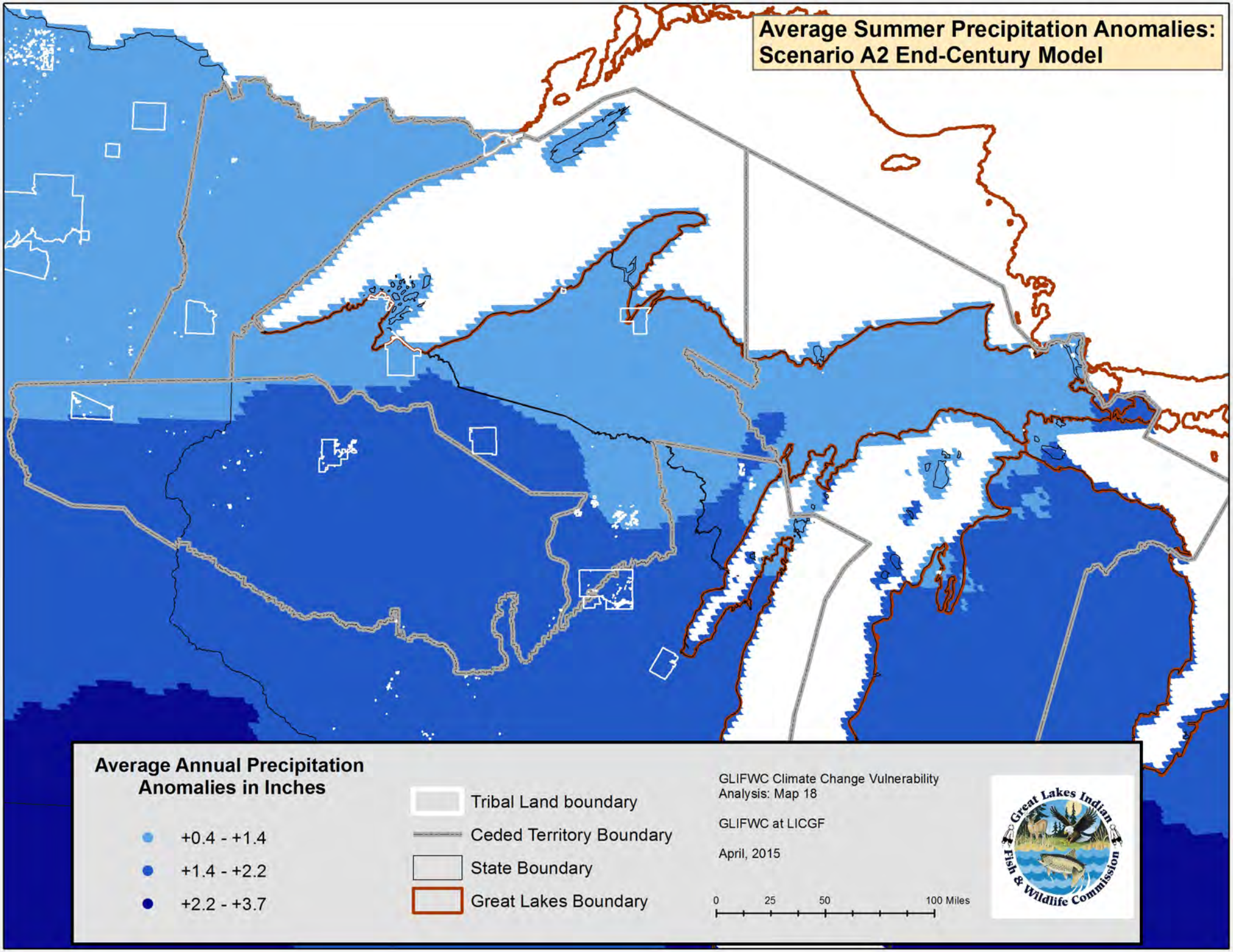

Average Winter Precipitation Anomalies:
Scenario A1B End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.1 - +0.3
+0.3 - +0.6
+0.6 - +0.9
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 13
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

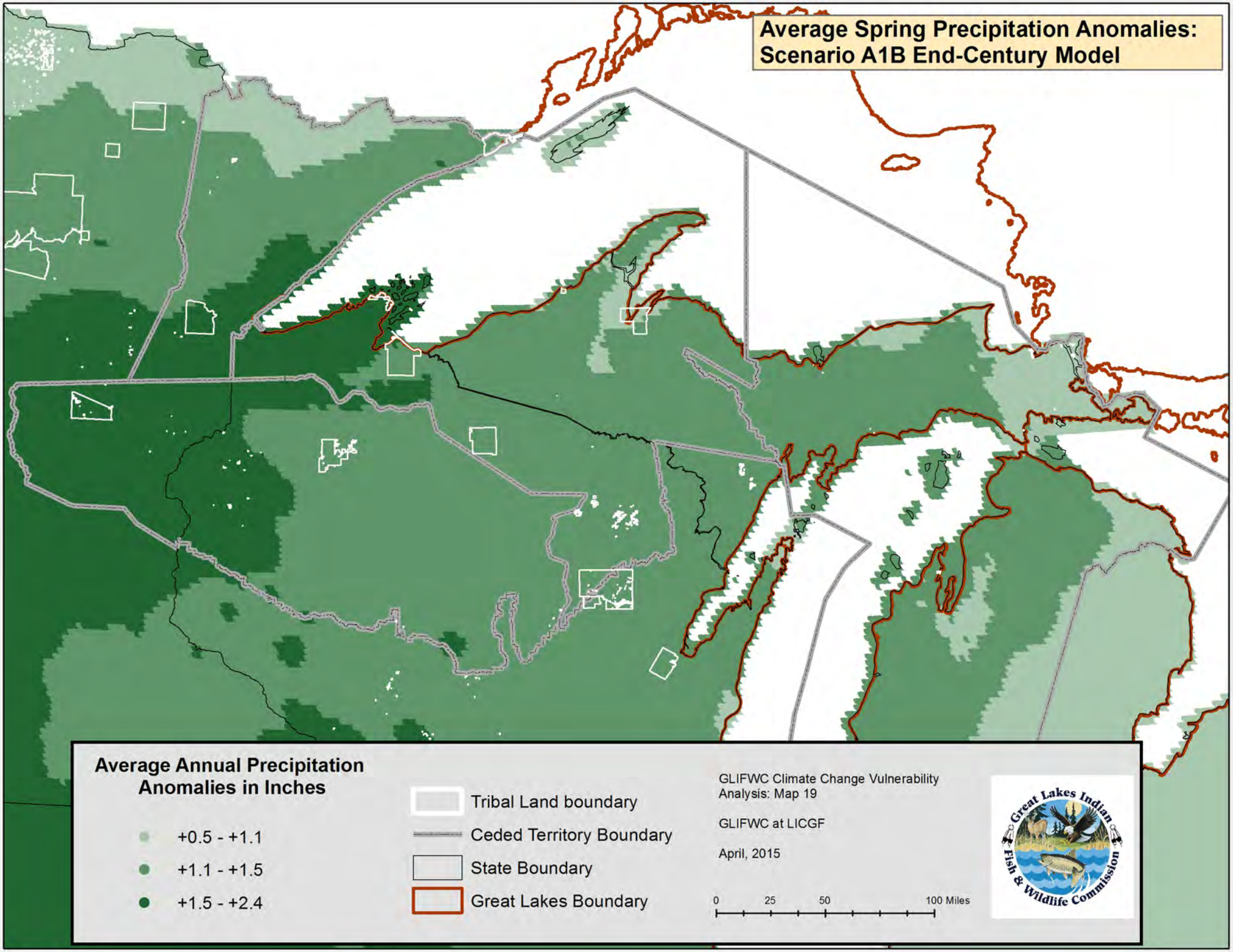

Average Winter Precipitation Anomalies:
Scenario A2 End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.4 - +0.7
+0.7 - +1.1
+1.1 - +1.8
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 14
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

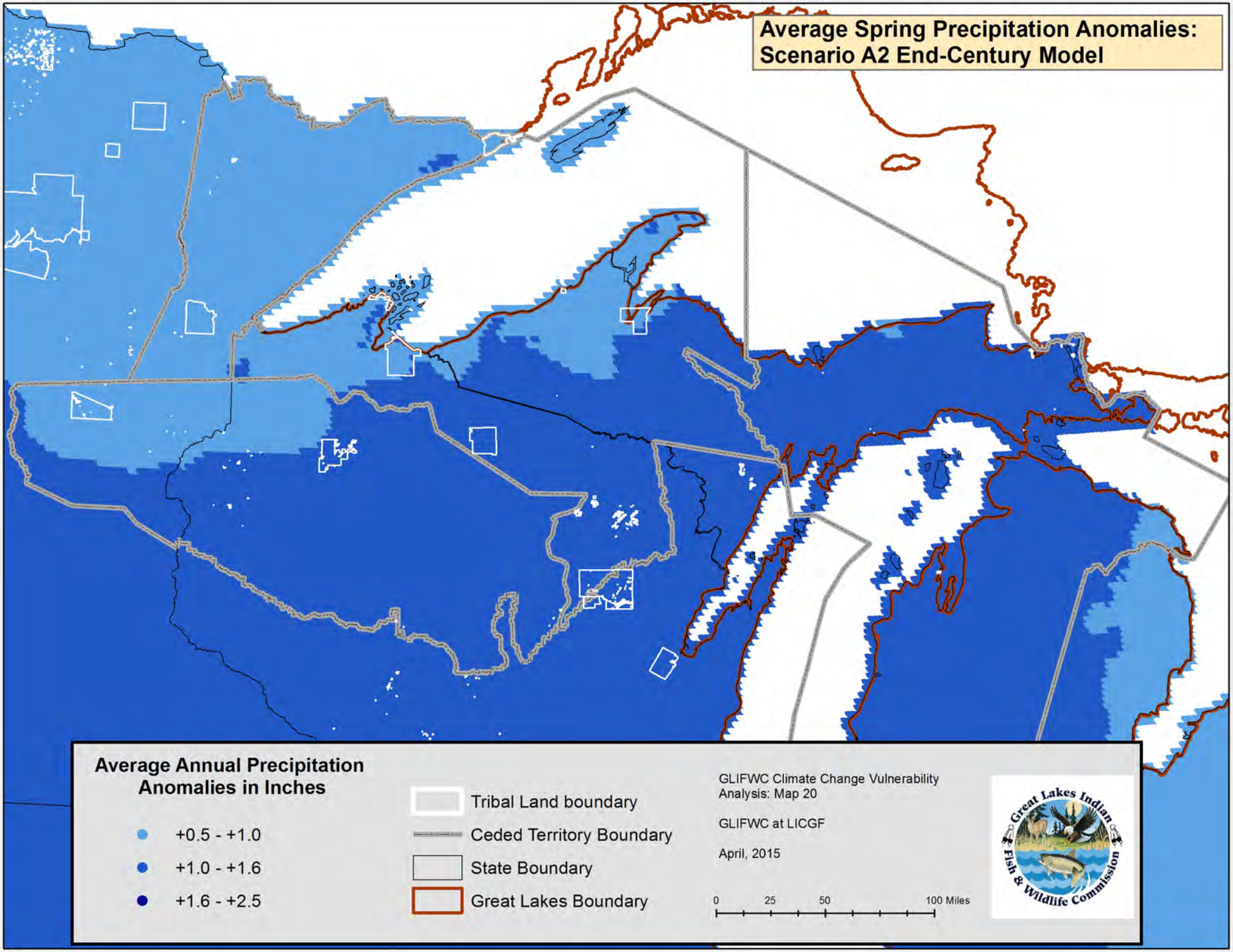

Average Fall Precipitation Anomalies:
Scenario A1B End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.1 - +0.4
+0.4 - +0.7
+0.7 - +1.1
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 15
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

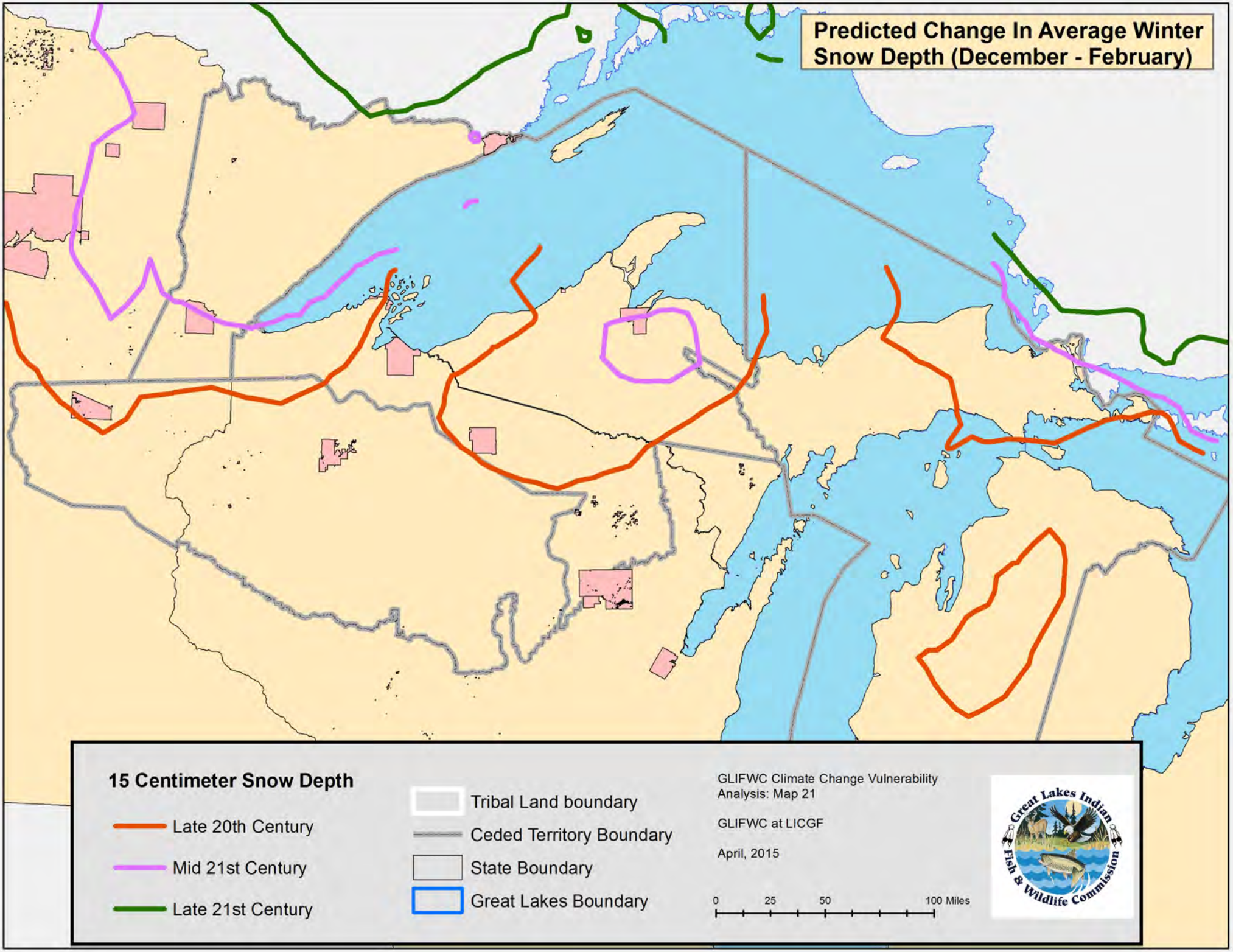

Average Fall Precipitation Anomalies:
Scenario A2 End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.5 - +0.7
+0.7 - +0.9
+0.9 - +1.5
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 16
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

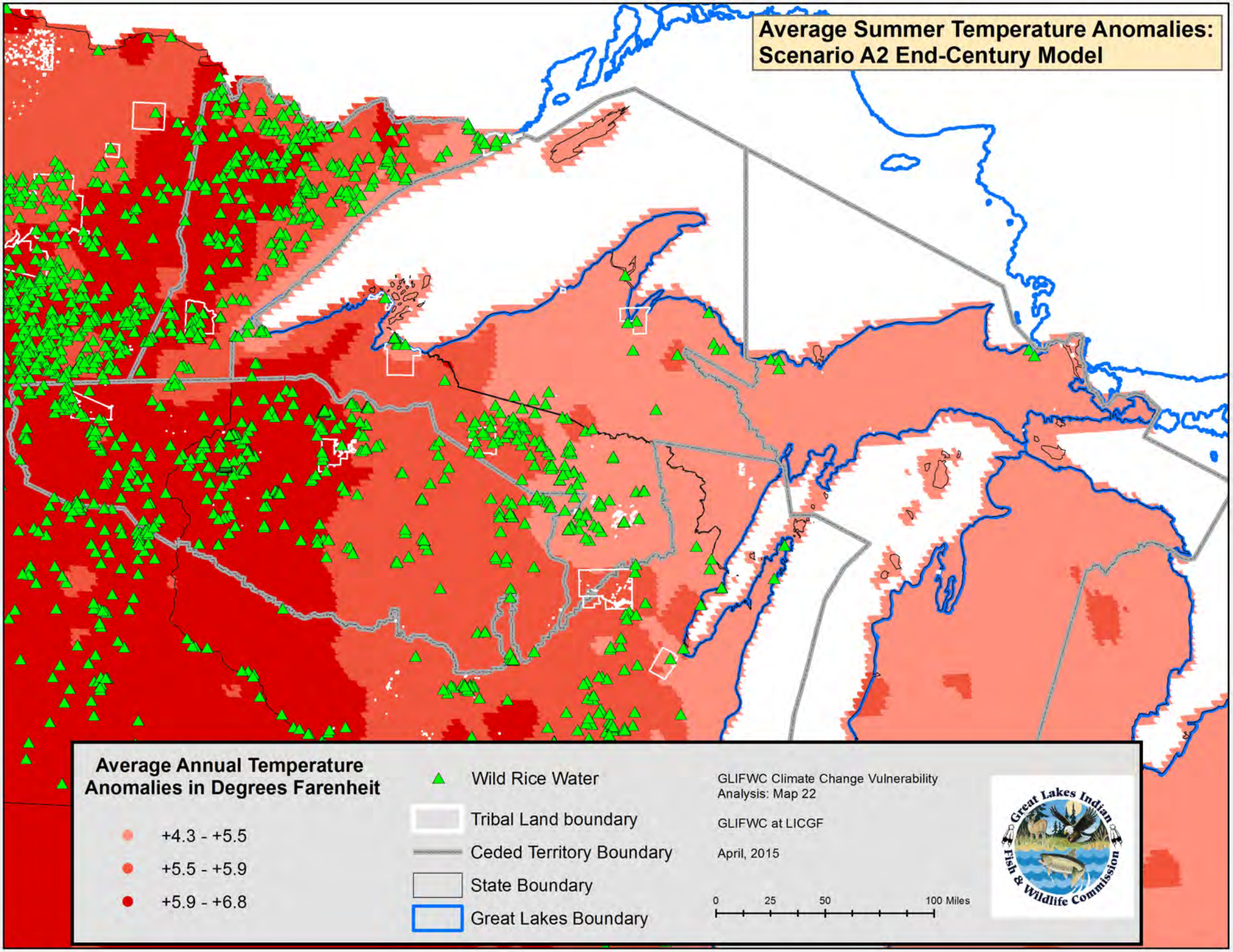

Average Summer Precipitation Anomalies:
Scenario A1B End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.2 - +1.2
+1.2 - +1.8
+1.8 - +3.3
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 17
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

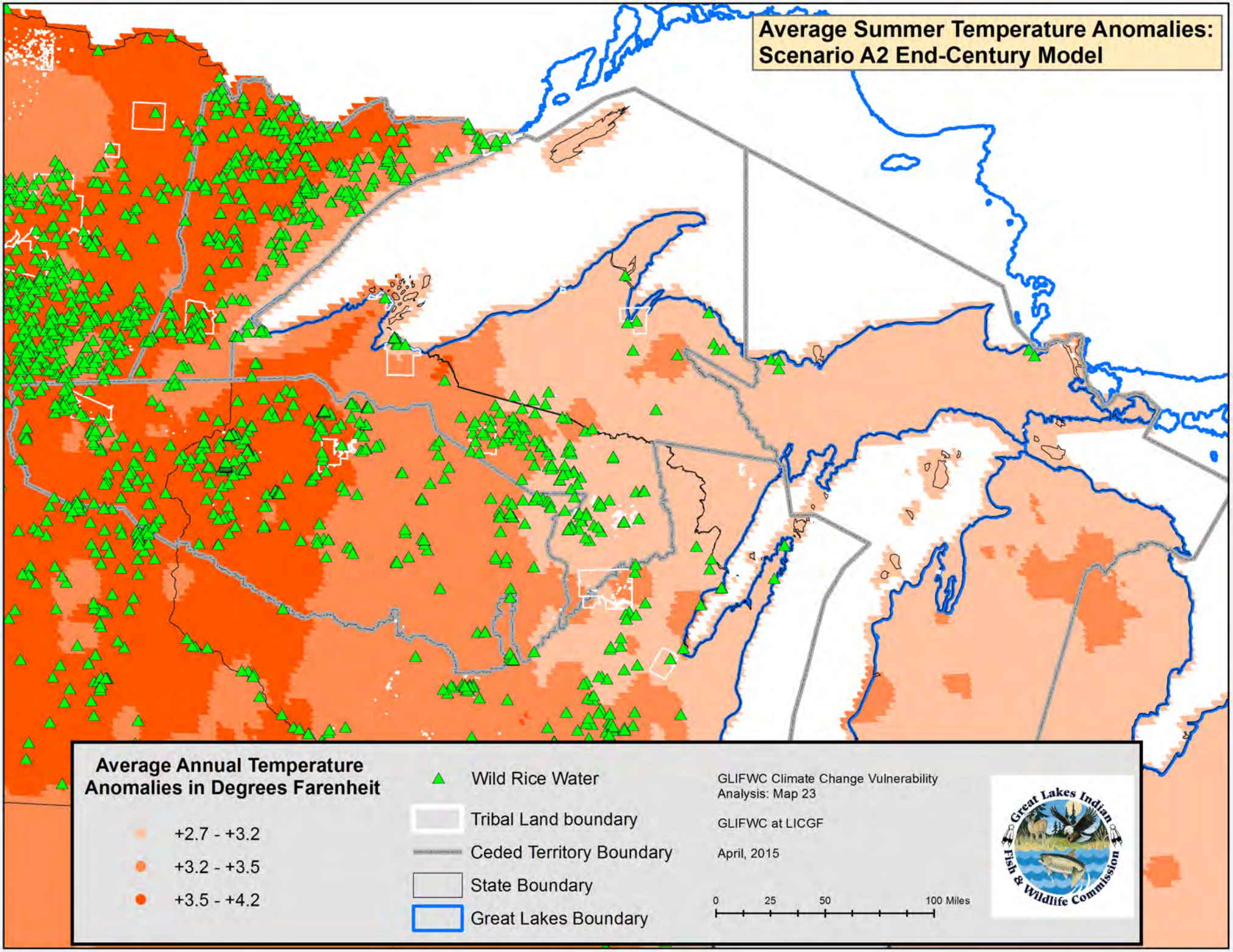

Average Summer Precipitation Anomalies:
Scenario A2 End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.4 - +1.4
+1.4 - +2.2
+2.2 - +3.7
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 18
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

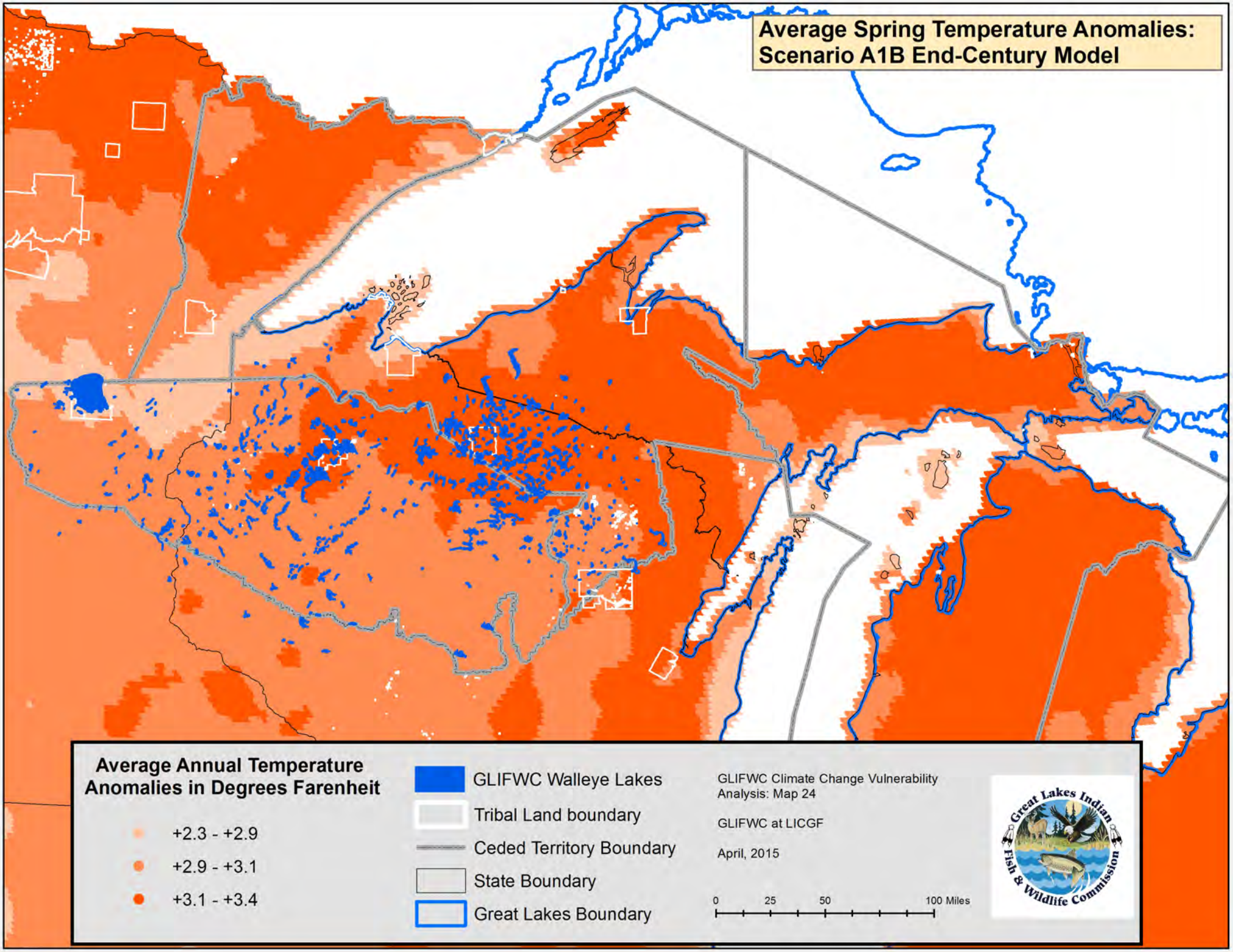

Average Spring Precipitation Anomalies:
Scenario A1B End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.5 - +1.1
+1.1 - +1.5
+1.5 - +2.4
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 19
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

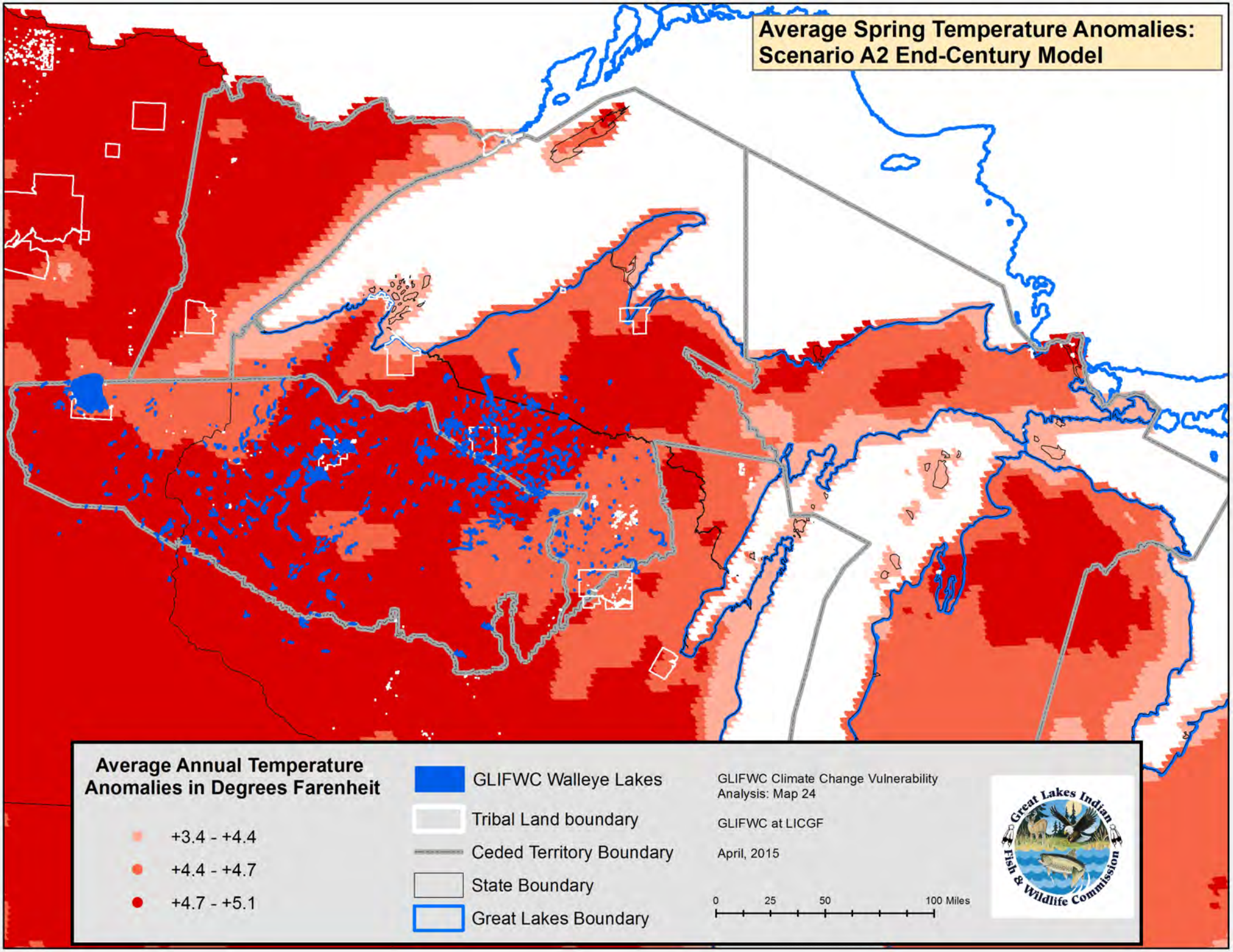

Average Spring Precipitation Anomalies:
Scenario A2 End-Century Model
Average Annual Precipitation Anomalies in Inches
+0.5 - +1.0
+1.0 - +1.6
+1.6 - +2.5
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 20
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

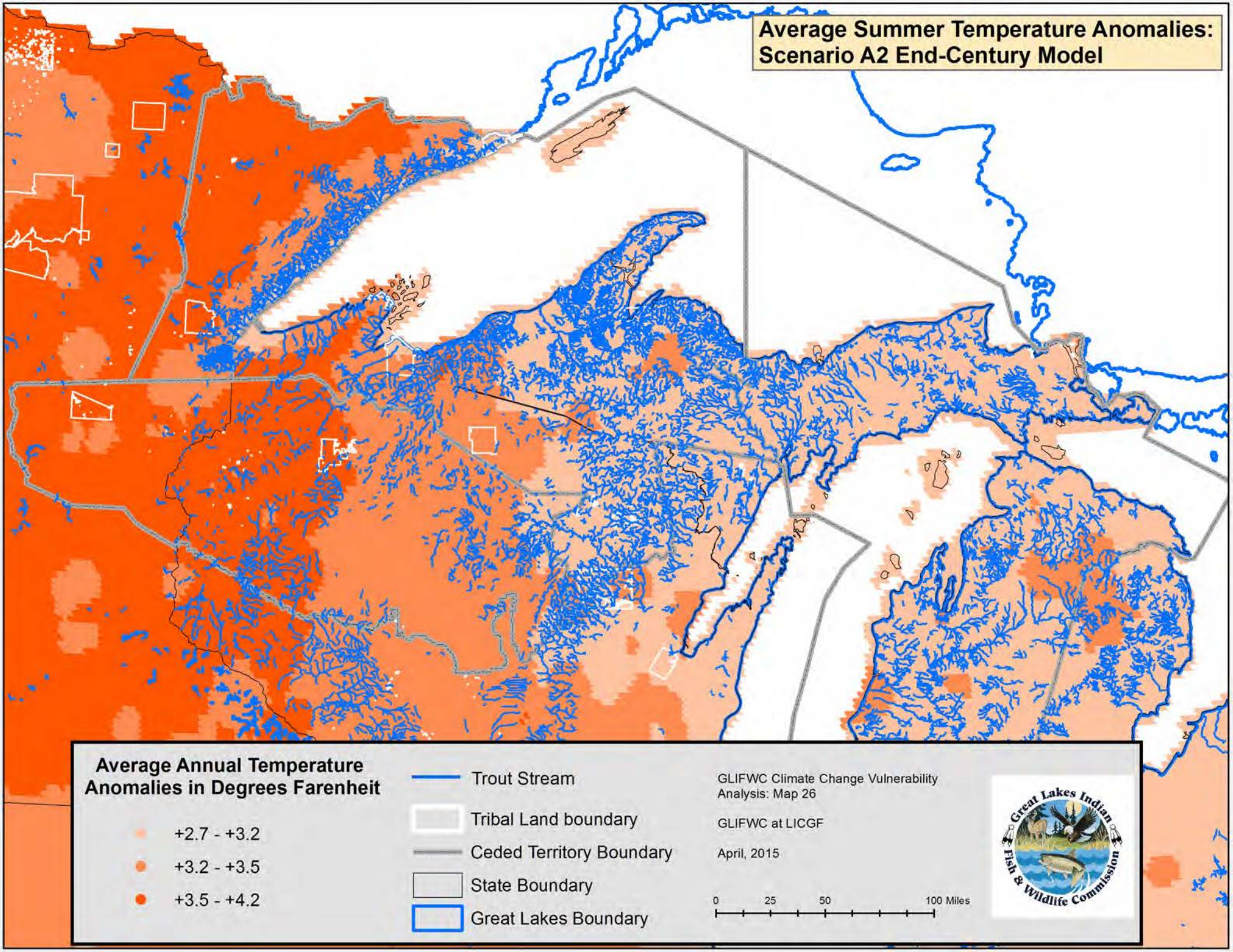

Predicted Change In Average Winter Snow Depth (December - February)
15 Centimeter Snow Depth
Late 20th Century
Mid 21st Century
Late 21st Century
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 21
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

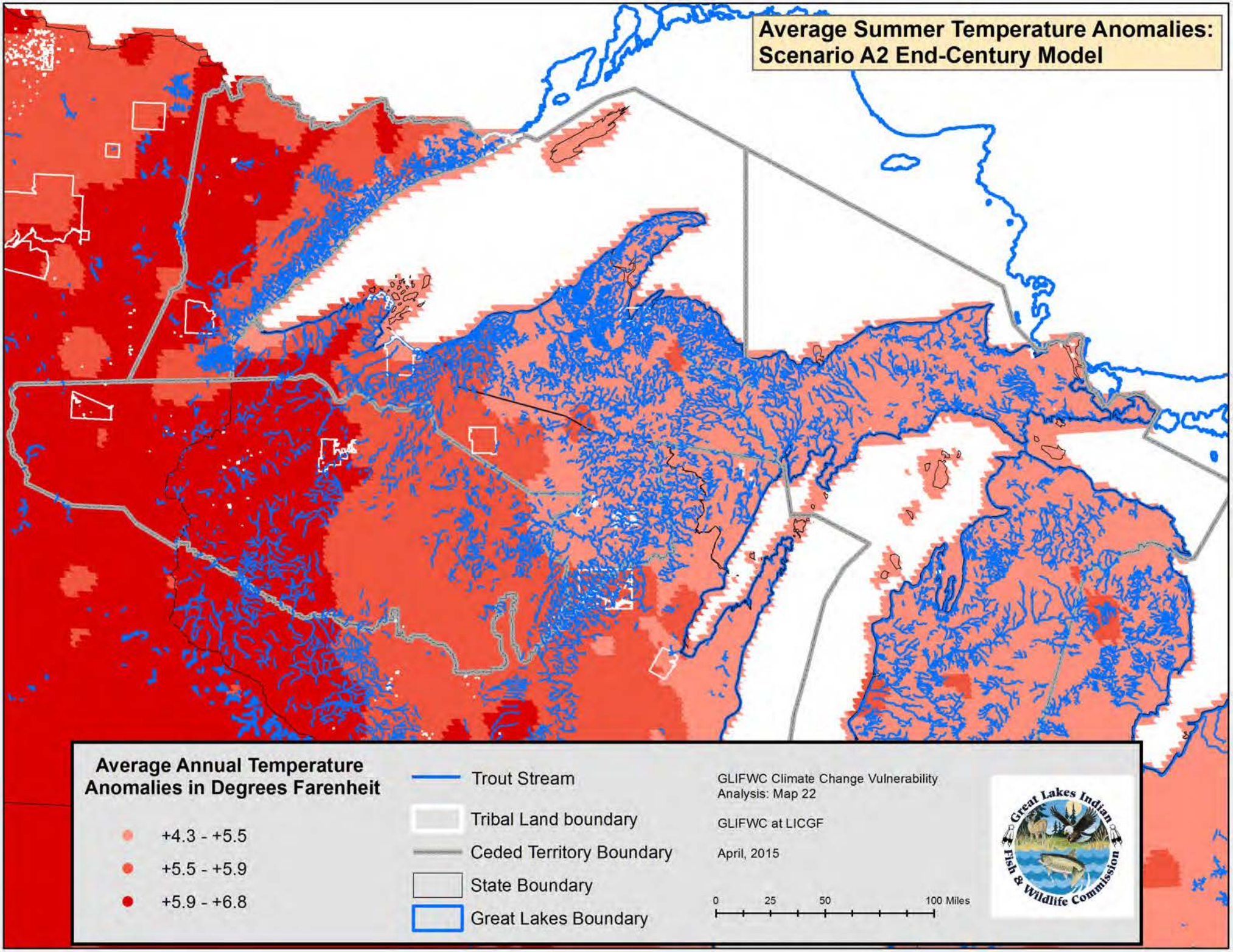

Average Summer Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.3 - +5.5
+5.5 - +5.9
+5.9 - +6.8
Wild Rice Water
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 22
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

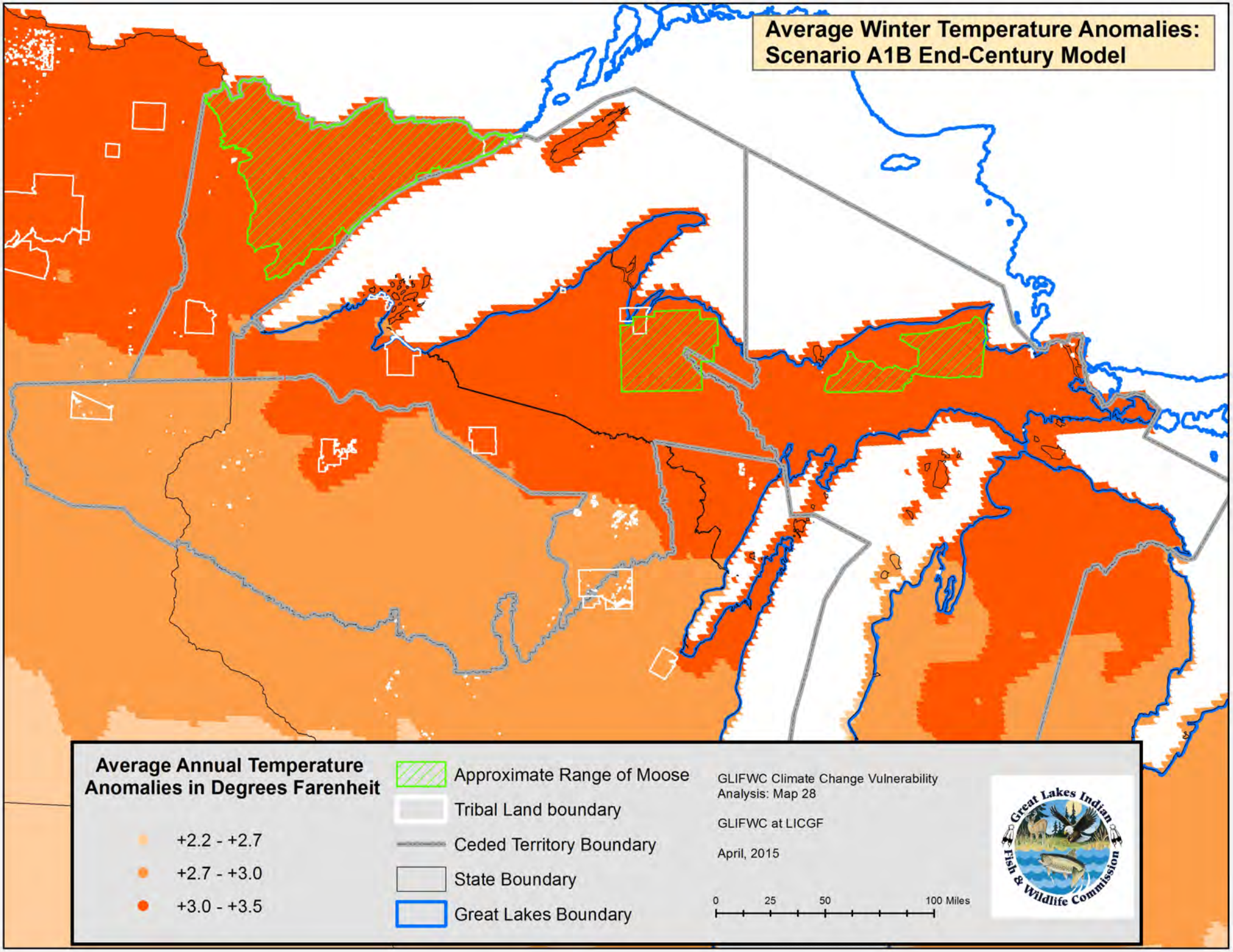

Average Summer Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+2.7 - +3.2
+3.2 - +3.5
+3.5 - +4.2
Wild Rice Water
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 23
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

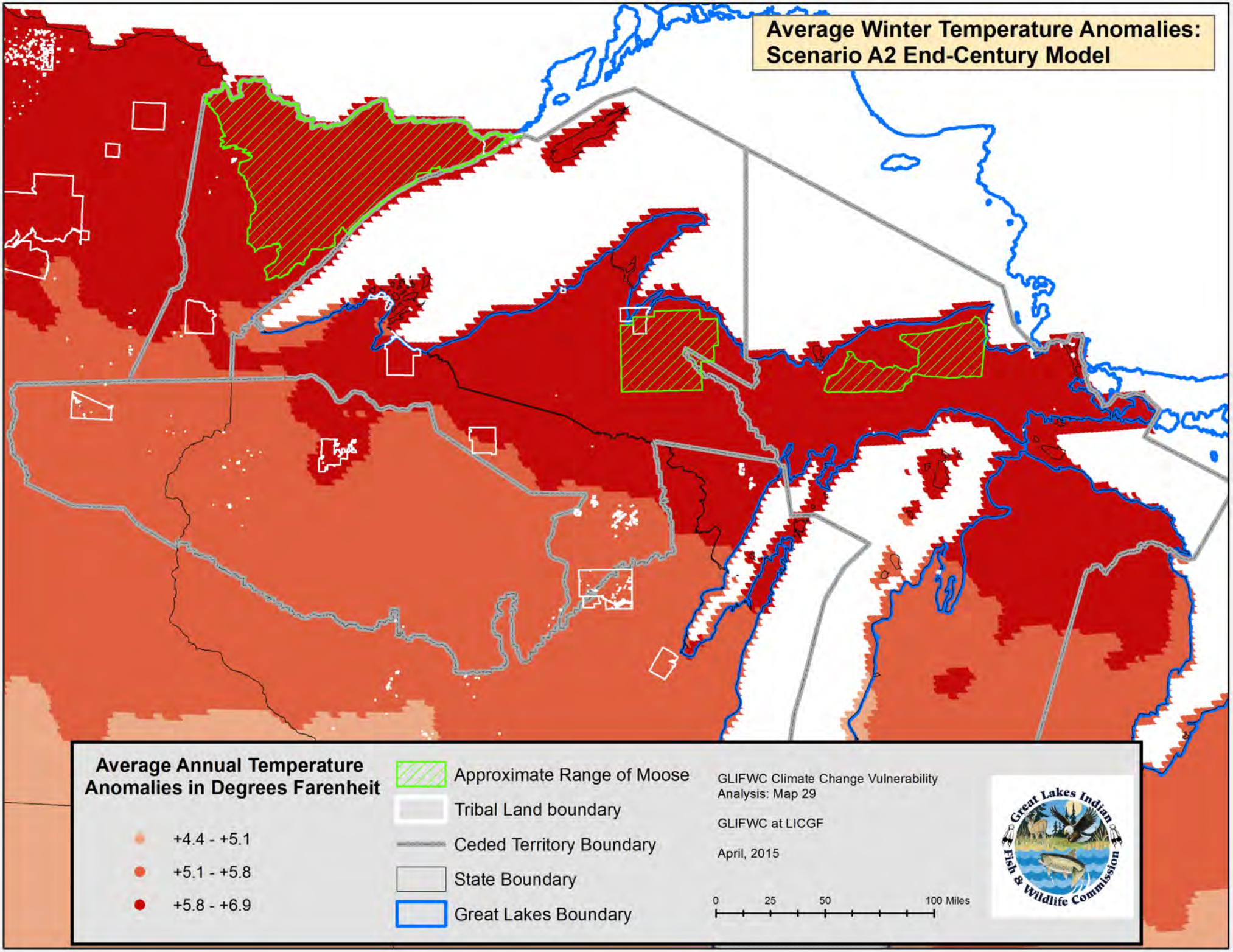

Average Spring Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+2.3 - +2.9
+2.9 - +3.1
+3.1 - +3.4
GLIFWC Walleye Lakes
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 24
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

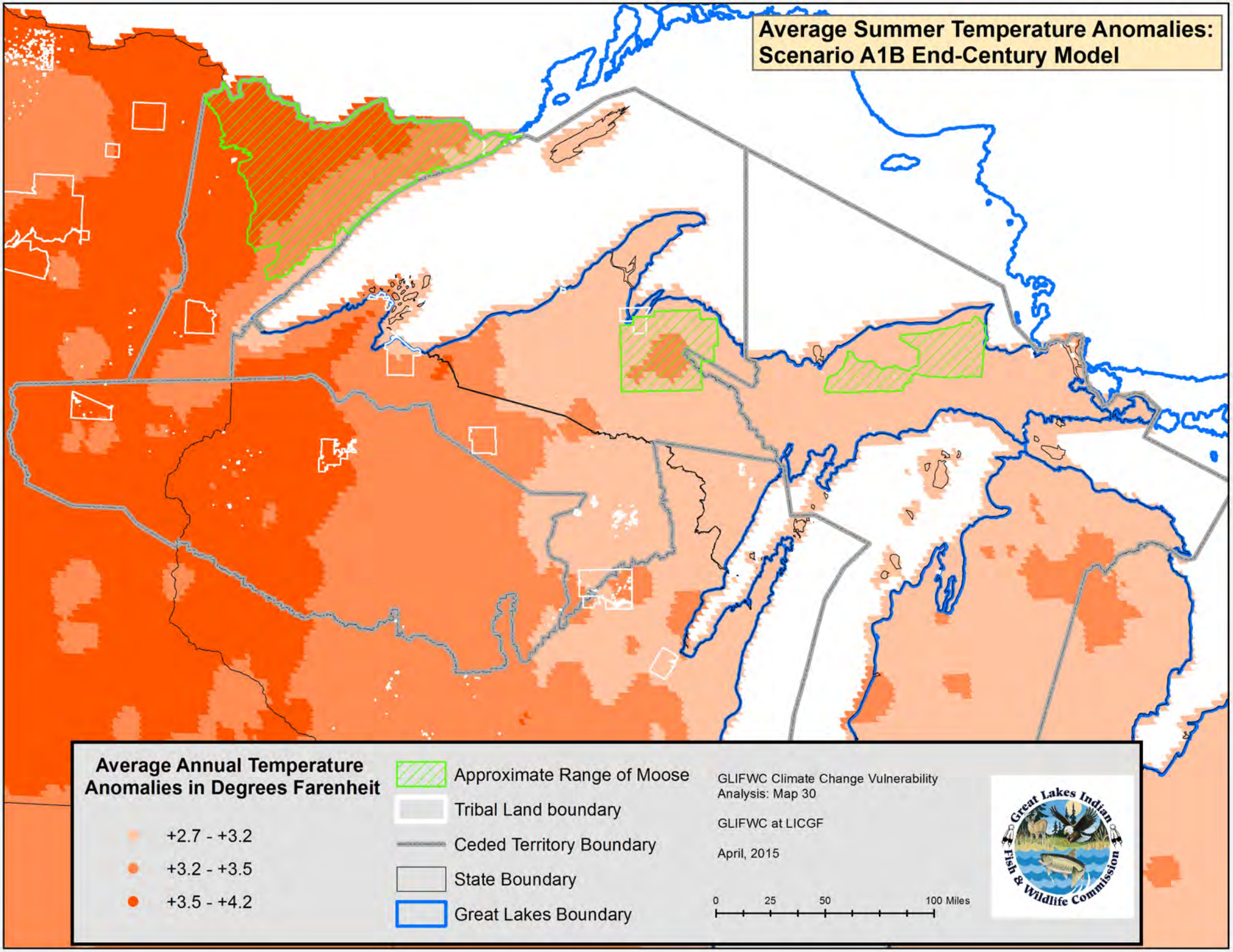

Average Spring Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+3.4 - +4.4
+4.4 - +4.7
+4.7 - +5.1
GLIFWC Walleye Lakes
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 24
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

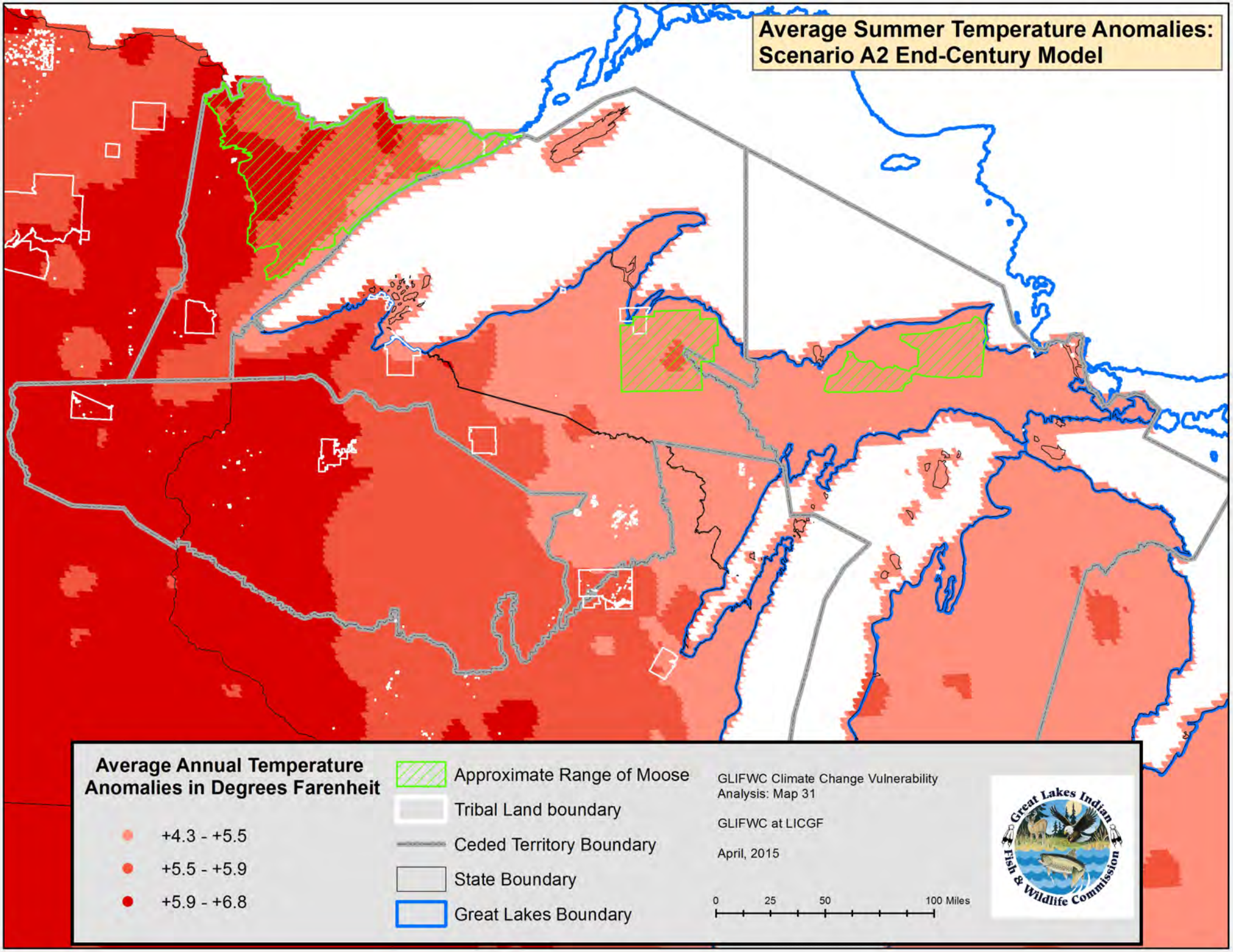

Average Summer Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+2.7 - +3.2
+3.2 - +3.5
+3.5 - +4.2
Trout Stream
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 26
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

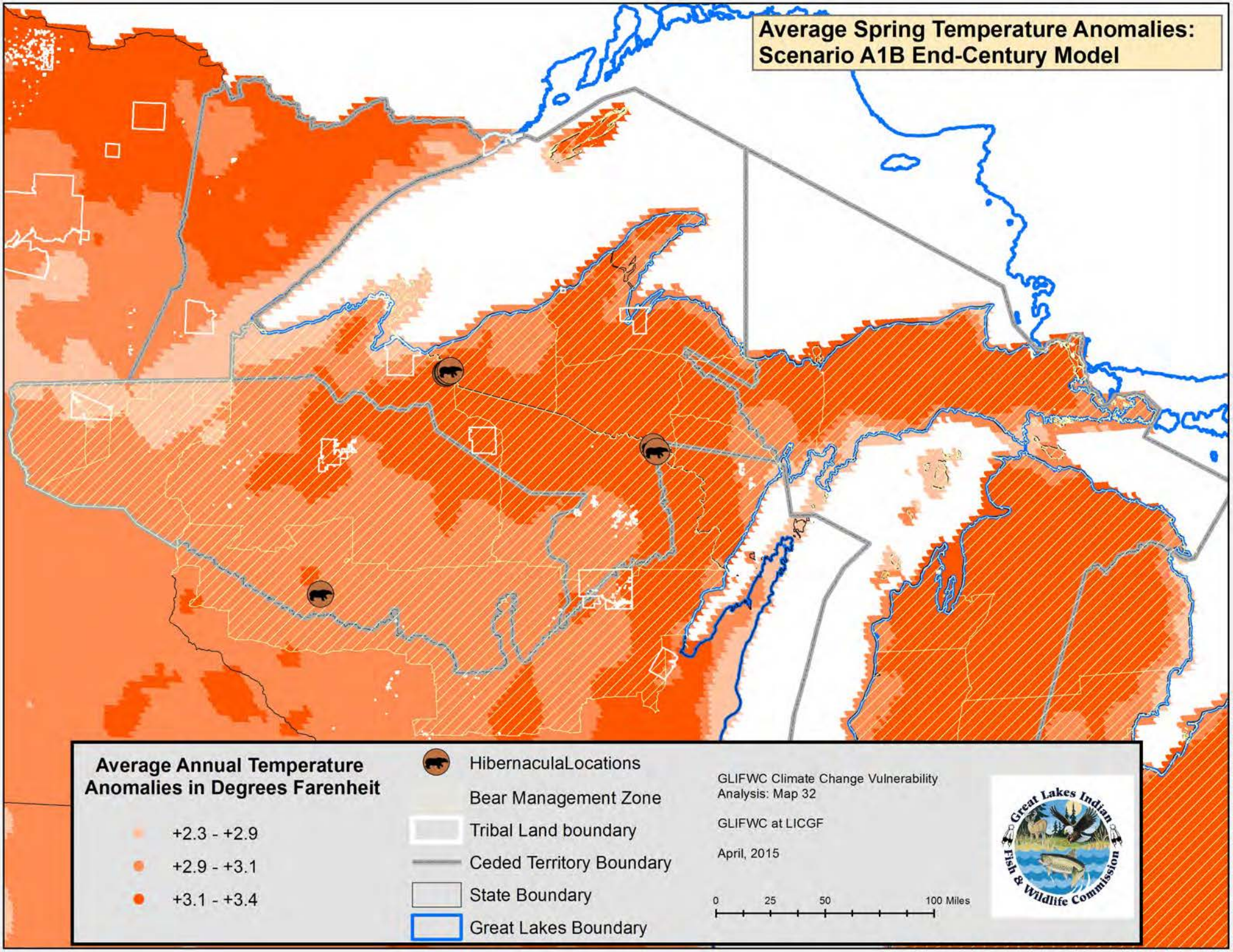

Average Summer Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.3 - +5.5
+5.5 - +5.9
+5.9 - +6.8
Trout Stream
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 22
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

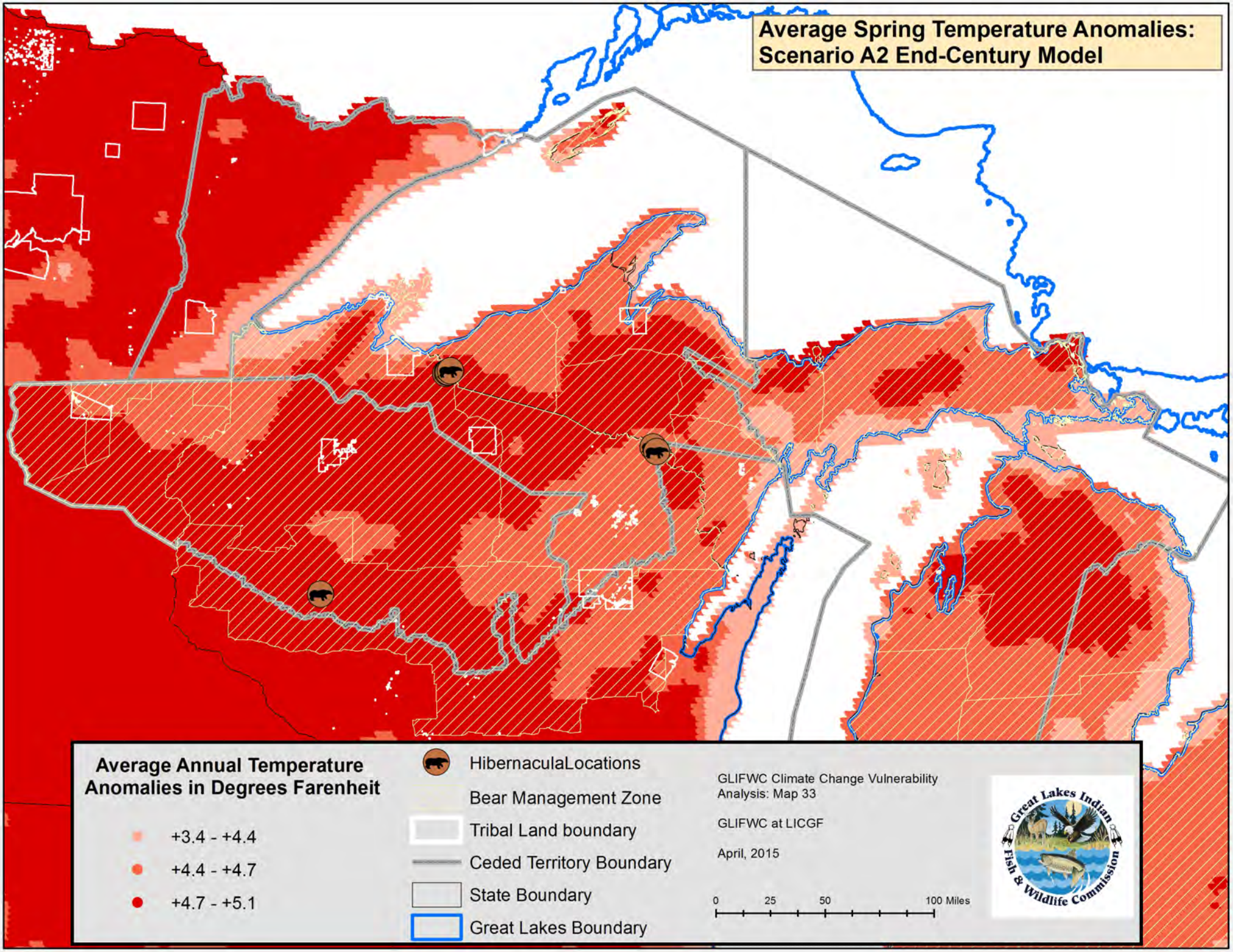

Average Winter Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+2.2 - +2.7
+2.7 - +3.0
+3.0 - +3.5
Approximate Range of Moose
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 28
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

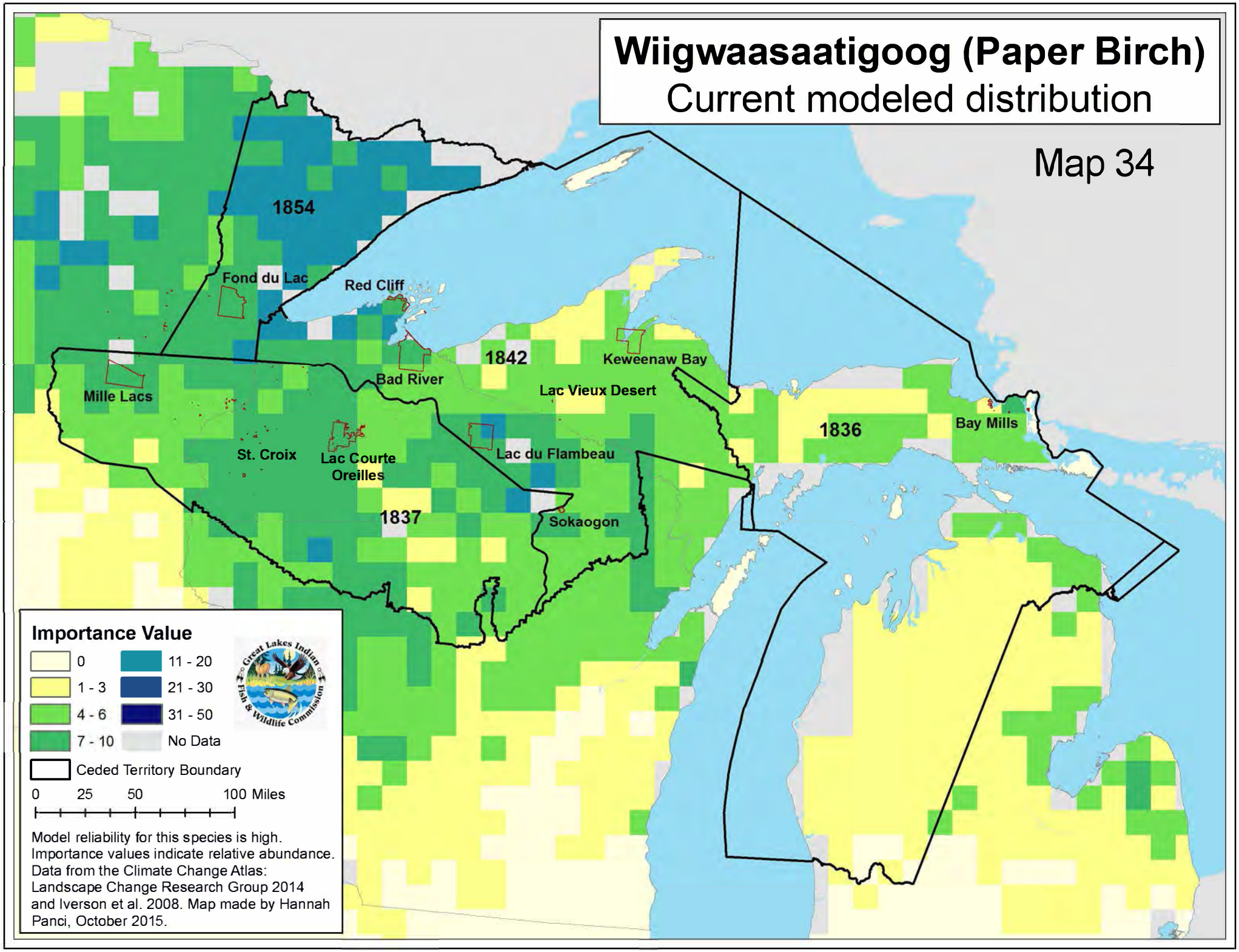

Average Winter Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.4 - +5.1
+5.1 - +5.8
+5.8 - +6.9
Approximate Range of Moose
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 29
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

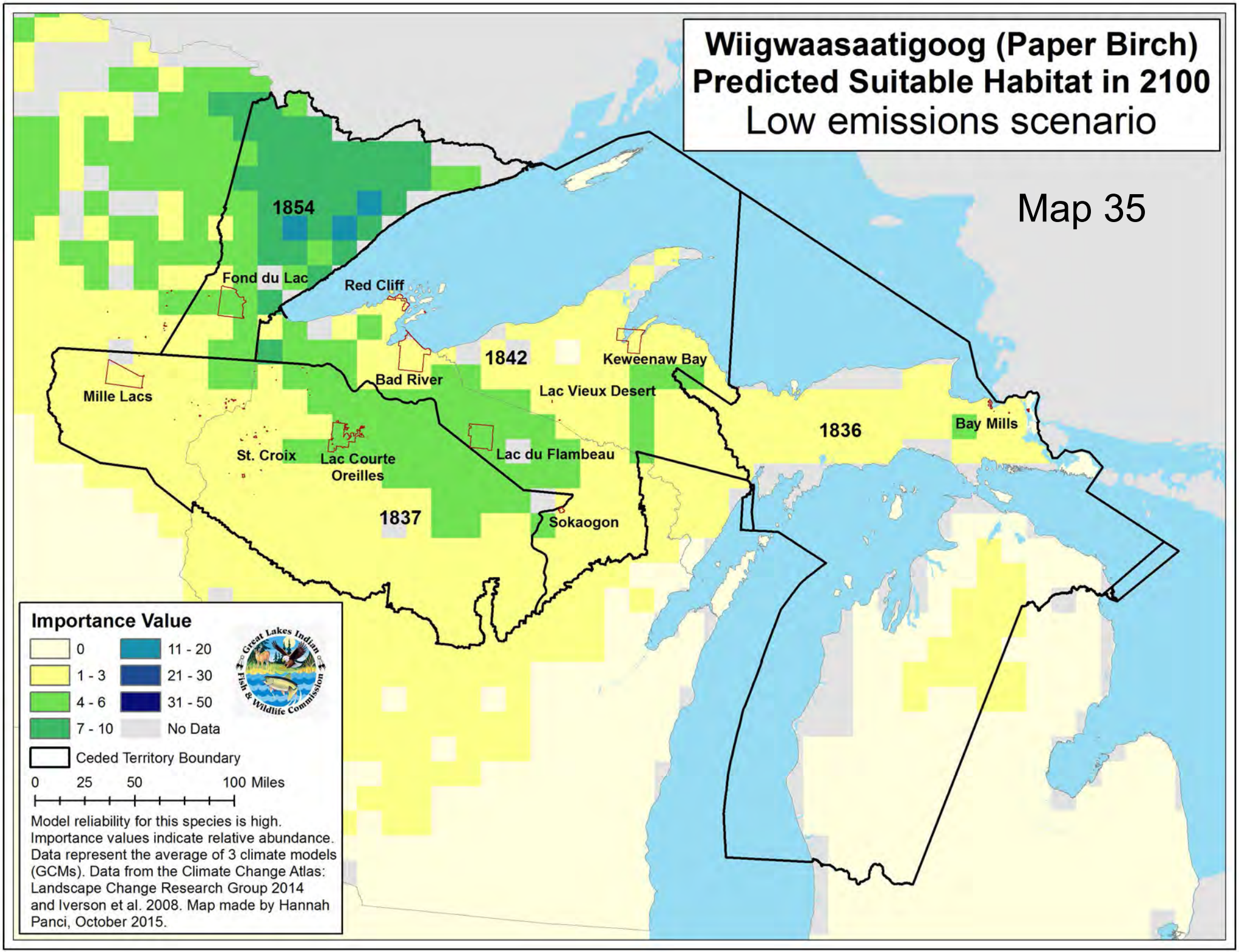

Average Summer Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+2.7 - +3.2
+3.2 - +3.5
+3.5 - +4.2
Approximate Range of Moose
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 30
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

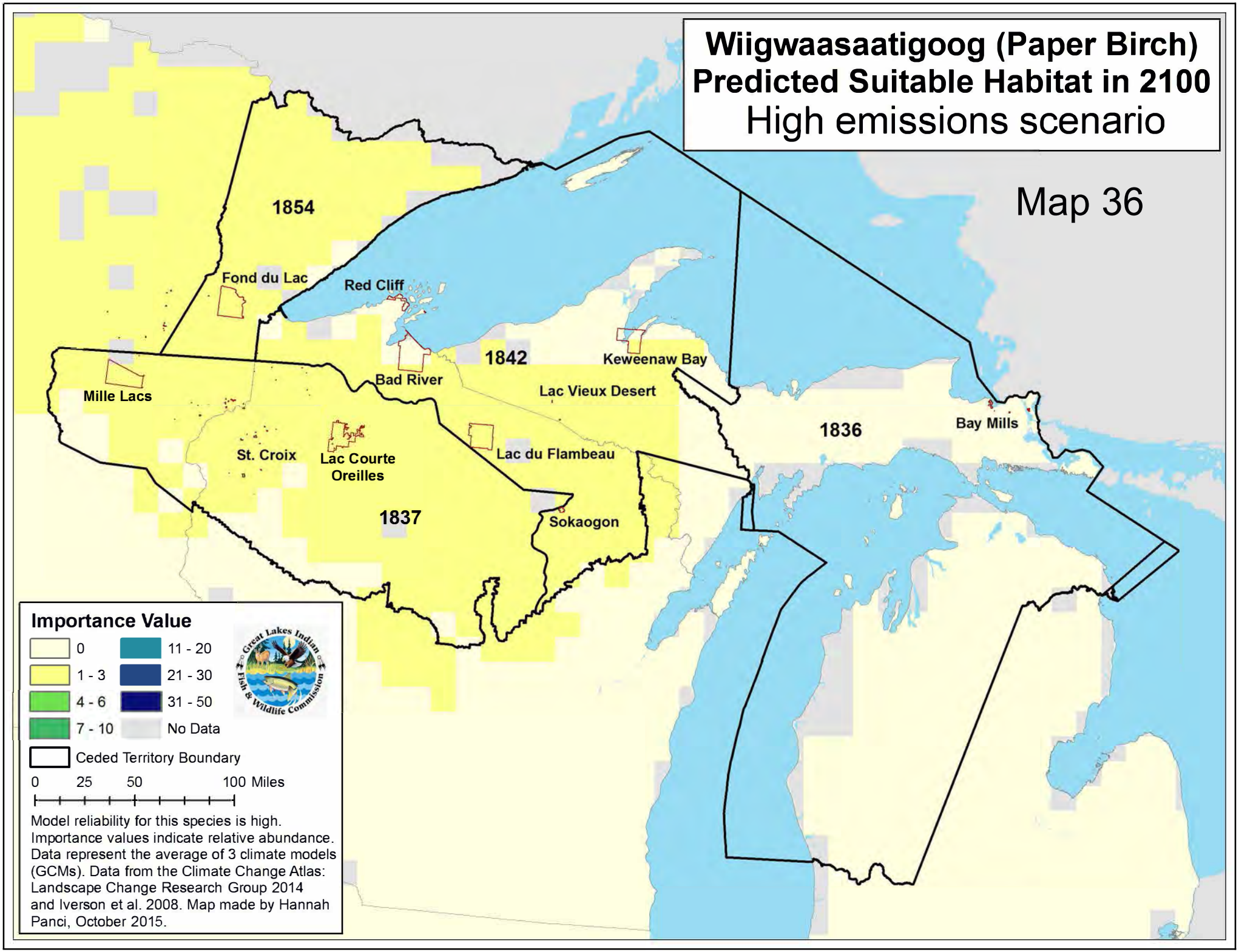

Average Summer Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+4.3 - +5.5
+5.5 - +5.9
+5.9 - +6.8
Approximate Range of Moose
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 31
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

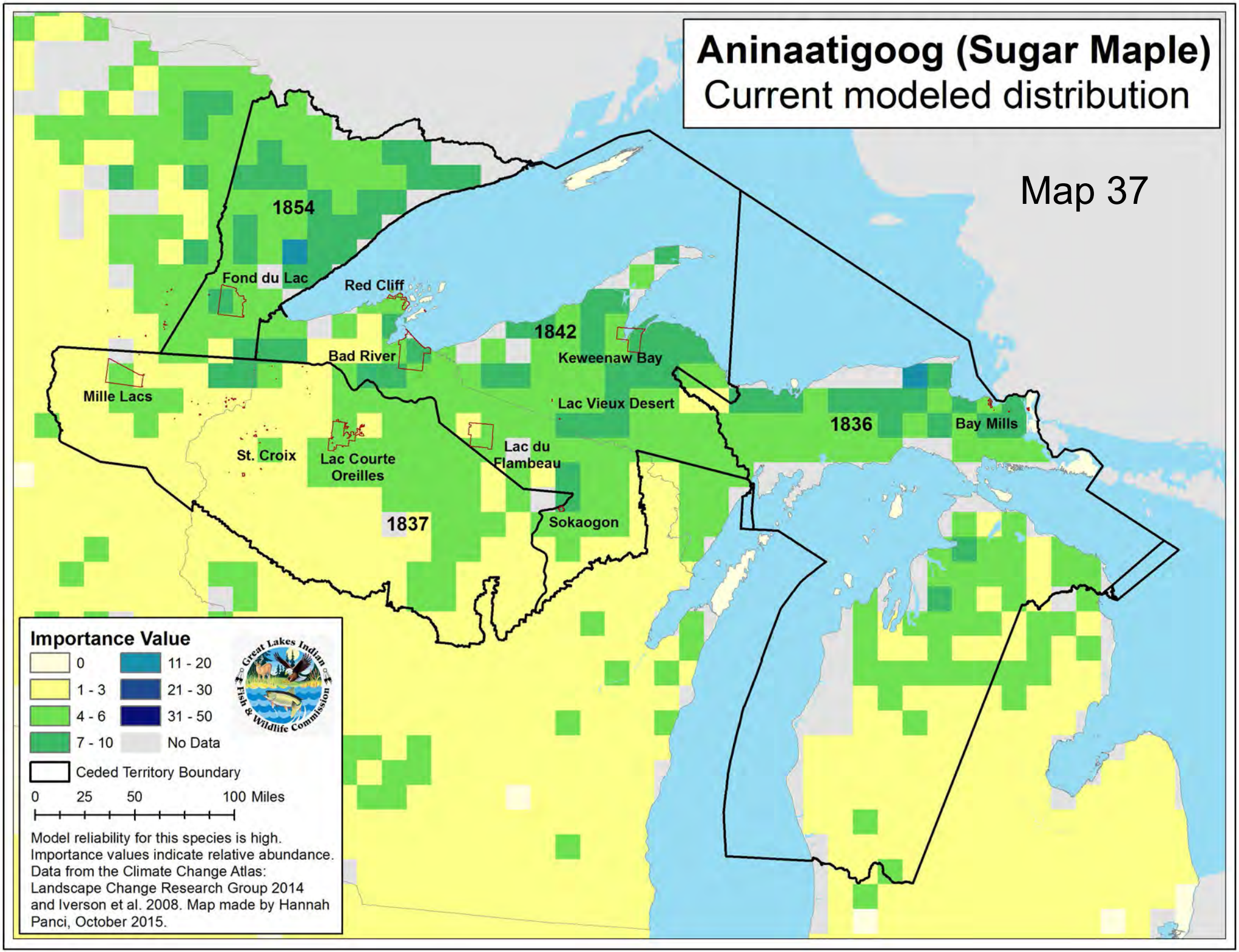

Average Spring Temperature Anomalies:
Scenario A1B End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+2.3 - +2.9
+2.9 - +3.1
+3.1 - +3.4
HibernaculaLocations
Bear Management Zone
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 32
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

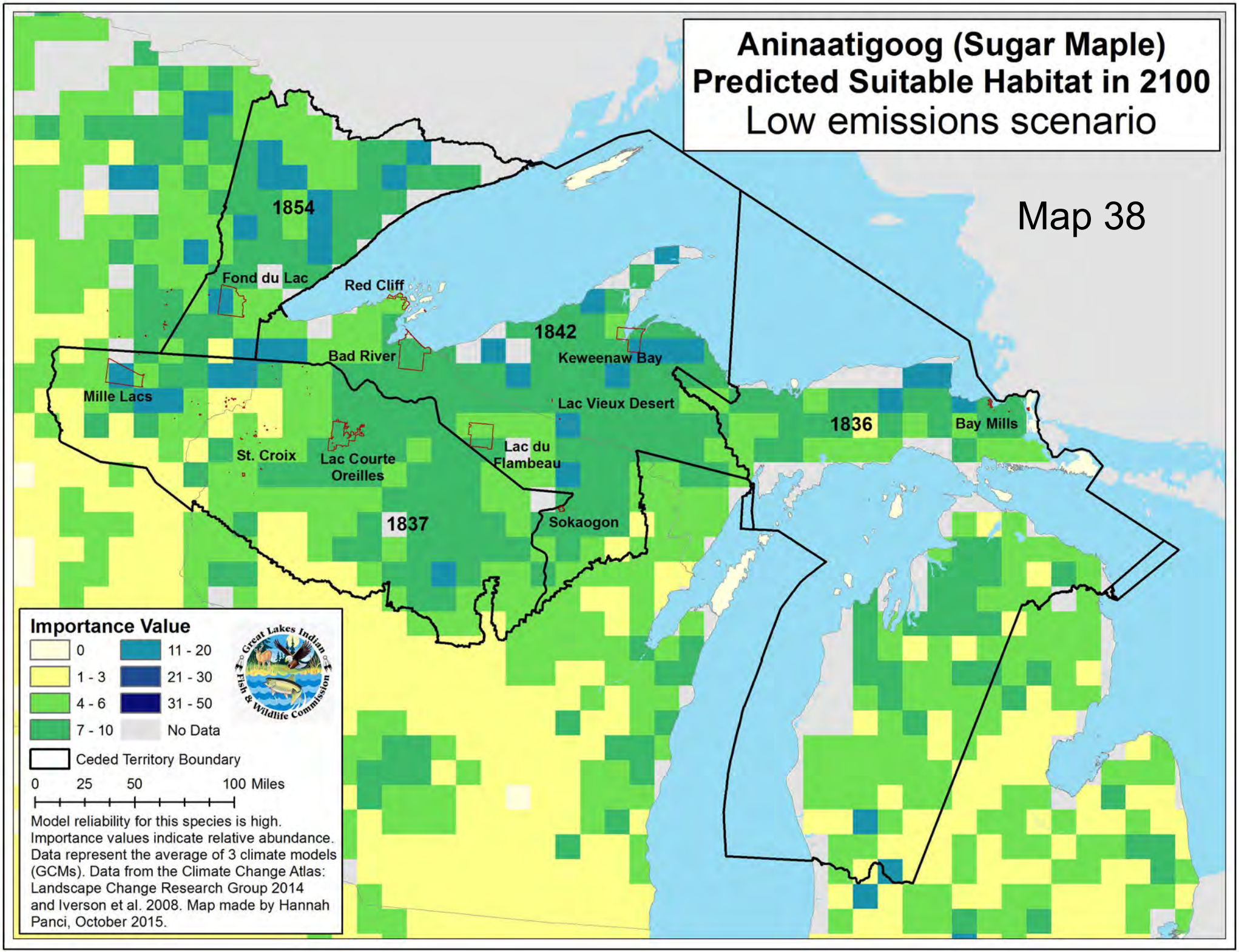

Average Spring Temperature Anomalies:
Scenario A2 End-Century Model
Average Annual Temperature Anomalies in Degrees Farenheit
+3.4 - +4.4
+4.4 - +4.7
+4.7 - +5.1
HibernaculaLocations
Bear Management Zone
Tribal Land boundary
Ceded Territory Boundary
State Boundary
Great Lakes Boundary
GLIFWC Climate Change Vulnerability Analysis: Map 33
GLIFWC at LICGF
April, 2015
0
25
50
100 Miles
Great Lakes Indian Fish & Wildlife Commission

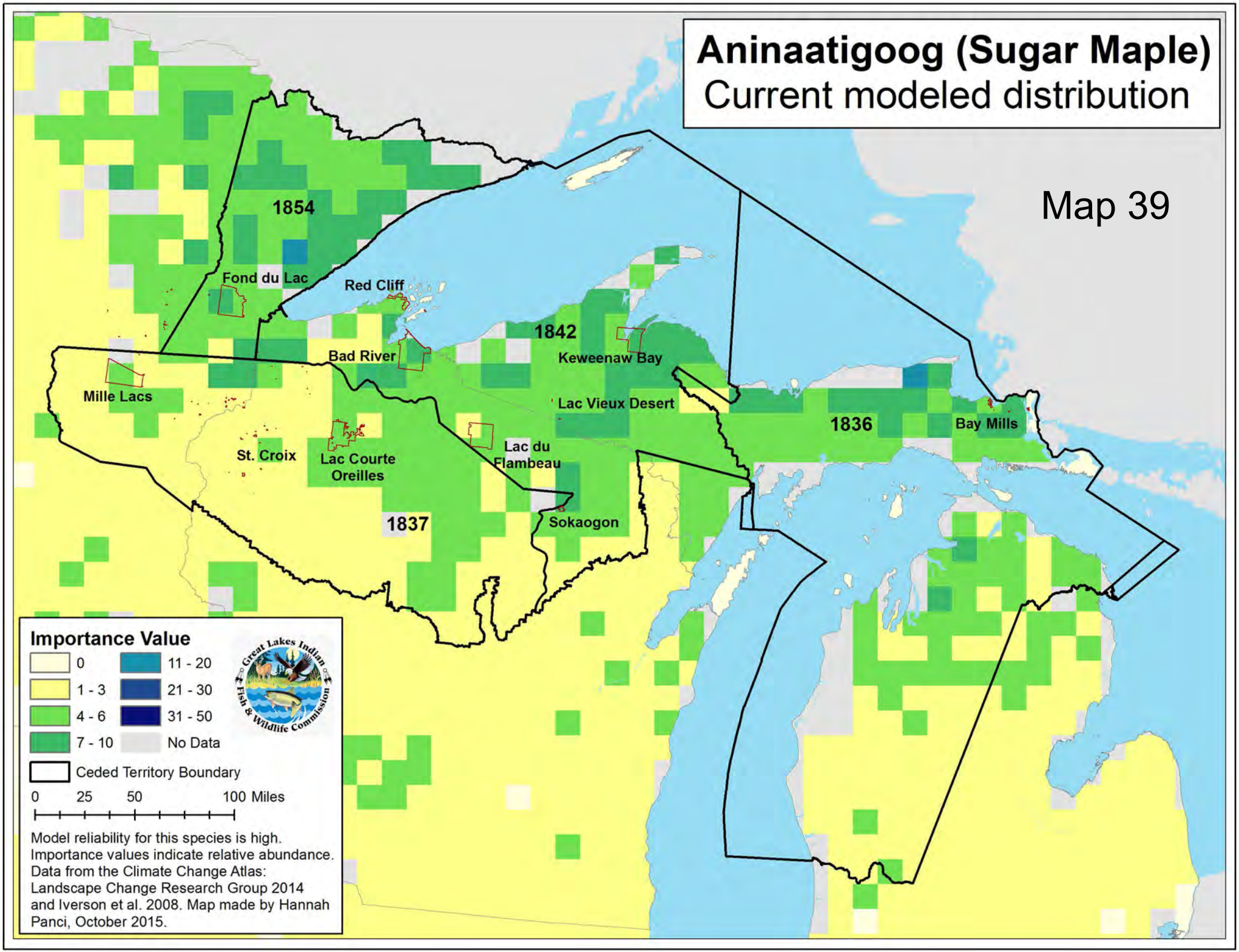

Wiigwaasaatigoog (Paper Birch)
Current modeled distribution
Map 34
1854
Fond du Lac
Red Cliff
1842
Keweenaw Bay
Bad River
Mille Lacs
Lac Vieux Desert
1836
Bay Mills
St. Croix
Lac Courte Oreilles
Lac du Flambeau
1837
Sokaogon
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
No Data
Ceded Territory Boundary
0 25 50 100 Miles
Great Lakes Indian Fish & Wildlife Commission
Model reliability for this species is high. Importance values indicate relative abundance. Data from the Climate Change Atlas: Landscape Change Research Group 2014 and Iverson et al. 2008. Map made by Hannah Panci, October 2015.


Wiigwaasaatigoog (Paper Birch)
Predicted Suitable Habitat in 2100
Low emissions scenario
Map 35
1854
1842
1836
1837
Fond du Lac
Red Cliff
Bad River
Keweenaw Bay
Lac Vieux Desert
Mille Lacs
St. Croix
Lac Courte Oreilles
Lac du Flambeau
Sokaogon
Bay Mills
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
No Data
Ceded Territory Boundary
0 25 50 100 Miles
Great Lakes Indian Fish & Wildlife Commission
Model reliability for this species is high. Importance values indicate relative abundance. Data represent the average of 3 climate models (GCMs). Data from the Climate Change Atlas: Landscape Change Research Group 2014 and Iverson et al. 2008. Map made by Hannah Panci, October 2015.


Wiigwaasaatigoog (Paper Birch)
Predicted Suitable Habitat in 2100
High emissions scenario
Map 36
1854
1842
1836
1837
Fond du Lac
Red Cliff
Bad River
Keweenaw Bay
Lac Vieux Desert
Mille Lacs
St. Croix
Lac Courte Oreilles
Lac du Flambeau
Sokaogon
Bay Mills
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
No Data
Ceded Territory Boundary
0 25 50 100 Miles
Model reliability for this species is high. Importance values indicate relative abundance. Data represent the average of 3 climate models (GCMs). Data from the Climate Change Atlas: Landscape Change Research Group 2014 and Iverson et al. 2008. Map made by Hannah Panci, October 2015.
Great Lakes Indian Fish & Wildlife Commission


Aninaatigoog (Sugar Maple)
Current modeled distribution
Map 37
1854
1842
1836
1837
Fond du Lac
Red Cliff
Bad River
Keweenaw Bay
Mille Lacs
Lac Vieux Desert
Bay Mills
St. Croix
Lac Courte Oreilles
Lac du Flambeau
Sokaogon
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
No Data
Ceded Territory Boundary
0 25 50 100 Miles
Model reliability for this species is high. Importance values indicate relative abundance. Data from the Climate Change Atlas: Landscape Change Research Group 2014 and Iverson et al. 2008. Map made by Hannah Panci, October 2015.
Great Lakes Indian Fish & Wildlife Commission


Aninaatigoog (Sugar Maple)
Predicted Suitable Habitat in 2100
Low emissions scenario
Map 38
1854
1842
1836
1837
Fond du Lac
Red Cliff
Bad River
Keweenaw Bay
Mille Lacs
Lac Vieux Desert
Bay Mills
St. Croix
Lac Courte Oreilles
Lac du Flambeau
Sokaogon
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
No Data
Ceded Territory Boundary
0 25 50 100 Miles
Great Lakes Indian Fish & Wildlife Commission
Model reliability for this species is high. Importance values indicate relative abundance. Data represent the average of 3 climate models (GCMs). Data from the Climate Change Atlas: Landscape Change Research Group 2014 and Iverson et al. 2008. Map made by Hannah Panci, October 2015.


Aninaatigoog (Sugar Maple)
Current modeled distribution
Map 39
1854
1842
1836
1837
Fond du Lac
Red Cliff
Bad River
Keweenaw Bay
Mille Lacs
Lac Vieux Desert
Bay Mills
St. Croix
Lac Courte Oreilles
Lac du Flambeau
Sokaogon
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
No Data
Ceded Territory Boundary
0 25 50 100 Miles
Great Lakes Indian Fish & Wildlife Commission
Model reliability for this species is high.
Importance values indicate relative abundance.
Data from the Climate Change Atlas:
Landscape Change Research Group 2014
and Iverson et al. 2008. Map made by Hannah
Panci, October 2015.

Annotated Bibliography

Lake Superior Fish

Lake Whitefish: Adikameg

1. Bronte, C.R., Ebener M.P., Schreiner D.R., DeVault D.S., Petzold M.M., Jensen D.A., Richards C., and Lozano S.J. (2003). Fish Community Change in Lake Superior, 1970-2000. *Canadian Journal of Fisheries and Aquatic Sciences,* 60(12), 1552–1574. Available at http://www.fws.gov/midwest/fisheries/scientific-pubs/p-2003-2.pdf

Summary: The Fish Community Change in Lake Superior discusses the changes in Lake Superior's fish communities from 1970 – 2000. In specific it touches on habitat degradation, contaminants, effects of climate warming, phosphorus loading, intentional and unintentional species introductions, as well as other topics. Habitat protection and enhancement to prevent additional damaging effects is needed to further restoration.

Specific pages to note: Pg. 1554: Climate warming is projected to increase thermal habitat; would be for Lake Trout, Lake Whitefish, Northern Pike, where non-indigenous species would benefit. This article focuses on fish species recovery.

References Cited to Consider:

- Bronte, C.R., and Hoff, M.H. 1996. Population status and trends for Lake Superior forage fishes, 1978–95. In Minutes of the 1996 Annual Meeting of the Lake Superior Committee, Great Lakes Fishery Commission. Great Lakes Fishery Commission, Ann Arbor, Mich.
- Bronte, C.R., Schram, S.T., Selgeby, J.H., and Swanson, B.L. 1995. Density independent survival of wild lake trout in the Apostle Islands area of Lake Superior. J. Gt. Lakes Res. 21 (Suppl. 1): 246–252.
- Bronte, C.R., Hesselberg, R.J., Shoesmith, J.A., and Hoff, M.H. 1996. Discrimination among spawning concentrations of Lake Superior lake herring based on trace element profiles in sagittae. Trans. Am. Fish. Soc.125: 852–859.
- Ebener, M.P. 1990. Assessment and mark–recapture of Lake Whitefish spawning stocks around the Keweenaw Peninsula area of Lake Superior, 1987–1990. Admin. Rep. 90-10, Great Lakes Indian Fish and Wildlife Commission, Odanah, Wis.

- *Hill, D.K., and Magnuson, J.J. 1990. Potential effects of global climate warming on the growth and prey consumption of Great Lakes fishes. Trans. Am. Fish. Soc. 119: 265–275*.
- *Magnuson, J.J., Meisner J.D., and Hill, D.K. 1990. Potential changes in thermal habitat of Great Lakes fishes due to global climate warming. Trans. Am. Fish. Soc. 119: 254–264*.
- *Mandrak, N.E. 1989. Potential invasion of the Great Lakes by fish species associated with climate warming. J. Gt. Lakes Res. 15:306–316*.
- Selgeby, J.H. 1982. Decline of lake herring (Coregonus artedii) in Lake Superior: an analysis of the Wisconsin herring fishery. Can. J. Fish. Aquat. Sci. 39: 554–563.
- Sinokrot, B.A., Stefan, H.G., McCormick, J.H., and Eaton, J.G. 1995. Modeling of climate change effects on stream temperatures and fish habitats below barrier dams and near groundwater inputs. Clim. Change, 30: 181–200.

2. Great Lakes Area National Park Service U.S. Department of the Interior. 2007. Climate Change: Dying Birch trees, minimal snowpack, and ice-free lakes are just some Impacts of Midwest Warming. Available at http://www.nps.gov/apis/naturescience/upload/2007%20MWR%20Climate%20Change%20Site%20Bulletin%20-%20Great%20Lakes%20FINAL.pdf

Summary: This article, Dying Birch Trees, Minimal Snowpack, and Ice-Free Lakes Are Just Some Impacts of Midwest Warming discusses climate change effects in the Midwest Region. It touches on the science reports by the U.S. Global Change Research Program as well as others and how they show that this is due to greenhouse gases produced by human activities. In specific the article has sections on Temperature and Precipitation, The Ecological Effects, New Faces in New Places, and Recreation, Health and Safety.

Specific pages to note: * Cool tree species are projected to lose habitat in the U.S. Sugar Maple and Paper Birch are expected to shift towards Canada. For the Apostle Island Lakeshore and Michigan Upper peninsula Paper Birch may lose all habitats. *Coldwater fish such as Trout will decrease in abundance. Whitefish spawning areas will be disturbed and Native fish will be threatened.

3. Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting Climate Change in the Great Lakes Region. A Report of the Union of Concerned Scientists and the Ecological Society of America. Available at

http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf

Summary: Confronting Climate Change in the Great Lakes Region is a report of The Union of Concerned Scientists and The Ecological Society of America. This report explains that growing evidence suggests that climate change is already affecting the Great Lakes Region: winters are shorter, average temperatures are warmer, lake ice cover is decreasing, and heavy rainstorms are more common. The potential consequences from climate change for the Great Lakes Region are confronted for the economic as well as the environmental impacts.

Specific pages to note: **Pg. 2:** Whitefish reproduction could be threatened with the loss of winter ice [Coldwater fish (Lake Trout, Whitefish, Herring) and Coolwater fish (Northern Pike, Walleye) are likely to decline in abundance]. **Pg. 54-55**: If warmwater fish species expand and increase in number in Lake Superior, this could lead to the extirpation (local extinction) of native minnows. This could have negative impacts on Lake Trout and other Native predators. "Climate warming will greatly reduce the amount of thermally suitable habitat for Lake Trout in many inland lakes." **Pg. 60:** Moose could be harmed by warming: increase in deer populations could carry disease that will stress the moose population.

References Cited to Consider:

- *Hill, D.K., and J.J. Magnuson (1990). Potential effects of global climate warming on the growth and prey consumption of Great Lakes fi sh. Transactions of the American Fisheries Society 119:265–275. American Fisheries Society 119:265–275.*
- Magnuson, J.J., et al. (1997). Potential effects of climate change on aquatic systems: Laurentian Great Lakes and Precambrian Shield Region. In Freshwater Ecosystems and Climate Change in North America: A Regional Assessment. C.E. Cushing, ed. New York: John Wiley & Sons, pp. 7–53.
- *Magnuson, J.J., J.D. Meisner, and D.K. Hill (1990). Potential changes in the thermal habitat of Great Lakes fish after global climate warming. Transactions of the American Fisheries Society 119:254–264. American Fisheries Society 119:254–264*
- Shuter, B.J., C.K. Minns, and N. Lester (2002). Climate change, freshwater fi sh and fi sheries: Case studies from Ontario and their use in assessing potential impacts. In Fisheries in a Changing Climate. N.A. McGinn, ed. Bethesda, Md.: American Fisheries Society, pp. 77–88.
- *Stefan, H.G., X. Fang, and J.G. Eaton (2001). Simulated fish habitat changes in North American lakes in response to projected climate warming. Transactions of the American Fisheries Society 130:459–477*.

4. National Wildlife Federation. 2010. Improving the Odds: Using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem. Available at http://www.nwf.org/News-and-Magazines/Media-Center/News-by-Topic/Global-Warming/2010/10-29-10-Great-Lakes-Adaptation-Report.aspx.

Summary: Improving the Odds was created by the National Wildlife Federation to bring awareness to Climate Change and to reduce the impacts of Climate Change. The report describes and analyzes climate-readiness initiatives in the Great Lakes Region. There are specifically looking at restoration practices that reduce climate impacts, implementing climate ready strategies and others. This is crucial to protect our natural resources, infrastructures, public health, as well as fresh water.

Specific pages to note: **Pg. 31:** It is expected that the Pine Marten will find no suitable habitat in Wisconsin. **Pg. 40:** Increased temperature of Lake Superior would benefit Sea Lamprey. This in turn will negatively affect fish species. Sea Lamprey feed on fish and warmer waters would allow for bigger growing Sea Lamprey. This will negatively affect Lake Trout, Herring, Whitefish as well as other species.

References Cited to Consider:

- Wisconsin Initiative on Climate Change Impacts. 2010. Wildlife Working Group. http://wicci.wisc.edu/workinggroups/wildlife/index.htm
- US Environmental Protection Agency. Climate Change. http://www.epa.gov/climatechange/impacts-adaptation/
- U.S. Department of the Interior National Park Service. 2007. Climate Change and Impacts to Resources around the Great Lakes. August 2007

5. Sousounis, P.J. and J.M. Bisanz, eds. 2000. Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. A Summary by the Great Lakes Regional
Assessment Group. U.S. Global Change Research Program. Available at http://www.geo.msu.edu/glra/PDF_files/GLRA_report.pdf.

Summary: Preparing for a Changing Climate was for the U.S. Global Change Research Program as an investment in science for the Nation's future. This report covers the potential consequences of climate variability and change. Climate change may bring negative affects to water resources, ecology, coastlines, human health, and others. They discuss the Great Lakes region and the impacts that are found in stream flow, aquatic and terrestrial ecosystems,

agriculture, and quality of life.

Specific pages to note: **Pg. 45**: Lake Trout would either potentially increase in size due to global warming (If their prey also increases in size) but would decrease in size if their prey simply stays the same size. **Pg. 92:** Less ice coverage may cause a fast decline of Whitefish; there would be a growing number of unprotected spawning areas.

References Cited to Consider:

- Chao, P.T.,1999: Great Lakes Water Resources-Climate Change Impact Analysis. Proceedings of the Speciality Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States. American Water Resources Association, Atlanta Georgia, May 10-12. pp. 307-310
- Davis, M.B., and C. Zabinski, 1992: Changes in geographical range resulting from greenhouse warming: effects on biodiversity in forests. P. 297-308 in Global Warming and Biological Diversity, R.L. Peters and T.E. Lovejoy, eds, Yale University Press, New Haven CT.
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- He, H.A.S., D.J. Mladenoff, and T.R. Crow, 1999: Link- ing an ecosystem model and a landscape model to study for- est species response to climate warming. Ecological Modelling , 114, 213-233
- *Hill, D., and J.J. Magnuson, 1990: Potential effects of global climate warming on the growth and prey consumption of Great Lakes fish. Trans. Am. Fish. Soc., 119, 265-275*
- Jones, E.A., D.D. Reed, and P.V. Desanker, 1994: Ecological implications of projected climate change scenarios in forest ecosystems of central North America. Agricultural and Forest Meteorology,72, 2-3
- *Magnuson, J.J., J.D. Meisner and D.K. Hill, 1990: Potential changes in the thermal habitat of Great Lakes fish after global climate warming. Trans. Am. Fish. Soc. 119, 254-264.*
- *Magnuson, J.J., H.A. Regier, B.J. Shuter, D.K. Hill, J.A. Holmes, and J.D. Meisner, 1989: Potential responses of Great Lakes fishes and their habitat to global climate warming. University of Wisconsin and Toronto. U.S. Environmental Protection Agency, Washington, D. C. Report number EPA-230-05-89-055*.

Lake Trout: Namegos

1. Betz, C.R., Asplund T., and Hurley J. (2010). Water Resources Working Group Report. *Wisconsin Initiative on Climate Change Impacts.* Available at

http://www.wicci.wisc.edu/report/Water-Resources.pdf.

Summary: The Wisconsin Initiative on Climate Change Impacts discusses Wisconsin's changing climate and the impact this has on its water resources. Water Resources can indicate climate change at 'various temporal and spatial scales.' While climate change will affect Wisconsin differently in each geographic region, it is projected that all water resources will be affected in both quantity and quality.

Specific pages to note: **pg. VI**: Increased temperature could make coolwater and coldwater fish to no longer dominate some of Wisconsin's streams. Trout habitats will also be affected. **Pg. 33-35:** If rainfall is to increase, this will result in increased sediment and nutrient loads (from surrounding land and streams). This increase in sediment and nutrient loads could negatively impact the walleye population (who rely on sight to feed). There is the potential for warmwater fish to increase in abundances with coldwater species (such as Lake Trout) shifting farther north in search of cooler waters.

References Cited To Consider:

- Bradley et al., 1999. Phonological Changes Reflect Climate Change in Wisconsin. Proc. Natl. Acad. Sci., 96: 9701-9704
- Wisconsin Academy of Sciences, Arts and Letters (2003). *Waters of Wisconsin: The future of our aquatic ecosystems and resources.* Madison, WI: Wisconsin Academy of Sciences, Arts, & Letters.
- Wisconsin Initiative on Climate Change Impacts (2010). Cold water Fish and Fisheries Working Group Report. Wicci.wisc.edu.

2. Bronte, C.R., Ebener M.P., Schreiner D.R., DeVault D.S., Petzold M.M., Jensen D.A., Richards C., and Lozano S.J. (2003). Fish Community Change in Lake Superior, 1970-2000. *Canadian Journal of Fisheries and Aquatic Sciences,* 60(12), 1552–1574. Available at http://www.fws.gov/midwest/fisheries/scientific-pubs/p-2003-2.pdf

Summary: The Fish Community Change in Lake Superior discusses the changes in Lake Superior's fish communities from 1970 – 2000. In specific it touches on habitat degradation, contaminants, effects of climate warming, phosphorus loading, intentional and unintentional species introductions, as well as other topics. Habitat protection and enhancement to prevent additional damaging effects is needed to further restoration.

Specific pages to note: **Pg. 1554:** Climate warming is projected to increase thermal habitat; would be for Lake Trout, Lake Whitefish, Northern Pike, where non-indigenous species would

benefit. This article focuses on fish species recovery.

References Cited to Consider:

- Bronte, C.R., and Hoff, M.H. 1996. Population status and trends for Lake Superior forage fishes, 1978–95. In Minutes of the 1996 Annual Meeting of the Lake Superior Committee, Great Lakes Fishery Commission. Great Lakes Fishery Commission, Ann Arbor, Mich.
- Bronte, C.R., Schram, S.T., Selgeby, J.H., and Swanson, B.L. 1995. Density independent survival of wild lake trout in the Apostle Islands area of Lake Superior. J. Gt. Lakes Res. 21 (Suppl. 1): 246–252.
- Bronte, C.R., Hesselberg, R.J., Shoesmith, J.A., and Hoff, M.H. 1996. Discrimination among spawning concentrations of Lake Superior lake herring based on trace element profiles in sagittae. Trans. Am. Fish. Soc.125: 852–859.
- Ebener, M.P. 1990. Assessment and mark–recapture of lake whitefish spawning stocks around the Keweenaw Peninsula area of Lake Superior, 1987–1990. Admin. Rep. 90-10, Great Lakes Indian Fish and Wildlife Commission, Odanah, Wis.
- *Hill, D.K., and Magnuson, J.J. 1990. Potential effects of global climate warming on the growth and prey consumption of Great Lakes fishes. Trans. Am. Fish. Soc. 119: 265–275*.
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- *Mandrak, N.E. 1989. Potential invasion of the Great Lakes by fish species associated with climate warming. J. Gt. Lakes Res. 15:306–316*.
- Selgeby, J.H. 1982. Decline of lake herring (Coregonus artedii)in Lake Superior: an analysis of the Wisconsin herring fishery. Can. J. Fish. Aquat. Sci. 39: 554–563.
- Sinokrot, B.A., Stefan, H.G., McCormick, J.H., and Eaton, J.G. 1995. Modeling of climate change effects on stream temperatures and fish habitats below barrier dams and near groundwater inputs. Clim. Change, 30: 181–200.

3. Casselman, J.M. 2002. Effects of temperature, global extremes, and climate change on year-class production of warmwater, coolwater, and coldwater fishes in the Great Lakes basin. Am. Fish. Soc. Symp. 31: 39–60. Available at ftp://142.36.245.139/.virtual/slk6ftp/pub/outgoing/requests/!age_analysis/CD1/Selected%20Age-Growth%20Publications/Climate%20and%20year-class%20production%20of%20fish,%20AFS%20Symposium,%20C.pdf

Summary: The Effects of Temperature, Global Extremes, and Climate Change on Year-Class Production of Warmwater, Coolwater, and Coldwater fishes in the Great Lakes Basin discuss the impacts of global warming on fisheries. For this they explain the effects of temperature change on fish. Global warming will substantially increase the year-class strength of warmwater species. It will also significantly impact the year-class strength and structure of fish communities in the Great Lakes Basin. Notably decreasing amounts of coldwater and coolwater fish species and increasing warrmwater fish species.

Specific pages to note: **Pg. 51:** Increased water temperature could have affected Northern Pike negatively; decreasing their year-class strength. **Pg. 52:** For Lake Trout, temperature increase would affect their spawning success. If the water temperature increases, their successful spawning survival would drastically decrease. *Water temperature increase would alter the food web and prey base. *Increase of water temperature would positively affect warmwater fish.

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- Christie, W. J., and H. A. Regier. 1973. Temperature as a major factor influencing reproductive success of fish—two examples. Rapports et Proces-Verbaux des Reunions Conseil International pour l'Exploration de la Mer 164:208–218
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- *Stefan, H. G., X. Fang, and J. G. Eaton. 2001. Simulated fish habitat changes in North American lakes in response to projected climate warming. Transactions of the American Fisheries Society 130:459–477*.

4. Great Lakes Area National Park Service U.S. Department of the Interior. 2007. Climate Change: Dying Birch trees, minimal snowpack, and ice-free lakes are just

some Impacts of Midwest Warming. Available at http://www.nps.gov/apis/naturescience/upload/2007%20MWR%20Climate%20Change%20Site%20Bulletin%20-%20Great%20Lakes%20FINAL.pdf

Summary: This article, Dying Birch Trees, Minimal Snowpack, and Ice-Free Lakes Are Just Some Impacts of Midwest Warming discusses climate change effects in the Midwest Region. It touches on the science reports by the U.S. Global Change Research Program as well as others and how they show that this is due to greenhouse gases produced by human activities. In specific the article has sections on Temperature and Precipitation, The Ecological Effects, New Faces in New Places, and Recreation, Health and Safety.

Specific pages to note: * Cool tree species are projected to lose habitat in the U.S. Sugar Maple and Paper Birch are expected to shift towards Canada. For the Apostle Island Lakeshore and Michigan Upper peninsula Paper Birch may lose all habitats. *Coldwater fish such as Trout will decrease in abundance. Whitefish spawning areas will be disturbed and Native fish will be threatened.

5. International Joint Commission (IJC). 2003. Climate Change and Water Quality in the Great Lakes Basin. Available at http://www.ijc.org/rel/pdf/climate_change_2003.pdf.

Summary: Climate Change and Water Quality in the Great Lakes Basin is a report of the Great Lakes Water Quality Board to the International Joint Commission. It discusses how our climate has been changing and will continue to change in the future. Investigations on climate change were undertaken. In the full report it is broken into the Water Quality Board's Advice to the International Joint Commission, Climate Change and Water Quality in the Great Lakes Region – Risks, Opportunities and Responses, Summary of the Climate Change Workshop, and Cross Boarder Tools and Strategies.

Specific pages to note: **Pg. 52:** Lake warming may shorten breeding windows for fish. This could affect both Lake Trout and Northern Pike. These fish species as well as coldwater fish species could potentially lose their habitat area.

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6. Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting Climate Change in the Great Lakes Region. A Report of the Union of Concerned Scientists and the Ecological Society of America. Available at http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf

Summary: Confronting Climate Change in the Great Lakes Region is a report of The Union of Concerned Scientists and The Ecological Society of America. This report explains that growing evidence suggests that climate change is already affecting the Great Lakes Region: winters are shorter, average temperatures are warmer, lake ice cover is decreasing, and heavy rainstorms are more common. The potential consequences from climate change for the Great Lakes Region are confronted for the economic as well as the environmental impacts.

Specific pages to note: **Pg. 2:** Whitefish reproduction could be threatened with the loss of winter ice [Coldwater fish (Lake Trout, Whitefish, Herring) and Coolwater fish (Northern Pike, Walleye) are likely to decline in abundance]. **Pg. 54-55**: If warmwater fish species expand and increase in number in Lake Superior, this could lead to the extirpation (local extinction) of native minnows. This could have negative impacts on Lake Trout and other Native predators.

"Climate warming will greatly reduce the amount of thermally suitable habitat for Lake Trout in many inland lakes." **Pg. 60:** Moose could be harmed by warming: increase in deer populations could carry disease that will stress the moose population.

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- *Stefan, H.G., X. Fang, and J.G. Eaton (2001). Simulated fish habitat changes in North American lakes in response to projected climate warming. Transactions of the American Fisheries Society 130:459–477*.

7. National Wildlife Federation. 2010. Improving the Odds: Using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem. Available at http://www.nwf.org/News-and-Magazines/Media-Center/News-by-Topic/Global-Warming/2010/10-29-10-Great-Lakes-Adaptation-Report.aspx.

Summary: Improving the Odds was created by the National Wildlife Federation to bring awareness to Climate Change and to reduce the impacts of Climate Change. The report describes and analyzes climate-readiness initiatives in the Great Lakes Region. There are specifically looking at restoration practices that reduce climate impacts, implementing climate ready strategies and others. This is crucial to protect our natural resources, infrastructures, public health, as well as fresh water.

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allow for bigger growing Sea Lamprey. This will negatively affect Lake Trout, Herring, Whitefish as well as other species.

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- Wisconsin Initiative on Climate Change Impacts. 2010. Wildlife Working Group. http://wicci.wisc.edu/workinggroups/wildlife/index.htm
- US Environmental Protection Agency. Climate Change. http://www.epa.gov/climatechange/impacts-adaptation/
- U.S. Department of the Interior National Park Service. 2007. Climate Change and Impacts to Resources around the Great Lakes. August 2007

8. Sousounis, P.J. and J.M. Bisanz, eds. 2000. Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. A Summary by the Great Lakes Regional Assessment Group. U.S. Global Change Research Program. Available at http://www.geo.msu.edu/glra/PDF_files/GLRA_report.pdf.

Summary: Preparing for a Changing Climate was for the U.S. Global Change Research Program as an investment in science for the Nation's future. This report covers the potential consequences of climate variability and change. Climate change may bring negative affects to water resources, ecology, coastlines, human health, and others. They discuss the Great Lakes region and the impacts that are found in stream flow, aquatic and terrestrial ecosystems, agriculture, and quality of life.

Specific pages to note: **Pg. 45**: Lake Trout would either potentially increase in size due to global warming (If their prey also increases in size) but would decrease in size if their prey simply stays the same size. **Pg. 92:** Less ice coverage may cause a fast decline of Whitefish; there would be a growing number of unprotected spawning areas.

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- Chao, P.T.,1999: Great Lakes Water Resources-Climate Change Impact Analysis. Proceedings of the Speciality Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States. American Water Resources Association, Atlanta Georgia, May 10-12. pp. 307-310
- Davis, M.B., and C. Zabinski, 1992: Changes in geographical range resulting from greenhouse warming: effects on biodiversity in forests. P. 297-308 in Global Warming and Biological Diversity, R.L. Peters and T.E. Lovejoy, eds, Yale University Press, New Haven CT.
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- He, H.A.S., D.J. Mladenoff, and T.R. Crow, 1999: Link- ing an ecosystem model and a landscape model to study for- est species response to climate warming. Ecological Modelling , 114, 213-233
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- *Magnuson, J.J., J.D. Meisner and D.K. Hill, 1990: Potential changes in the thermal habitat of Great Lakes fish after global climate warming. Trans. Am. Fish. Soc. 119, 254-264.*
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Lake Sturgeon: Name

Lake Herring:

1. Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting Climate Change in the Great Lakes Region. A Report of the Union of Concerned Scientists and the Ecological Society of America. Available at http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf

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- U.S. Department of the Interior National Park Service. 2007. Climate Change and Impacts to Resources around the Great Lakes. August 2007

In land Fish

Walleye: Ogaa

1. Betz, C.R., Asplund T., and Hurley J. (2010). Water Resources Working Group Report. *Wisconsin Initiative on Climate Change Impacts.* Available at http://www.wicci.wisc.edu/report/Water-Resources.pdf.

Summary: The Wisconsin Initiative on Climate Change Impacts discusses Wisconsin's changing climate and the impact this has on its water resources. Water Resources can indicate climate change at 'various temporal and spatial scales.' While climate change will affect Wisconsin differently in each geographic region, it is projected that all water resources will be affected in both quantity and quality.

Specific pages to note: **pg. VI**: Increased temperature could make coolwater and coldwater fish to no longer dominate some of Wisconsin's streams. Trout habitats will also be affected. **Pg. 33-35:** If rainfall is to increase, this will result in increased sediment and nutrient loads (from surrounding land and streams). This increase in sediment and nutrient loads could negatively impact the walleye population (who rely on sight to feed). There is the potential for warmwater fish to increase in abundances with coldwater species (such as Lake Trout) shifting farther north in search of cooler waters.

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- Bradley et al., 1999. Phonological Changes Reflect Climate Change in Wisconsin. Proc. Natl. Acad. Sci., 96: 9701-9704
- Wisconsin Academy of Sciences, Arts and Letters (2003). *Waters of Wisconsin: The future of our aquatic ecosystems and resources.* Madison, WI: Wisconsin Academy of Sciences, Arts, & Letters.
- Wisconsin Initiative on Climate Change Impacts (2010). Cold water Fish and Fisheries Working Group Report. Wicci.wisc.edu.

2. Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting Climate Change in the Great Lakes Region. A Report of the Union of Concerned Scientists and the Ecological Society of America. Available at http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf

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Northern Pike: Ginoozhe

1. Bronte, C.R., Ebener M.P., Schreiner D.R., DeVault D.S., Petzold M.M., Jensen D.A., Richards C., and Lozano S.J. (2003). Fish Community Change in Lake Superior, 1970-2000. *Canadian Journal of Fisheries and Aquatic Sciences,* 60(12), 1552–1574. Available at http://www.fws.gov/midwest/fisheries/scientific-pubs/p-2003-2.pdf

Summary: The Fish Community Change in Lake Superior discusses the changes in Lake Superior's fish communities from 1970 – 2000. In specific it touches on habitat degradation, contaminants, effects of climate warming, phosphorus loading, intentional and unintentional species introductions, as well as other topics. Habitat protection and enhancement to prevent additional damaging effects is needed to further restoration.

Specific pages to note: **Pg. 1554:** Climate warming is projected to increase thermal habitat; would be for Lake Trout, Lake Whitefish, Northern Pike, where non-indigenous species would benefit. This article focuses on fish species recovery.

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- Bronte, C.R., and Hoff, M.H. 1996. Population status and trends for Lake Superior forage fishes, 1978–95. In Minutes of the 1996 Annual Meeting of the Lake Superior Committee, Great Lakes Fishery Commission. Great Lakes Fishery Commission, Ann Arbor, Mich.
- Bronte, C.R., Schram, S.T., Selgeby, J.H., and Swanson, B.L. 1995. Density independent survival of wild lake trout in the Apostle Islands area of Lake Superior. J. Gt. Lakes Res. 21 (Suppl. 1): 246–252.

- Bronte, C.R., Hesselberg, R.J., Shoesmith, J.A., and Hoff, M.H. 1996. Discrimination among spawning concentrations of Lake Superior lake herring based on trace element profiles in sagittae. Trans. Am. Fish. Soc.125: 852–859.
- Ebener, M.P. 1990. Assessment and mark–recapture of lake whitefish spawning stocks around the Keweenaw Peninsula area of Lake Superior, 1987–1990. Admin. Rep. 90-10, Great Lakes Indian Fish and Wildlife Commission, Odanah, Wis.
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- *Casselman, J.M., D.M. Brown, J.A. Hoyle, and T.H. Eckert. 2002. "Effects of climate change and global warming on year-class strength and relative abundance of smallmouth bass in eastern Lake Ontario." American Fisheries Society Symposium 31: 73-9.*
- Cherry, M. 1998. "Genetic implications of climate change." In S. Colombo and L. Buse (eds.) The Impacts of Climate Change on Ontario's Forests. Forest Research Information Paper No. 43. Ontario: Ministry of Natural Resources. ***Mentions Sugar Maple**
- Davis, M., C. Douglas, R. Calcote, K. Cole, M. Green Winkler, and R. Flaknes. 1999. "Holocene climate in the western Great Lakes national parks and lakeshores: implications for future climate change." Conservation Biology 14 (4): 968-983.
- *Hill, D. and J. Magnuson. 1990. "Potential effects of global climate warming on the growth and prey consumption of Great Lakes fish." Transactions of the American Fisheries Society 119: 265-275*.
- Iverson, L. and A. Prasad. 2001. "Potential changes in tree species richness and forest community types following climate change." Ecosystems 4: 186-199.
- Walker, K., M. Davis, and S. Sugita. 2002. "Climate change and shifts in the potential tree species range limits in the Great Lakes region." Journal of Great Lakes Research 28 (4): 555-567.

4. Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting Climate Change in the Great Lakes Region. A Report of the Union of Concerned Scientists and the Ecological Society of America. Available at http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf

Summary: Confronting Climate Change in the Great Lakes Region is a report of The Union of Concerned Scientists and The Ecological Society of America. This report explains that growing evidence suggests that climate change is already affecting the Great Lakes Region: winters are shorter, average temperatures are warmer, lake ice cover is decreasing, and heavy rainstorms

are more common. The potential consequences from climate change for the Great Lakes Region are confronted for the economic as well as the environmental impacts.

Specific pages to note: **Pg. 2:** Whitefish reproduction could be threatened with the loss of winter ice [Coldwater fish (Lake Trout, Whitefish, Herring) and Coolwater fish (Northern Pike, Walleye) are likely to decline in abundance]. **Pg. 54-55**: If warmwater fish species expand and increase in number in Lake Superior, this could lead to the extirpation (local extinction) of native minnows. This could have negative impacts on Lake Trout and other Native predators. "Climate warming will greatly reduce the amount of thermally suitable habitat for Lake Trout in many inland lakes." **Pg. 60:** Moose could be harmed by warming: increase in deer populations could carry disease that will stress the moose population.

References Cited to Consider:

- *Hill, D.K., and J.J. Magnuson (1990). Potential effects of global climate warming on the growth and prey consumption of Great Lakes fi sh. Transactions of the American Fisheries Society 119:265–275. American Fisheries Society 119:265–275.*
- Magnuson, J.J., et al. (1997). Potential effects of climate change on aquatic systems: Laurentian Great Lakes and Precambrian Shield Region. In Freshwater Ecosystems and Climate Change in North America: A Regional Assessment. C.E. Cushing, ed. New York: John Wiley & Sons, pp. 7–53.
- *Magnuson, J.J., J.D. Meisner, and D.K. Hill (1990). Potential changes in the thermal habitat of Great Lakes fish after global climate warming. Transactions of the American Fisheries Society 119:254–264. American Fisheries Society 119:254–264*
- Shuter, B.J., C.K. Minns, and N. Lester (2002). Climate change, freshwater fi sh and fi sheries: Case studies from Ontario and their use in assessing potential impacts. In Fisheries in a Changing Climate. N.A. McGinn, ed. Bethesda, Md.: American Fisheries Society, pp. 77–88.
- *Stefan, H.G., X. Fang, and J.G. Eaton (2001). Simulated fish habitat changes in North American lakes in response to projected climate warming. Transactions of the American Fisheries Society 130:459–477*.

Wildlife

Pine Marten (American Marten): Waabizheshi

1. National Wildlife Federation. 2010. Improving the Odds: Using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem. Available at http://www.nwf.org/News-and-Magazines/Media-Center/News-by-

Topic/Global-Warming/2010/10-29-10-Great-Lakes-Adaptation-Report.aspx.

Summary: Improving the Odds was created by the National Wildlife Federation to bring awareness to Climate Change and to reduce the impacts of Climate Change. The report describes and analyzes climate-readiness initiatives in the Great Lakes Region. There are specifically looking at restoration practices that reduce climate impacts, implementing climate ready strategies and others. This is crucial to protect our natural resources, infrastructures, public health, as well as fresh water.

Specific pages to note: **Pg. 31:** It is expected that the Pine Marten will find no suitable habitat in Wisconsin. **Pg. 40:** Increased temperature of Lake Superior would benefit Sea Lamprey. This in turn will negatively affect fish species. Sea Lamprey feed on fish and warmer waters would allow for bigger growing Sea Lamprey. This will negatively affect Lake Trout, Herring, Whitefish as well as other species.

References Cited to Consider:

- Wisconsin Initiative on Climate Change Impacts. 2010. Wildlife Working Group. http://wicci.wisc.edu/workinggroups/wildlife/index.htm
- US Environmental Protection Agency. Climate Change. http://www.epa.gov/climatechange/impacts-adaptation/
- U.S. Department of the Interior National Park Service. 2007. Climate Change and Impacts to Resources around the Great Lakes. August 2007

2. Wisconsin Department of Natural Resources: Bureau of Endangered Resources. 2011. Management and Conservation Plan for American Martens in Wisconsin. Available at http://dnr.wi.gov/files/PDF/pubs/ER/ER0697.pdf

Summary: Management and Conservation Plan For American Martens In Wisconsin was created by the Wisconsin Department of Natural Resources as a plan to update the conservation status of the American Marten to ensure they remain a viable member in Wisconsin today and for generations to come. This plan provides background information on Martens including both the cultural significance and socio-economic importance of the Marten. It also provides past and current status of the Marten's life histories, habitats, and threats. It provides information on current research, management goals, and research needs.

Specific pages to note: **Pg. 20:** Climate change will decrease the amount of snowfall or snow pack. Martens need this snow to help them escape from predators. They will also lose their advantage over fishers and other competitors resulting from climate change or climate

warming.

References Cited to Consider:

- Dumyahn, J.B., P.A. Zollner, and J.H. Gilbert. 2007. Winter home-range characteristics of American marten (Martes americana) in Northern Wisconsin. American Midland Naturalist 158:382-394.
- Proulx, G., K. Aubry, J. Birks, S. Buskirk, C. Fortin, H. Frost, W. Krohn, L. Mayo, V. Monakhov, D. Payer, M. Saeki, M. Santos-Reis, R. Weir, and W. Zielinski. 2004. World distribution and status of the genus Martes in 2000. Pp. 21-76 in in D.J. Harrison, A.K. Fuller, and G. Proulx, eds. Martens and fishers (Martes) in human-altered environments: An international perspective. Springer, New York, NY.
- Woodford, J., C. Eloranta, T. Rinaldi, and B. Kohn. 2005. Inventory, status, and management needs of American Marten in northeast Wisconsin. Wisconsin Department of Natural Resources, Madison, WI. 10pp.
- Wydeven, A.P., J.E. Wiedenhoeft, and J.E. Woodford. 2007. Status of the American marten in Wisconsin. Wisconsin Endangered Resources Report No. 135. Wisconsin Department of Natural Resources, Madison, WI. 9pp.

3. Wisconsin Initiative on Climate Change Impacts. 2011. Wisconsin's Changing Climate: Impacts and Adaptation. Nelson Institute for Environmental Studies, University of Wisconsin- Madison and the Wisconsin Department of Natural Resources. Available at http://www.wicci.wisc.edu/publications.php

Summary: This report was created by the Wisconsin Initiative on Climate Change Impacts. It discusses Wisconsin's changing climate in which we now have a warmer, wetter Wisconsin climate. This change has affected precipitation, air temperatures, the quantity and quality of Wisconsin's water resources, natural habitats, agriculture, as well as others. This report is to provide information so that Wisconsin can adapt to the impacts of climate change and create strategies to adapt successfully to current and future climate change.

Specific pages to note: **Chapter 4:** The marten needs areas underneath the snow. Climate warming will lead to increasing in snow density. This will decrease the amount of thermal insulation which the Marten needs for survival. Climate warming will expose the Marten to the cold weather. Also Climate change will threaten the Marten's food source. Martens will also be threatened by more preditation; there will be fewer areas for the Marten to hide.

Fisher: Ojiig Martes pennanti

1. Olson, L. E., Sauder, J. D., Albrecht, N. M., Vinkey, R. S., Cushman, S. A., & Schwartz, M. K. (2014). Modeling the effects of dispersal and patch size on predicted fisher (Pekania [Martes] pennanti) distribution in the US Rocky Mountains. *Biological Conservation*, *169*, 89-98.

Summary: Modeling the effects of dispersal and patch size on predicted fisher distribution in the US Rocky Mountains is an article discussing the impacts climate change will have on habitats. This article specifically looks at the fisher, an already threatened species. They specifically look at fishers located across western Montana and Northern Idaho.

Specific pages to note: **Pg. 93:**The variables that contribute the most to fisher habitat suitability are 25-20 m canopy height, montane riparian vegetation, topographic positions index and mean annual precipitation. 3.2: Fisher habitat is predicted to increase. Fisher habitat is also predicted to shift north. **Pg. 95:** Fishers were more likely to occur in areas with higher mean annual precipitation, mid-range minimum winter temperatures… across both models. **Pg. 97:** Fishers are predicted to expand under climate warming but if they cannot find suitable habitat to disperse in distance greater than 4km then they will likely decline over time.

References Cited to Consider:

- Chen, I.C., Hill, J.K., Ohlemuller, R., Roy D.B., Thomas C.D., 2011. Rapid range shifts of species associated with high levels of climate warming. Science 333, 1024–1026.
- Early, R., Sax, D.F., 2011. Analysis of climate paths reveals potential limitations on species range shifts. Ecology Letters 14, 1125–1133
- Jones, J.L., Garton, E.O., 1994. Selection of successional stages by fishers in north central Idaho. In: Buskirk, S.W., Harestad, A.S., Raphael, M.G., Powell, R.A. (Eds.), Marten, Sables and Fisher: Biology and Conservation. Cornell University Press, Ithaca, NY.
- *Krohn, W.B., Elowe, K.D., Boone, R.B., 1995. Relations among fishers, snow, and martens: development and evaluation of two hypotheses. The Forestry Chronicle 71, 97–105.*
- Wasserman, T.N., Cushman, S.A., Shirk, A.S., Landguth, E.L., Littell, J.S., 2012. Simulating the effects of climate change on population connectivity of American marten (Martes americana) in the northern Rocky Mountains, USA. Landscape Ecology 27, 211–225.

2. McCamman J. (2010). Report to the California Fish and Game Commission: A Status Review of the Fisher (Martes pennanti) in California. State of California Natural Resources Agency Department of Fish and Game. Available at, https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=27900

Summary: A status Review of the Fisher in California was created to report to the California Fish and Game Commission about the current status of the fisher. This report was designed to give background history on the Fisher and their habits, what is needed for their survival, their distribution and abundance, and potential threats to the Fisher. One threat indicated for the Fisher is the current and projected future climate change.

Specific pages to note: **Pg. 57-60:** Prey and den availability for the Fisher may change. Climate Change may exacerbate wildfires which would have negative impacts on Fishers. Stress caused by unideal temperature conditions may lead Fishers to become more susceptible to disease. Lack of deep snow may allow w the Fisher to inhabit areas otherwise not available (as long as wildfires do not destroy the areas making them unsuitable first).

References Cited to Consider:

- Green, G.A., L.A. Campbell, and D.C. MacFarlane. 2008. Submitted. A conservation assessment for fishers (*Martes pennanti*) in the Sierra Nevada of California. USDA Forest Service, Pacific Southwest Region, Vallejo, California, 72pages.
- Harvell, C. D., C. E. Mitchell, J. R. Ward, S. Altizer, A. P. Dobson, R. S. Ostfeld, and M.D. Samuel. 2002. Climate warming and disease risks for terrestrial and marine biota. Science 296 No. 5576: 2158-2162.
- Heinemeyer, K. S. and J. L. Jones. 1994. Fisher biology and management in the western United States: a literature review and adaptive management strategy. Version 1.1. USDA Forest Service Northern Region and Interagency Forest Carnivore Working Group. 120 pp.
- Moritz, C, J. L. Patton, C. J. Conroy, J. L. Parra, G. C. White, S. R. Beissinger. 2008. Impact of a century of climate change on small mammal communities in Yosemite National Park, USA. Science 322:261-264.
- *Safford, H.D. 2006. Potential impacts of climate change to fisher habitat in California: a preliminary assessment. Unpublished report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA*.

3. Safford, H.D. 2006. Potential impacts of climate change to fisher habitat in California: a preliminary assessment. Unpublished report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. Available at http://www.sierraforestlegacy.org/Resources/Conservation/SierraNevadaWildlife/PacificFisher/PF-Safford06.pdf

Summary: This unpublished article addresses the potential impacts that Climate Change could have on the Fisher. Findings indicate that fire is likely to become much more frequent which

would have negative impacts on the Fisher. Fires are likely to destroy many habitats needed by the Fisher for denning.

Specific pages to note: **Pg. 9:** Fishers will more than likely lose crucial denning habitat due to fire increases. However, Fishers may be enhanced by climate warming as long as precipitation levels stay about what they are currently.

References Cited to Consider:

- Harrison, D. J., A. K. Fuller, and G. Proulx. 2004. Martens and fishers (Martes) in human-altered environments: an international perspective. Springer, New York, New York, USA.
- *Krohn, W. B, W. J. Zielinski, and R. B. Boone. 1997. Relations among fishers, snow, and martens in California: results from small-scale spatial comparisons. Pp. 211-232, in: G. Proulx, H. N. Bryant, and P. M. Woodard (eds). Martes: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Canada.*

Bobcat: Gidaagaa – Bizhiw

Moose: Mooz

1. Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting Climate Change in the Great Lakes Region. A Report of the Union of Concerned Scientists and the Ecological Society of America. Available at http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf

Summary: Confronting Climate Change in the Great Lakes Region is a report of The Union of Concerned Scientists and The Ecological Society of America. This report explains that growing evidence suggests that climate change is already affecting the Great Lakes Region: winters are shorter, average temperatures are warmer, lake ice cover is decreasing, and heavy rainstorms are more common. The potential consequences from climate change for the Great Lakes Region are confronted for the economic as well as the environmental impacts.

Specific pages to note: **Pg. 2:** Whitefish reproduction could be threatened with the loss of winter ice [Coldwater fish (Lake Trout, Whitefish, Herring) and Coolwater fish (Northern Pike, Walleye) are likely to decline in abundance]. **Pg. 54-55**: If warmwater fish species expand and increase in number in Lake Superior, this could lead to the extirpation (local extinction) of

native minnows. This could have negative impacts on Lake Trout and other Native predators. "Climate warming will greatly reduce the amount of thermally suitable habitat for Lake Trout in many inland lakes." **Pg. 60:** Moose could be harmed by warming: increase in deer populations could carry disease that will stress the moose population.

References Cited to Consider:

- *Hill, D.K., and J.J. Magnuson (1990). Potential effects of global climate warming on the growth and prey consumption of Great Lakes fi sh. Transactions of the American Fisheries Society 119:265–275. American Fisheries Society 119:265–275.*
- Magnuson, J.J., et al. (1997). Potential effects of climate change on aquatic systems: Laurentian Great Lakes and Precambrian Shield Region. In Freshwater Ecosystems and Climate Change in North America: A Regional Assessment. C.E. Cushing, ed. New York: John Wiley & Sons, pp. 7–53.
- *Magnuson, J.J., J.D. Meisner, and D.K. Hill (1990). Potential changes in the thermal habitat of Great Lakes fish after global climate warming. Transactions of the American Fisheries Society 119:254–264. American Fisheries Society 119:254–264*
- Shuter, B.J., C.K. Minns, and N. Lester (2002). Climate change, freshwater fi sh and fi sheries: Case studies from Ontario and their use in assessing potential impacts. In Fisheries in a Changing Climate. N.A. McGinn, ed. Bethesda, Md.: American Fisheries Society, pp. 77–88.
- *Stefan, H.G., X. Fang, and J.G. Eaton (2001). Simulated fish habitat changes in North American lakes in response to projected climate warming. Transactions of the American Fisheries Society 130:459–477*.

2. Lankester, M.W. 2010. Understanding the Impact of Meningeal Worm, Parelaphostrongylus tenuis, on Moose Populations. Alces Vol. 46: 53-70.

Summary: Understanding the Impacts of Meningeal Worm on Moose Populations is an article that explores the declines in moose populations that have occurred during the past century. In general these decreases in moose population are associated with higher deer populations. This inverse relationship is caused by the Meningeal worm, a parasite that white-tailed deer carry and have shown deadly to moose population when stressed. Climate change causing warmer winters is a factor that has caused an increase in deer population in moose habitat.

Specific pages to note: **Pg. 54:** There is a seen inverse relationship between moose and deer density. Less severe winters allow for an increase of deer density that then transmits diseases to the moose populations. *With Climate warming the frequency of less-severe winters would increase. This would allow for an increase in deer density which would negatively affect moose

populations.

References Cited to Consider:

- *Lenarz, M. S., Nelson, M. E., Schrage, M. W., & Edwards, A. J. (2009). Temperature mediated moose survival in northeastern Minnesota. The Journal of Wildlife Management, 73(4), 503-510*.
- *Murray, D. L., Cox, E. W., Ballard, W. B., Whitlaw, H. A., Lenarz, M. S., Custer, T. W., ... & Fuller, T. K. (2006). Pathogens, nutritional deficiency, and climate influences on a declining moose population. Wildlife Monographs, 166(1), 1-30*.

3. Michigan Technical University. 2007. Global Warming Threatens Moose, Wolves. Michigan Tech News/Media, August 15, 2007. Available at http://www.admin.mtu.edu/urel/news/media_relations/592.

Summary: The article Global Warming Threatens Moose, Wolves discusses the fact that if moose and wolves go extinct it will because of humans that make climate change increase at a faster rate. Hot summers exacerbate moose ticks which combined with the heat are detrimental to moose populations. The hot summers and ticks make moose easy prey for wolves to kill. If moose continue to drop in population it will not only affect the moose themselves but wolf population as well.

Specific pages to note: *The heat threatens the Moose. Hot weather causes moose to forage less and rest more. If they forages less it will be less likely that they survive in the winter.

4. Minnesota Department of Natural Resources. 2011. Minnesota Moose Research and Management Plan. Available at http://www.dnr.state.mn.us/moose/index.html.

Summary: The Minnesota Moose Research and Management Plan which was created by the Minnesota Department of Natural Resources because the moose population in Minnesota is currently in decline. Their findings show that moose population decline is associated with increasing summer temperature. This report is recommendations to DNR to better understand what the moose populations need to reverse this decline.

Specific pages to note: **Pg. 30:** Research implies that climate warming is contributing to the high mortality rates of moose. Higher temperatures are contributing to stress on moose, which leave them vulnerable to disease, predators, parasites, etc. There is a link between moose populations and climate warming.

References Cited to Consider:

- *Lenarz, M. S., Nelson, M. E., Schrage, M. W., & Edwards, A. J. (2009). Temperature mediated moose survival in northeastern Minnesota. The Journal of Wildlife Management, 73(4), 503-510*.
- *Murray, D. L., Cox, E. W., Ballard, W. B., Whitlaw, H. A., Lenarz, M. S., Custer, T. W., ... & Fuller, T. K. (2006). Pathogens, nutritional deficiency, and climate influences on a declining moose population. Wildlife Monographs, 166(1), 1-30*.
- Post, E. and N. C. Stenseth. 1998. Large-Scale Climatic Fluctuation and Population Dynamics of Moose and White-Tailed Deer. Journal of Animal Ecology. 67: 537-543.

Plants

Wild Rice: Manoomin

1. Cuffe, S. 2014. Wild Rice and High Water: A Northern Harvest Under Threat. Briarpatch Magazine. Available at: http://briarpatchmagazine.com/articles/view/wild-rice-and-high-water

Summary: An article written to discuss Wild Rice and harvesters in Saskatchewan and Minnesota. Methods to try and control the wild rice while facing the effects of climate change. This article touches on the sensitivity wild rice has to environment change and that climate change can cause stress on the rice. Wild Rice is a traditionally important crop to the Anishinaabe and now there are domesticated hybrids of it, which also bring risks to the natural wild rice.

Specific Pages to Note: Wild rice is very susceptible to water change. If it gets too high at certain times of the year it will drown out the wild rice which, climate change could have an effect on. Strong winds, heavy rains, and hail can cause damage to wild rice crops. This plant also depends on a certain amount of natural water circulation, and is very particular of when, where, and how it grows.

2. Ojibwe Lifeway: Wild Rice Harvesting ("Dagwaagin" – Fall). Gikinoo'wizhiwe Onji Waaban (Guiding For Tomorrow) "G-WOW" Changing Climate, Changing Culture. Available at: http://www.g-wow.org/en-us/wildrice/default.aspx

Summary: Gikinoo'wizhiwe Onji Waaban is a website designed to look at Ojibwe lifeways and how they are affected by climate change. This specific one looks to understand wild rice, the importance of the crop to the Ojibwe people and climate related stressors that have been and

will affect these wild rice crops.

Specific Pages to Note: Climate Related issues: water level has dire consequences to wild rice; it can kill the plants with either too little or too much water. Intense rainfall can also drown wild rice plants or uproot them. Certain invasive species are out competing wild rice crops. Disease and insects that damage wild rice have been increasing noticeable with the warming climate.

3. Hoene, N. 2010. Climate Change, an Ojibwe Perspective. The Seiche. Minnesota Sea Grant, March 2010. Available at http://www.seagrant.umn.edu/newsletter/2010_03.html.

Summary: Climate Change, an Ojibwe Perspective is an article discussing different Tribal members and their observation on the effects of climate change. Wild Rice, Maple Sugar, Birch, Pine, and other elements used in the Ojibwe culture are discussed on how climate change will impact them.

Specific pages to note: **Maple Sugar:** Sap has been running sooner; with a warmer climate it could start to run, and then stop. **Wild Rice:** It cannot stand extreme water level changes. **Coldwater Fish:** They will not stay if the streams warm by even a few degrees. **Tree:** A warmer climate means the loss of Birch, and potentially Sugar Maple if there is an increase in forest fires.

4. Myers, J. 2014. Wild Rice Under the Microscope: Scientists Work Fast to Learn What Sulfate Does to Minnesota's Iconic Natural Food. Minnesota Department of Natural Resources. Available at: http://www.dnr.state.mn.us/volunteer/mayjun13/wild_rice.html

Summary: This is a study conducted by the University of Minnesota on wild rice, specifically on the impact sulfate has on wild rice. It is specifically meant to understand the relationship between sulfate and wild rice. It discusses what wild rice needs for growth and factors could affect its growth. One factor briefly mentioned is climate change.

Specific Pages to Note: If sulfate is placed in the lakes, wild rice will not immediately die; there is a whole ecosystem that has to react which happens over years. Climate warming, floods and droughts also cause problems for wild rice crops. There are seen decreases in the amount of wild rice crops that have been having rice in them.

5. Pember, Mary A. 2012. Climate Change Threatens the Ojibwe's Wild Rice Harvest. Indian Country Today Media Network. Available at: http://indiancountrytodaymedianetwork.com/2012/11/02/climate-change-threatens-ojibwes-wild-rice-harvest-143579

Summary: An article written for Indian Country Today Media Network first discussing the importance of Wild Rice to the Ojibwe stories, mentioning their migration story. It mentions how wild rice crops have seen a total loss in 2012. Finally it goes through how climate change is a factor relating to the decreased amounts of wild rice in the sloughs.

Specific Pages to Note: Wild rice, manoomin favor colder temperatures, climate warming could cause manoomin to shift farther north. It could also have caused higher rates of disease within the crops of manoomin.

6. Yeager, C. Where Food Grows on Water: Environmental and Human Threats to Wisconsin's Wild Rice. 2011. Circle of Blue. Available at: http://www.circleofblue.org/waternews/2011/world/where-food-grows-on-water-environmental-and-human-made-threats-to-wisconsins-wild-rice/

Summary: This article is written on Wisconsin's rice beds and the threats that they face from both humans and the environment. It discusses the various growing stages wild rice goes through. Examples of climate change harming wild rice being water levels in the Great Lakes, storms, and heavy rains. Lastly, the article touches on the importance of Wild Rice to the Anishinaabe with an interview from Joe Rose, Bad River Tribal Elder.

Specific Pages to Note: A warming climate could lead to lower water levels in the Great Lakes; this would have dire impacts on wild rice crops. Increased flooding or heavy rains caused from climate change could drown or uproot wild rice crops especially when it is in its floating leaf stage (a critical and fragile time in the growth cycle). There have been seen changes in wild rice beds caused by climate change in Wisconsin.

Trees

Sugar Maple: Ziinzibaakwadaatig

1. *Frumhoff, P.C.; McCarthy, J.J.; Melillo, J.M.; Moser, S.C.; Wuebbles, D.J. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). Cambridge,*

MA: Union of Concerned Scientists. Available at: http://www.northeastclimateimpacts.org/pdf/confronting-climate-change-in-the-u-s-northeast.pdf

Summary: This report discusses the Northeast and how they experience huge climate diversity within a small area. This area has also experienced drastic climate change since 1970, with a warming rate of almost 0.5 degrees Fahrenheit per decade. With the experienced climate warming there have been seen changes in the environment. This report was created to understand past and future climate change, to understand the potential effects that climate change could bring about.

Specific pages to note: **Pg. 49 & 55:** Projections indicate that male habitat will shift northward under either climate change scenario. Southern species of trees eventually become their replacements in the Northeast. Climate change will also leave the maple tree more susceptible to disease, pests, drought, wildfire, and storm damage. **Pg. 55 & 58:** Sugar maple is expected to lose drastic amounts of suitable habitat. It could have the chance of surviving under climate warming but a warmer winter is expected disrupt the winter pattern sugar maples need for optimal syrup production. **Pg. 59:** With a projected decrease in Maples and the loss of their colorful changing leaves in the fall, tourism could suffer in the Northeast. **Pg. 74:** Maple Syrup has seen a shift in the time it usual is produced, which has caused a decline in the syrup industry. Global warming is one possibility as to why this shift has occurred, and is likely to keep occurring.

References Cited to Consider:

- Belluck, P. 2007. Warm Winters Upset Rhythms of Maple Sugar. The New York Times, March 3. Available at: http://www.nytimes.com/2007/03/03/us/03maple.html?pagewanted=1&ei=5070&en=8309fa4efa4d66b6&ex=1173589200&emc=eta1.
- Case, C.F. 2005. Climate Change Could Sour U.S. Maple Sugaring. The Christian Science Monitor. April 6. Available at: http://www.csmonitor.com/2005/0406/p11s01-sten.html.
- *Clean Air-Cool Planet. 2007. Climate Change and the Northern Forest. Available at:* http://www.cleanair-coolplanet.org/information/factsheets.php.
- *Hayhoe, K., C.P. Wake, B. Anderson, X.-Z. Liang, E. Maurer, J. Zhu, J. Bradbury, A. DeGaetano, A. Hertel, and D. Wuebbles. 2008. Regional Climate Change Projections for the Northeast U.S. Mitigation and Adaptation Strategies for Global Change. In press.*

- *Iverson, L., A. Prasad, and S. Matthews. 2008. Potential Changes in Suitable Habitat for 134 Tree Species in the Northeastern United States. Mitigation and Adaptation Strategies for Global Change. In press.*
- *Mohan, J.E., J.M. Melillo, K. Lenoir, R. Hanifin, J.H. Blanchard, T. Sipe, S. Sistla, P.A. Steudler, F. Bowles, and F.A. Bazzaz. 2007. Shifting Temperate Forest Composition with Soil Warming. Nature. In review.*
- *Ollinger, S.V., C.L. Goodale, K. Hayhoe, and J.P. Jenkins. 2008. Potential Effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change. In press.*
- Sheehan, J.F., and The Adirondack Council. 1998. Acid rain: A Continuing National Tragedy. Elizabethtown, NY. Available at: http://www.adirondackcouncil.org/acrapub.pdg.

2. Great Lakes Area National Park Service U.S. Department of the Interior. 2007. Climate Change: Dying Birch trees, minimal snowpack, and ice-free lakes are just some Impacts of Midwest Warming. Available at http://www.nps.gov/apis/naturescience/upload/2007%20MWR%20Climate%20Change%20Site%20Bulletin%20-%20Great%20Lakes%20FINAL.pdf

Summary: This article, Dying Birch Trees, Minimal Snowpack, and Ice-Free Lakes Are Just Some Impacts of Midwest Warming discusses climate change effects in the Midwest Region. It touches on the science reports by the U.S. Global Change Research Program as well as others and how they show that this is due to greenhouse gases produced by human activities. In specific the article has sections on Temperature and Precipitation, The Ecological Effects, New Faces in New Places, and Recreation, Health and Safety.

Specific pages to note: * Cool tree species are projected to lose habitat in the U.S. Sugar Maple and Paper Birch are expected to shift towards Canada. For the Apostle Island Lakeshore and Michigan Upper peninsula Paper Birch may lose all habitats. *Coldwater fish such as Trout will decrease in abundance. Whitefish spawning areas will be disturbed and Native fish will be threatened.

3. Hoene, N. 2010. Climate Change, an Ojibwe Perspective. The Seiche. Minnesota Sea Grant, March 2010. Available at http://www.seagrant.umn.edu/newsletter/2010_03.html.

Summary: Climate Change, an Ojibwe Perspective is an article discussing different Tribal members and their observation on the effects of climate change. Wild Rice, Maple Sugar, Birch,

Pine, and other elements used in the Ojibwe culture are discussed on how climate change will impact them.

Specific pages to note: **Maple Sugar:** Sap has been running sooner; with a warmer climate it could start to run, and then stop. **Wild Rice:** It cannot stand extreme water level changes. **Coldwater Fish:** They will not stay if the streams warm by even a few degrees. **Tree:** A warmer climate means the loss of Birch, and potentially Sugar Maple if there is an increase in forest fires.

4. Ojibwe Lifeway: Maple Sugaring and Birch Bark Harvesting ("Ziigwan" – Spring). Gikinoo'wizhiwe Onji Waaban (Guiding for Tomorrow) "G-Wow" Changing Climate, Changing Culture. Available at: http://www.g-wow.org/en-us/maple_birch/default.aspx

Summary: Gikinoo'wizhiwe Onji Waaban is a website designed to look at Ojibwe lifeways and how they are affected by climate change. This specific one looks to understand both sugar maples and birch bark trees. It covers the specific cultural importance of these trees. As well as, includes impacts they face resulting from climate change and possible climate change stressors.

Specific Pages to Note: Climate warming will cause a decrease in suitable habitat for Sugar Maple. Climate warming could also have an impact on soil moisture which will inhibit Sugar Maple's effectiveness to receive water and nutrients. Climate change may also allow for an increase in disease and pests. Lastly, shorter winters may cause stress on the Sugar Maple and allow for greater vulnerability to pests. This in turn will cause a decrease in the Maple Sap production.

5. *Rustad, L., Campbell, J., Dukes, J.S., Huntington, T., Lambert, K.F., Mohan, J., Rodenhouse, N. Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada. United States Department of Agriculture. 2012. Available at*: http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs99.pdf

Summary: This was created to study climate change and the effects it poses on forest ecosystems with the goal to provide important insights for forest science, management, and policy. Climate change is predicted to have dire effects on habitat locations of tree species. A decline in suitable habitats is expected with a change in abundance and distribution of wildlife.

Specific pages to note: **Pg. 13**: Tourism would be affected with a shift from Sugar maples to Oaks. **Pg. 17 & 18:** Table 2. Shows that Sugar maple is expected to lose suitable habitat. Maple will lose habitat in either climate change scenario. **Pg. 20:** Sugar maple could decline based on prolonged thaw-freeze events.

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- *Frumhoff, P.C.; McCarthy, J.J.; Melillo, J.M.; Moser, S.C.; Wuebbles, D.J. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists. 146 p.*
- *Iverson, L.R.; Prasad, A.; Matthews, S. 2008. Modeling Potential Climate Change Impacts on the Trees of the Northeastern United States. Mitigation and Adaptation Strategies for Global Change. 13: 517-540.*
- *Ollinger, S.V.; Goodale, C.L.; Hayhoe, K.; Jenkins, J.P. 2008. Potential Effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change. 13: 467-485.*
- *Woodall, C.W.; Oswalt, C.M.; Westfall, J.A.; Perry, C.H.; Nelson, M.D.; Finley, A.O. 2009. An Indicator of Tree Migration in Forests of the Eastern United States. Forest Ecology and Management. 257: 1434-1444*.

6. http://www.fs.fed.us/nrs/atlas/tree/241
http://www.fs.fed.us/nrs/atlas/tree/318
http://www.fs.fed.us/nrs/atlas/tree/375
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Summary: These websites show the current distribution of the Northern White Cedar, Sugar Maple, Paper Birch, and Black Ash respectively. They are maps created by the United States Department of Agriculture Forest Service to show the current distribution, projected future habitat, and predictor maps of these tree species. They are interactive maps where you can see climate change affecting the tree species with consideration of specific factors.

Paper Birch: Wiigwaasaatig

1. *Frumhoff, P.C.; McCarthy, J.J.; Melillo, J.M.; Moser, S.C.; Wuebbles, D.J. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists.* Available at: http://www.northeastclimateimpacts.org/pdf/confronting-climate-change-in-the-u-s-northeast.pdf

Summary: This report discusses the Northeast and how they experience huge climate diversity within a small area. This area has also experienced drastic climate change since 1970, with a warming rate of almost 0.5 degrees Fahrenheit per decade. With the experienced climate warming there have been seen changes in the environment. This report was created to understand past and future climate change, to understand the potential effects that climate change could bring about.

Specific pages to note: **Pg. x:** Birch forests are predicted t shift dramatically northward in predicted climate change scenarios. **Pg. 49:** Figure 6. Shows the predicted shift birch is expected to take under two climate change scenarios. **Pg. 55:** Birch is projected to shift northward in either climate change scenario, with oak trees taking over to replace them. Climate change may leave birch more vulnerable to disease, pests, drought, wildfire, and storm damage. **Pg. 59:** The loss of birch with their colorful leaves in the fall could cause a decrease in tourism.

References Cited to Consider:

- *Clean Air-Cool Planet. 2007. Climate Change and the Northern Forest. Available at:* http://www.cleanair-coolplanet.org/information/factsheets.php.
- *Hayhoe, K., C.P. Wake, B. Anderson, X.-Z. Liang, E. Maurer, J. Zhu, J. Bradbury, A. DeGaetano, A. Hertel, and D. Wuebbles. 2008. Regional Climate Change Projections for the Northeast U.S. Mitigation and Adaptation Strategies for Global Change. In press.*
- *Iverson, L., Prasad, and S. Matthews. 2008. Potential Changes in Suitable Habitat for 134 Tree Species in the Northeastern United States. Mitigation and Adaptation Strategies for Global Change. In press*.
- *Mohan, J.E., J.M. Melillo, K. Lenoir, R. Hanifin, J.H. Blanchard, T. Sipe, S. Sistla, P.A. Steudler, F. Bowles, and F.A. Bazzaz. 2007. Shifting Temperate Forest Composition with Soil Warming. Nature. In review.*
- *Ollinger, S.V., C.L. Goodale, K. Hayhoe, and J.P. Jenkins. 2008. Potential Effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change. In press.*

2. Great Lakes Area National Park Service U.S. Department of the Interior. 2007. Climate Change: Dying Birch trees, minimal snowpack, and ice-free lakes are just some Impacts of Midwest Warming. Available at http://www.nps.gov/apis/naturescience/upload/2007%20MWR%20Climate%20Change%20Site%20Bulletin%20-%20Great%20Lakes%20FINAL.pdf

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Summary: Climate Change, an Ojibwe Perspective is an article discussing different Tribal members and their observation on the effects of climate change. Wild Rice, Maple Sugar, Birch, Pine, and other elements used in the Ojibwe culture are discussed on how climate change will impact them.

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4. Iverson, L., A.M. Prasad, S.N. Matthews, M. Peters. 2008. Estimating Potential Habitat for 134 Eastern US Tree Species Under Six Climate Scenarios. Forest Ecology and Management 254: 390-406.

Summary: This article is a map of 134 tree species selected from random forests to study their responses to climate change. It is to show the current as well as potential future habitats of these species according to two emission scenarios with three climate models. Generally most specie habitats move northeast, with it being more drastically in a higher emission scenario. Generally there are quite a lot of species predicted to lose suitable habitat areas.

Specific Pages to Note: **Pg. 401:** Birch can sustain some habitat under low emissions but once under high emissions, it is eliminated. **Pg. 404:** Forests are expected to lose habitat under either scenarios.

References Cited to Consider:

- Chaing, J., Iverson, L.R., Prasad, A.M., Brown, K., 2006. Interactions of Changing Climate and Shifts in Forest Composition on Stand Carbon Balance. In: Ecological Society of America, 91st Annual Meetings, Memphis, TN.
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5. Ojibwe Lifeway: Maple Sugaring and Birch Bark Harvesting ("Ziigwan" – Spring). Gikinoo'wizhiwe Onji Waaban (Guiding for Tomorrow) "G-Wow" Changing Climate, Changing Culture. Available at: http://www.g-wow.org/en-us/maple_birch/default.aspx

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Specific Pages to Note: Climate warming will cause a decrease in suitable habitat for Paper Birch. Climate warming could also have an impact on soil moisture which will inhibit birch effectiveness to receive water and nutrients. Climate change may also allow for an increase in disease and pests. Lastly, shorter winters may cause stress on the paper birch and allow for greater vulnerability to pests.

6. *Rustad, L., Campbell, J., Dukes, J.S., Huntington, T., Lambert, K.F., Mohan, J., Rodenhouse, N. Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada. United States Department of Agriculture. 2012. Available at*: http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs99.pdf

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Specific pages to note: **Pg. 17:** Graph shows that Paper birch will experience a (87%) loss in suitable habitat under predicted climate change scenarios. **Pg. 18:** Under either climate change scenario, birch habitat experiences habitat loses out to oak and hickory habitats. **Pg. 20** Birch experiences habitat loss due to extended winter thaw cycles.

References Cited to Consider:

- Balch, R.E. 1944. The Dieback of Birch in the Maritime Region. Contribution No. 3. Fredericton, NB: Dominion of Canada, Department of Agriculture, Division of Entomology.

- Bourque, C.P.A.; Cox, R.M.; Allen, D.J.; Arp, P.A.; Meng, F.R. 2005. Spatial Extent of Winter Thaw Events in Eastern North America: Historical Weather Records in Relation to Yellow Birch Decline. Climate Change Biology. 11: 1477-1492.
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- *Frumhoff, P.C.; McCarthy, J.J.; Melillo, J.M.; Moser, S.C.; Wuebbles, D.J. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists. 146 p.*
- *Iverson, L.R.; Prasad, A.; Matthews, S. 2008. Modeling Potential Climate Change Impacts on the Trees of the Northeastern United States. Mitigation and Adaptation Strategies for Global Change. 13: 517-540.*
- *Ollinger, S.V.; Goodale, C.L.; Hayhoe, K.; Jenkins, J.P. 2008. Potential Effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change. 13: 467-485.*
- *Woodall, C.W.; Oswalt, C.M.; Westfall, J.A.; Perry, C.H.; Nelson, M.D.; Finley, A.O. 2009. An Indicator of Tree Migration in Forests of the Eastern United States. Forest Ecology and Management. 257: 1434-1444*.

7. http://www.fs.fed.us/nrs/atlas/tree/241
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Summary: These websites show the current distribution of the Northern White Cedar, Sugar Maple, Paper Birch, and Black Ash respectively. They are maps created by the United States Department of Agriculture Forest Service to show the current distribution, projected future habitat, and predictor maps of these tree species. They are interactive maps where you can see climate change affecting the tree species with consideration of specific factors.

Northern White Cedar: Nookomis Giizhik

1. *Rustad, L., Campbell, J., Dukes, J.S., Huntington, T., Lambert, K.F., Mohan, J., Rodenhouse, N. Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada. United States Department of Agriculture. 2012. Available at*: http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs99.pdf

Summary: This was created to study climate change and the effects it poses on forest ecosystems with the goal to provide important insights for forest science, management, and policy. Climate change is predicted to have dire effects on habitat locations of tree species. A decline in suitable habitats is expected with a change in abundance and distribution of wildlife.

Specific pages to note: **Pg. 17:** Graph shows a decrease in Northern White Cedar is expected to have a (73%) decrease in suitable habitat.

References Cited to Consider:

- *Frumhoff, P.C.; McCarthy, J.J.; Melillo, J.M.; Moser, S.C.; Wuebbles, D.J. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists. 146 p.*
- *Iverson, L.R.; Prasad, A.; Matthews, S. 2008. Modeling Potential Climate Change Impacts on the Trees of the Northeastern United States. Mitigation and Adaptation Strategies for Global Change. 13: 517-540.*
- *Ollinger, S.V.; Goodale, C.L.; Hayhoe, K.; Jenkins, J.P. 2008. Potential Effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change. 13: 467-485.*
- *Woodall, C.W.; Oswalt, C.M.; Westfall, J.A.; Perry, C.H.; Nelson, M.D.; Finley, A.O. 2009. An Indicator of Tree Migration in Forests of the Eastern United States. Forest Ecology and Management. 257: 1434-1444*.

2. United States Department of Agriculture. 2014. Michigan Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Northwoods Climate Change Response Framework Project. Available at: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs129.pdf

Summary: This report was created by the United States Department of Agriculture to explain how the forests in northern Michigan will be affected by Climate Change. It specifically discusses the forests in the eastern and northern parts of the Upper Peninsula. It identifies major forest trends and stressors that are currently threatening Michigan forests. Using climate projections they identified the potential future impacts of climate change on forests.

Specific pages to note: **Pg. 96:** Table 17. Northern White Cedar decreases in both climate change scenarios. **Pg. 101:** Northern White Cedar experienced increased climate stress in both scenarios of climate change. As the climate warms it is expected to face increasing climate

related stress. **Pg. 121 & 128 & 134:** Northern White Cedar is expected to lose suitable habitat for survival. **Pg. 134:** Deer will inhibit the regeneration ability of Northern White Cedar which will add the future climate related stress. **Pg. 157:** Native American Tribes are likely to face decreased availability of culturally important tree species such as the Northern White Cedar.

References Cited to Consider:

- Chhin, J.M.; Iverson, L.R.; Prasad, A.; Brown, K.J. 2008. Effects of Climate Change and Shifts in Forest Composition on Forest Net Primary Production. Journal of Integrative Plant Biology. 50(11): 1426-1439.
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- Hall, K. 2012. Climate Change in the Midwest:Impacts on Biodiversity and Ecosystesms. In: Winkler, J.; Andersen, J.; Hatfield, J.; Bidwell, D.; Brown, D., coordinators. U.S. National Climate Assessment Midwest technical input report. Available at http://glisa.msu.edu/docs/NCA/MTIT_Biodiversity.pdf.
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- Ollinger, S.; Goodale, C.; Hayhoe, K.; Jenkins, J. 2008. Potential effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change. 13(5): 467-485.
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- Scheller, R.M.; Mladenoff, D.J. 2005. A spatially interactive Simulation of Climate Change, Harvesting, Wind, and Tree Species Migration and Projected Changes to Forest Composition and Biomass in Northern Wisconsin, USA. Global Change Biology. 11(2): 307-321.

3. Whitman, A. 2013. Suggested Climate Change Adaptation Strategies for The Narrows WMA, Stands 1 and 5. Manomet Center for Conservation Sciences. Available at: https://www.manomet.org/sites/default/files/publications_and_tools/2013%20Manomet%20-%20Suggested%20Climate%20Change%20Adaptation%20Strategies%20for%20The%20Narrows%20WMA%20VT%20FINAL.pdf

Summary: This article is on Climate Change of the forests and forest habitats in Vermont. They have the projected climate change impacts that Vermont's forests in the south will experience including temperature, drought, lack of snow cover, and wildfire. The article gets over the current challenges that Vermont is facing and how they are trying to manage the impacts from climate change.

Specific Pages to Note: **Pg. 2 & 3:** Cedar seedling have a high mortality is greatest at temperatures above 90 degrees F, global warming could impact the mortality rate of cedar seedling. **Pg. 3:** Drought may have negative impacts on white cedar's regeneration abilities.

References Cited to Consider:

- Allen, C., A. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, and N. Cobb. 2010. A Global Overview of Drought and Heat-Induced Tree Mortality Reveals Emerging Climate Change Risks For Forests. Forest Ecology and Management 259: 660-684.
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- *Iverson, L.R., A.M. Prasad, and M.W. Schwartz. 2005. Predicting Potential Changes in Suitable Habitat and Distribution by 2100 for Tree Species of the Eastern United States. Journal of Agricultural Meteorology 61: 29 – 37.*
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- *Ollinger, S., C. Goodale, K. Hayhoe, and J. Jenkins. 2008. Potential Effects of Climate Change and Rising CO_2 on Ecosystem Processes in Northeastern U.S. Forests. Mitigation and Adaptation Strategies for Global Change 13: 541 – 554.*
- Rustad, L., J. Campbell; J. Dukes; T. Huntington; K. Lambert, J. Mohan, and N. Rodenhouse. 2012. Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada. Gen. Tech. Rep. NRS-99. Newtown Square, PA: USDA. Forest Service, Northern Research Station. 48 p.

4. http://www.fs.fed.us/nrs/atlas/tree/241
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Black Ash: Baapaagimaak

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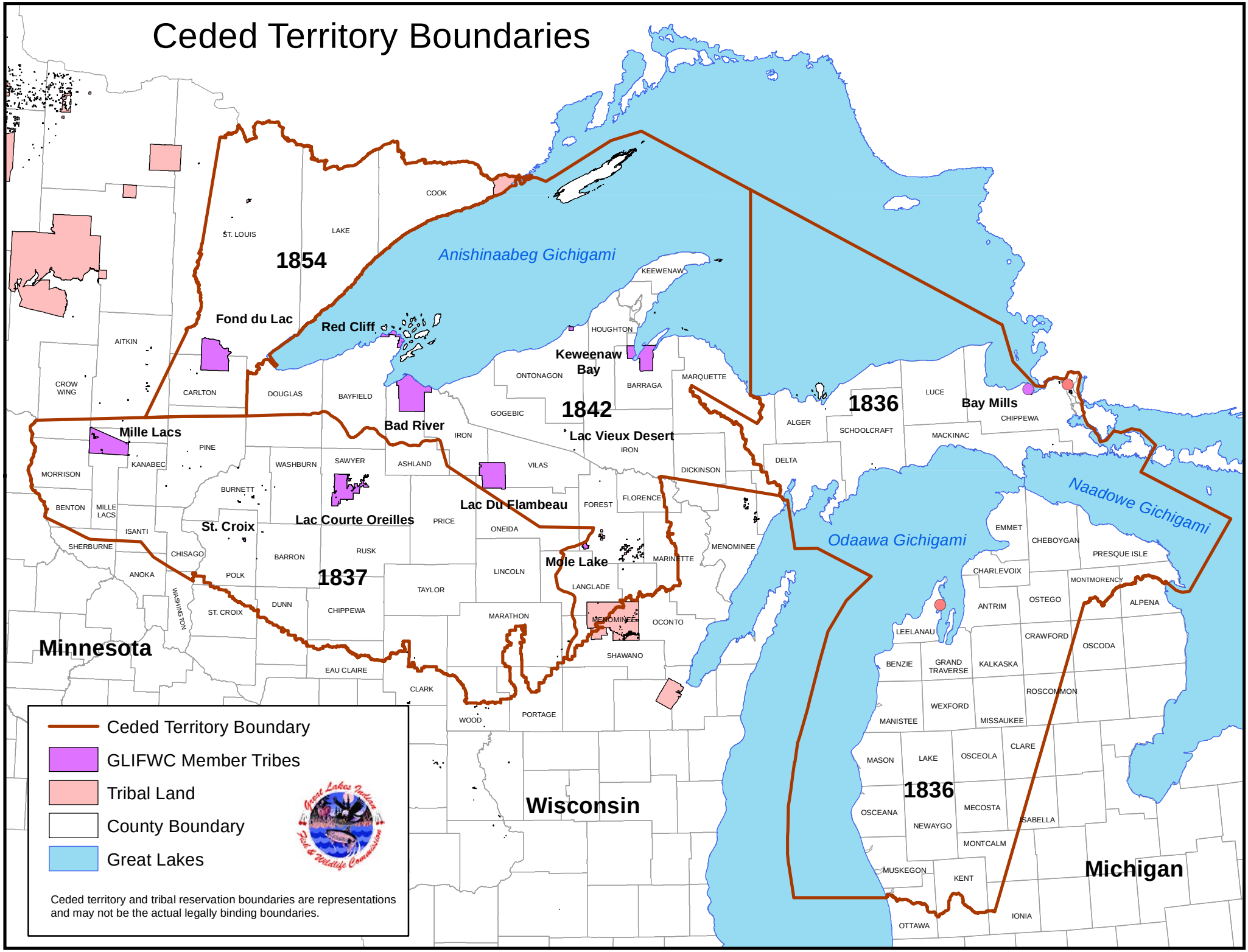
Ceded Territory Boundaries