Implementing Comprehensive Wildlife Vulnerability Assessments and Developing Fish and Medicinal Plant Assessment Frameworks for the 1836 Ceded Territory

Funded by the Bureau of Indian Affairs - 2015 Tribal Cooperative Landscape Conservation Program – Category 2 – Climate Adaptation Planning

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Introduction

The 2015 Tribal Cooperative Landscape Conservation Program (TCLCP) funding provided through the Bureau of Indian Affairs allowed the Sault Ste. Marie Tribe of Chippewa Indians – Natural Resources Department (STNRD) to build upon previous efforts to complete a vulnerability assessment for snowshoe hare. With the 2015 Tribal Cooperative Landscape Conservation Program funding, STNRD aimed to use the methodologies developed for the snowshoe hare vulnerability assessment to implement vulnerability assessments for a broader array of important tribal wildlife species and develop a framework to assess the vulnerability of important fish and plant species.

Understanding vulnerability of wildlife species to climate change is important to Sault Tribe members for a number of reasons. Many of the species included in Sault Tribe's climate change vulnerability assessment (CCVA) are important because they occupy important roles in tribal culture and/or they are of value as a subsistence species. Understanding the impacts of climate change on these species can help the Tribe better plan for continued sustainable harvest and exercise of treaty rights within the 1836 Treaty Ceded Territory.

Summary of Grant Objectives

The 2015 TCLCP project ""Implementing Comprehensive Wildlife Vulnerability Assessments and Developing Fish and Medicinal Plant Assessment Frameworks for the 1836 Ceded Territory" aimed to meet four objectives:

1) Assess vulnerability of wildlife to projected changes in climatic conditions in the 1836 Treaty Ceded Territory

2) Develop adaptation planning resources for wildlife in the 1836 Treaty Ceded Territory

3) Develop framework to assess important fish and medicinal plants

4) Increase involvement in regional climate change initiatives such as the Upper Midwest and Great Lakes Landscape Conservation Cooperative beyond the Forest Working Group

Each of these objectives was met and the resulting products are included within this report. A climate change vulnerability assessment was carried out for 14 wildlife species important to the Sault Tribe community. The resulting rankings and CCVA results are currently

being used within the Sault Tribe Natural Resources Department (STNRD) as adaptation planning resources. A framework for assessing vulnerability of important fish and plant species was developed to guide future climate change vulnerability assessment results. The STNRD remained engaged with the Upper Midwest and Great Lakes Landscape Conservation Cooperative and engaged in multiple tribal climate change adaptation forums over the course of the project.

Project Benefits

This project provides three benefits to STNRD, the Sault Tribe, and regional natural resources managers:

1. Inform fish, wildlife, and plant harvest and habitat management practices for all agencies managing resources in the 1836 Treaty Ceded Territory

2. Provide a sound basis for STNRD to consult on forest management and habitat management practices with the aim of increasing the adaptive capacity of tribally important fish, wildlife, and plant species within the 1836 Treaty Ceded Territory

3. The project will allow the STNRD to conduct vulnerability assessments and adaptation plans and bring the data derived to bear through our participation in the Upper Midwest and Great Lakes Landscape Conservation Cooperative and other regional and tribal climate change adaptation initiatives

Description of Species Selection for the CCVA

STNRD worked to engage the Sault Tribe community in selection of species for this climate change vulnerability assessment. STNRD did this through two public meetings, three public coffee hours, and by setting up an informational booth at the annual Sault Ste. Marie pow-wow (see timeline below) in early to mid-2017. Interested community members were asked to provide input on species they thought should be included in the CCVA by completing a survey and through discussions with STNRD employees. Ultimately, STNRD selected a suite of 14 species for this assessment that included both species that community members found important as well as those that are of interest to ongoing STNRD assessments and clearly of importance as demonstrated by annual subsistence harvest data.

Date	Community Engagement Activity
January 9th, 2017	Inland Conservation Committee meeting, public meeting for CCVA held
February 6th, 2017	Inland Conservation Committee meeting, second public meeting for CCVA held
March 3rd, 2017	Public Coffee Hour held
April 7th, 2017	Public Coffee Hour held
May 5th, 2017	Public Coffee Hour held
July 7th to July 9th, 2017	Sault Ste. Marie Powwow

Table 1 Community engagement activities

	Anishinaabe	English	Scientific
Panel 1 – Upland Birds	Bine	Ruffed grouse	*Bonasa umbellus*
	Aagask	Sharp-tailed grouse	*Tympanuchus phasianellus*
	Mashkodese	Spruce grouse	*Falcipennis canadensis*
	Badashka'anzhi	American woodcock	*Scolopax minor*
	Mizise	Wild turkey	*Meleagris gallopavo*
Panel 2 – Waterfowl and Waterbirds	Ininishib	Mallard	*Anas platyrhynchos*
	Mitigoningwiishib	Wood duck	*Aix sponsa*
	Maang	Common loon	*Gavia immer*
	Jiwiiskwiiskiwe	Wilson's snipe	*Gallinago delicata*
	Ajijaak	Sandhill crane	*Grus canadensis*
Panel 3 - Mammals	Waabizheshi	American marten	*Martes americana*
	Amik	North American beaver	*Castor canadensis*
	Makwa	Black bear	*Ursus americanus*
	Waawaashkeshi	White-tailed deer	*Odocoileus virginianus*

Table 2 Focal species for the climate change vulnerability assessment

Description of the "System for Assessing Vulnerability of Species" and Modifications

The "System for Assessing Vulnerability of Species," or SAVS, tool was modified and used to complete this climate change vulnerability assessment (Bagne et al. 2011). This is the same method that was employed in the previous snowshoe hare vulnerability assessment completed by STNRD. This method was developed by the United States Forest Service- Rocky Mountain Research Station and is suitable for use with terrestrial vertebrates. The SAVS assessment examines the potential impact of climate change to a given species by taking species' sensitivity and exposure into consideration. Additionally this method accounts for the adaptive capacity of a given species to climate change. Accounting for both the potential impacts and adaptive capacity of organisms to climate change can give SAVS tools users an idea

of climate change vulnerability (Figure 1, Glick et al. 2011). By answering 22 questions (see Table 5 below) regarding species' attributes related to vulnerability and resilience for a given location and climate scenario, SAVS tool users can generate a relative vulnerability score. The suite of questions relates to a given species habitat, physiology, phenology, and biotic interactions. Additionally, and importantly, this tool allows natural resources managers to identify areas of uncertainty with regard to climate vulnerability, which aid in development of future research directions. Ultimately, STNRD hopes to use the results of these assessments in the development of adaptive management plans for tribally-important species.

Using the SAVS method, STNRD assembled three panels of wildlife professionals from tribal, federal, state, university, and non-profit agencies that were subject matter experts for a given suite of species. Panel members were asked to complete modified SAVS questionnaires for 4-5 species (panel groups listed below). Prior to completing SAVS questionnaires, panel members were provided with background information including literature excerpts related to the SAVS questions for each species and pertinent climate projection information and resources. Panel members were asked to respond to the SAVS questionnaires while considering changes and impacts within the 1836 Treaty Ceded Territory over the next 50-80 years.

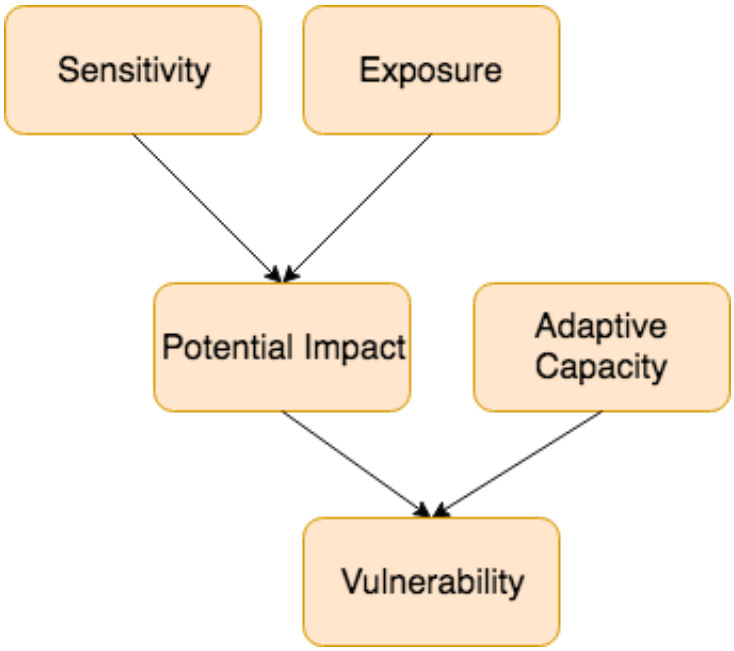

Figure 1 Conceptual diagram of components of climate change vulnerability, modified from Glick et al. (2011)

Panel	Name	Affiliation at time of report
1	Charlotte Roy	Minnesota Department of Natural Resources
1	Joseph Bump	University of Minnesota
1	Steve Sjogren	United States Forest Service – Hiawatha National Forest (retired)
1	Joseph Lautenbach	Sault Ste. Marie Tribe of Chippewa Indians – Natural Resources Department
1	David Haukos	Kansas State University
1	Ryan Boyer	National Wild Turkey Federation
2	Dave Luukkonen	Michigan Department of Natural Resources
2	Greg Soulliere	Upper Mississippi River & Great Lakes Region Joint Venture, United States Fish & Wildlife Service
2	Caleb Putnam	Audubon Great Lakes
2	Christie Deloria	United States Fish & Wildlife Service
2	Joe Kaplan	Common Coast Research and Conservation
3	Eric Clark	Sault Ste. Marie Tribe of Chippewa Indians – Natural Resources Department
3	Ari Cornman	Little River Band of Ottawa Indians
3	Gary Roloff	Michigan State University – Department of Fisheries and Wildlife
3	Dwayne Etter	Michigan Department of Natural Resources

Table 3 CCVA expert panel members

Panel members completed SAVS questionnaires independently for each of the species on their assigned panel. After allowing adequate time for panel members to respond to SAVS questionnaires and provide comments, the SAVS questionnaires for each species were scored individually. For an example of how the established SAVS question and scoring method works, refer to the attached SAVS scoring document.

Date	SAVS Expert Panel Activity
April 28th, 2017	Panel 1 – Introductory Conference Call
May 19th, 2017	Panel 2 – Introductory Conference Call
June 9th, 2017	Panel 3 – Introductory Conference Call
August 14th, 2017	Panel 1 – SAVS Questionnaires Due
August 16th, 2017	Panel 2 – SAVS Questionnaires Due
August 23rd, 2017	Panel 3 – SAVS Questionnaires Due
September 13th, 2017	Panel 1 – Wrap-up Discussion Conference Call
September 19th, 2017	Panel 2 – Wrap-up Discussion Conference Call
September 29th, 2017	Panel 3 – Wrap-up Discussion Conference Call

Table 4 Expert panel activities

One of the strengths of this CCVA was the use of multi-member panels, instead of a single individual, to complete the SAVS questionnaires. By creating panels, we were able to draw on the collective knowledge of multiple wildlife experts for each group of focal species. Doing so required STNRD to adapt the SAVS method for this multi-responder approach. To do this, STNRD took the individual quantitative responses to each SAVS question for each species and averaged panel member responses for each question. The same was done for the uncertainty scores associated with each question. This resulted in a final mean vulnerability score for each question and species as well as a mean estimate of uncertainty for each question and overall measure of uncertainty for each species. Additionally, STNRD asked panel members to share comments regarding rationale for their responses, to highlight specific reasons for uncertainty, or to provide references to justify their responses. Comments were optional, but those that were provided were helpful for interpretation of final results.

SAVS Questions	
Category: Habitat	
1	Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
2	Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
3	Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
4	Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
5	Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Category: Physiology	
1	Physiological thresholds: Are limiting physiological conditions expected to change?
2	Sex ratio: Is sex ratio determined by temperature?
3	Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
4	Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
5	Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
6	Energy requirements: What is this species' metabolic rate?
Category: Phenology	
1	Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
2	Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
3	Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
4	Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Category: Biotic Interactions	
1	Food resources: Are important food resources for this species expected to change?
2	Predators: Are important predator populations for this species expected to change?
3	Symbionts: Are populations of symbiotic species expected to change?
4	Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
5	Competitors: Are populations of important competing species expected to change?

Table 5 Summary of SAVS questions broken down into 4 categories

Climate Projection Information

Panel members contributing to this climate change vulnerability assessment were provided with a number of climate projection resources to use as reference material when completing the SAVS questionnaires. One primary resource used was the "Michigan Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Northwoods Climate Change Response Framework Project" (Handler et al. 2014).

Panel members were also provided with the climate summary compiled by Tracy Swem as part of the Eastern Upper Peninsula Snowshoe Hare Vulnerability Assessment (Swem 2015). This summary compiled information from a few resources, including the aforementioned Michigan Forest Ecosystem Vulnerability Assessment and Synthesis (Handler et al. 2014) into a user-friendly summary totaling four pages.

Another resource shared with all panel members were localized climate information reports created for the eastern Upper Peninsula and the northern Lower Peninsula as the result of a collaboration between the Great Lakes Integrated Sciences and Assessment Center and the Inter-Tribal Council of Michigan, which was funded by a United States Bureau of Indian Affairs Tribal Climate Resilience Program Grant to the Inter-Tribal Council of Michigan.

Key findings from the "Michigan Forest Ecosystem Vulnerability Assessment and Synthesis" (Handler et al. 2014), taken directly from Tracy Swem's "Eastern Upper Peninsula Snowshoe Hare Vulnerability Assessment":

- The assessment area is projected to experience an average annual temperate increase of 1.3°F under the PCM B1 scenario and 7.1°F under GFDL A1F1 by the end of the century compared to the baseline period of 1971 to 2000.
- In the assessment area, snowfall will decrease and rainfall will take its place.
- The report concludes that runoff could increase by over 100 percent, with most dramatic increases in the Eastern Upper Peninsula.
- LANDIS-II projects that Balsam fir, Balsam poplar, Black ash, Black spruce, Eastern hemlock, Jack pine, Northern pin oak, Northern white cedar, Paper birch, Red pine, White spruce, and Yellow birch will all decline by the end of the century.
- Decline of aspen in Michigan.
- Increased fire activity and increased browsing by deer.

CCVA Summary Results

Results from the climate change vulnerability assessment indicated a range of vulnerability to climate change impacts, with vulnerability scores ranging from those that could be slightly resilient (scores ranging from 0 to -5; i.e., white-tailed deer, mallard, wild turkey, and wood duck) to slightly vulnerable (scores ranging from 0 to 5; i.e., black bear, North American beaver, Wilson's snipe, common loon, sandhill crane, American woodcock, sharp-tailed grouse) to those that could be considered moderately vulnerable (scores ranging from 5 to 15; i.e., American marten, ruffed grouse, snowshoe hare, spruce grouse). Final scores are summarized in Table 6.

- Higher scores indicate higher vulnerability. Negative scores indicate the potential for a species to benefit from projected changes in climate.
- Overall vulnerability scores range from -20 (least vulnerable, species may benefit from projected changes) to 20 (species being highly vulnerable to climate change).
- Categorical vulnerability scores (for habitat, physiology, phenology, and biotic interactions) range from -5 to 5.
- Uncertainty values are percentage uncertainty (0.42 = 42% uncertainty).

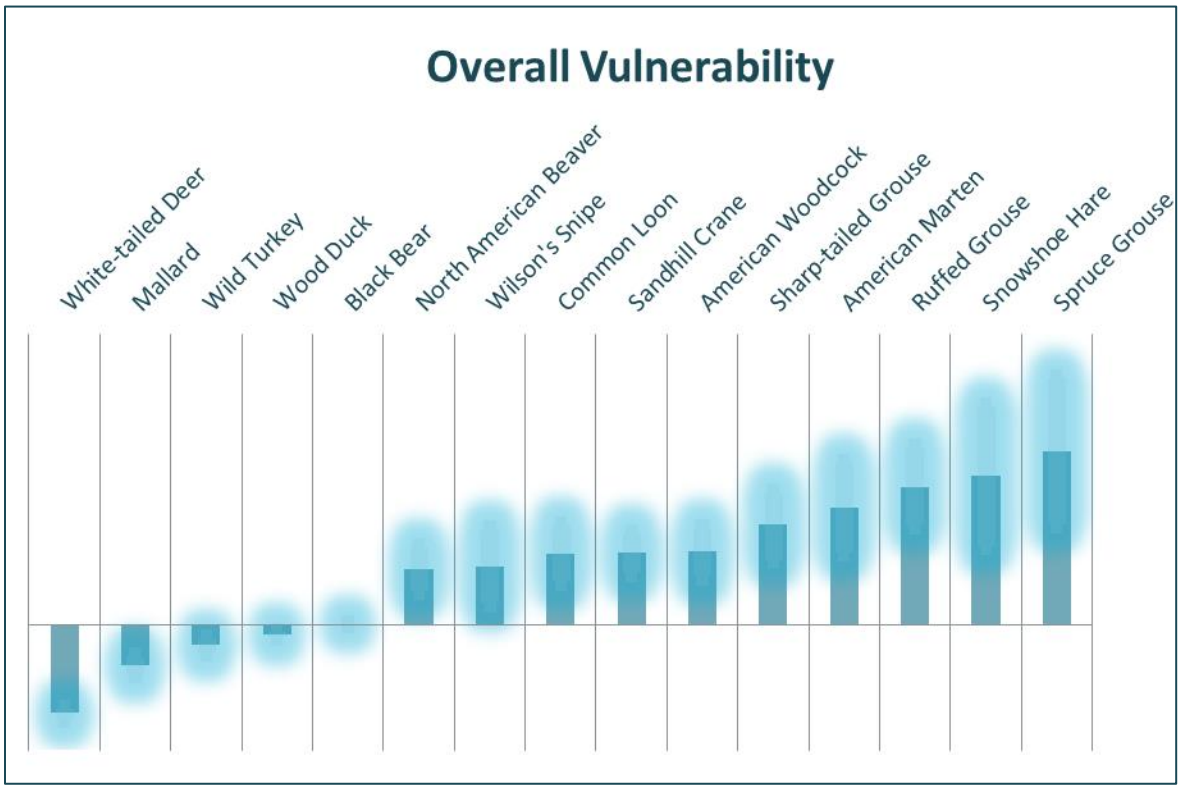

Figure 2 Visual representation of relative vulnerability of CCVA focal species. Dark blue bars represent vulnerability (increasing bar represents increasing vulnerability) and light blue represents the associated uncertainty score.

Species	Overall Vulnerability	Overall Uncertainty	Habitat Vulnerability	Habitat Uncertainty	Physiology Vulnerability	Physiology Uncertainty	Phenology Vulnerability	Phenology Uncertainty	Biotic Interaction Vulnerability	Biotic Interaction Uncertainty
Spruce Grouse	8.38	0.42	3.4	0.37	1.42	0.4	2.69	0.55	0.6	0.4
Snowshoe Hare	7.18	0.47	3.81	0.41	0.86	0.53	-1.05	0.38	2	0.57
Ruffed Grouse	6.67	0.28	3	0.26	0.63	0.28	2.25	0.25	0.6	0.32
American Marten	5.65	0.38	2.68	0.36	0.83	0.38	0.52	0.31	1	0.45
Sharp-tailed Grouse	4.83	0.33	1.86	0.17	0.3	0.26	2.69	0.5	0.2	0.55
American Woodcock	3.53	0.33	0.57	0.36	0.47	0.3	2.63	0.36	0.4	0.32
Sandhill Crane	3.47	0.28	1.1	0.2	0.38	0.21	1.4	0.35	0.65	0.4
Common Loon	3.44	0.39	0.35	0.52	0.3	0.2	1.48	0.2	1.7	0.57
Wilson's Snipe	2.84	0.63	1.6	0.73	-0.33	0.53	1.21	0.6	0.25	0.61
North American Beaver	2.69	0.39	0.71	0.52	0.28	0.28	1.67	0.17	0.33	0.53
Black Bear	0.07	0.27	-0.08	0.24	-1.67	0.28	2.57	0.17	0	0.4
Wood Duck	-0.44	0.3	-0.07	0.29	-0.8	0.23	-0.19	0.35	0.6	0.36
Wild Turkey	-0.95	0.36	-2.5	0.38	0.08	0.28	2.5	0.38	0.33	0.4
Mallard	-1.92	0.23	-0.55	0.26	-1.19	0.18	-0.17	0.15	0.15	0.33
White-tailed Deer	-4.23	0.06	-1.67	0	-1.67	0	0.14	0	-0.5	0.27

Table 6 Overall and categorical vulnerability and uncertainty scores for CCVA focal species

Framework for assessing vulnerability of fish and plants to climate change

In general, tools available to natural resource managers interested in carrying out climate change vulnerability assessments for fish, plants, and wildlife species fall into two categories: coarse-filter and fine-filter approaches. Using a coarse filter approach allows natural resource managers to obtain a qualitative categorization of vulnerability using established indices. The System for Assessing Vulnerability of Species, or SAVS, method used to complete Sault Tribe's climate change vulnerability assessment falls into the coarse-filter approach category. Conversely, fine-filter approaches allow managers to determine where and how species may be vulnerable to climate change using models, which are often spatially explicit. While fine-filter approaches have many benefits, they are also more time consuming and can be more expensive to carry out, especially for a large group of species. Recently STNRD has strived to better incorporate community giikendaasowin (*knowledge*) into adaptation planning work in addition to available course-filter assessment approaches. Future climate change vulnerability assessment work will continue to utilize this holistic approach to adaptation planning.

Many natural resource managers seeking to assess vulnerability of large suites of species to climate change employ NatureServe's Climate Change Vulnerability Index (CCVI, Young et al. 2011). The CCVI uses a scoring system to assess vulnerability based on projected exposure for a species and three factors associated with climate sensitivity, which include indirect exposure to climate change, species-specific sensitivity factors including dispersal ability, temperature, and precipitation sensitivity, and documented response of a given species to climate change. The CCVI was created for use with terrestrial and aquatic plants and animals. The outputs of a CCVI analysis aid in the ranking of species by their relative vulnerability and highlight which factors are driving species vulnerability. The CCVI approach is useful to managers interested in understanding relative vulnerability of large suites of species to climate change.

Inter-tribal Council of Michigan, Inc. (ITCMI), an organization representing 12 federally recognized tribes in Michigan, including the Sault Ste. Marie Tribe of Chippewa Indians, used the CCVI approach to assess climate vulnerability of 17 fish species, 78 plant and tree species, and 29 wildlife species across Michigan (Clark 2016). The Michigan Natural Features Inventory and Michigan Department of Natural Resources also completed climate change vulnerability assessments using the CCVI to assess vulnerability of 400 Michigan species (Hoving et al. 2013). The results of these assessments are valuable for natural resources managers seeking to prioritize future adaptation planning work and for highlighting research needs.

Using both coarse-filter and fine-filter approaches together with community giikendaasowin can be an informative and holistic approach to assessing vulnerability and

planning for climate change. In this process, community giikendaasowin would be considered and utilized throughout the process. A coarse-filter approach such as NatureServe's CCVI would be used first to identify priority species for further assessment, followed by a fine-filter approach to examine projected responses in more detail. For example, to better understand climate vulnerability of a suite of plant and fish species, Sault Tribe community members would be engaged in conversations relating to species of importance and community giikendaasowin could be used to prioritize species for further consideration. Next, a fine-filter approach could be used to understand the mechanisms of vulnerability. One fine-filter approach that may be of interest to tribal members exercising treaty rights within the 1836 Treaty Ceded Territory could be the use of species distribution models (e.g., MaxEnt or Biomod2 in R) in order to help predict whether species will or will not remain within the 1836 Treaty Ceded Territory under a given climate change scenario. Given that treaty rights are tied to a static geographic region, understanding whether species will persist, move into, or move out of the Treaty Ceded Territory can better help the Tribe and STNRD plan for continued opportunities to exercise treaty rights.

Future Work

Moving forward, STNRD plans to use the results and information generated as a result of this climate change vulnerability assessment for adaptation planning and when considering future research directions. Many of the species found to be the most vulnerable as a part of this assessment are of great importance to Sault Tribe for a variety of reasons. Interestingly, many of the species that were found to be the most vulnerable (e.g., spruce grouse, snowshoe hare, and American marten) were also species that panel members had the greatest uncertainty about when responding to the SAVS questionnaire. In many cases, this uncertainty highlights specific research gaps that need to be addressed before we can more accurately predict climate vulnerability and more importantly engage in effective adaptive management for a given species.

A few themes that emerged in terms of areas of uncertainty included:

- understanding how habitat components will change with climate change
- predicting how precipitation regimes will change, and specifically how changes in snow quality will impact overwintering species
- understanding how climate-influenced changes in disturbance regimes (e.g., fire) will impact wildlife species both directly and indirectly
- predicting what new and existing diseases will be an issue with a changed climate as well as understanding how the rates of disease spread will change

Literature Cited

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APPENDIX 1

Breakdown of Results by Species

In the following pages, the summarized SAVS results for each species are displayed in a table, which include the overall vulnerability score, the overall uncertainty score, as well as the associated scores for vulnerability and uncertainty for each of the four categories evaluated in the SAVS questions: habitat, physiology, phenology, and biotic interactions.

- Higher scores indicate higher vulnerability. Negative scores indicate the potential for a species to benefit from projected changes in climate.
- Overall vulnerability scores range from -20 (least vulnerable, species may benefit from projected changes) to 20 (species being highly vulnerable to climate change).
- Categorical vulnerability scores (for habitat, physiology, phenology, and biotic interactions) range from -5 to 5.
- Uncertainty values are percentage uncertainty (0.42 = 42% uncertainty).

Following the summary score table for each species is a table of comments provided by panel members. While comments were not required, panel members were asked to provide comments to provide rationale for their responses, to highlight specific reasons for uncertainty, or to provide references to justify their responses. Comments are organized by question and have not been edited.

Reference to Scoring Tables

Please refer to the document titled “Appendix 2 – SAVS Scoring Tables – Sault Tribe CCVA” for scoring tables for each species.

Reference to SAVS Questionnaires

Please refer to the document titled “Appendix 3 – Spruce Grouse SAVS – Sault Tribe CCVA” for an example of the questionnaires that were distributed to panel members and used for each species.

Waabizheshi || American marten || *Martes americana*

Species: American Marten	
Overall Vulnerability	**Overall Uncertainty**
5.65	0.38
Habitat Vulnerability	**Habitat Uncertainty**
2.68	0.36
Physiology Vulnerability	**Physiology Uncertainty**
0.83	0.38
Phenology Vulnerability	**Phenology Uncertainty**
0.52	0.31
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
1	0.45

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
I'm assuming "breeding habitat" is available larger snag trees which are associated more with timber harvest than climate change, per sa. However, my answer reflects a lack of knowledge regarding the future of timbering practices in upper MI.
available information from the northerwood vulnerability assessment..and probably other sources suggest that conifer (red pine, white pine,eastern hemlock, balsalm fir, and northern white cedar) will decline by the end of the century.
Even though climate projections indicate more winter precipitaion as rainfall, I believe the overall spatial distribution of annual snowfall will remain pretty consistent, hence not impacting the distirbution of potential breeding habitat (those habitats will likely be of lower quality though).
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Changes could be associated with timber harvest practices as well as climate change. Additional change will also include invasive species which may or may not be associated with climate change.
same [As 1]
1. S. D. Handler et al., in Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment (Island Press, 2014; http://www.treesearch.fs.fed.us/pubs/47125), pp. 114–151.
Recent data on marten suggest that they can persist in a broader range of forest vegetation types than previoulsy thought.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
See response to H1.
in Nichols 20xx, marten preferentially chose aspen as den sites…I will double check this. Aspen are a climate loser. It is unknown if this is an actual limitation.
I predict a short-term increase linked to beech bark disease (increased number of cavities and downed

wood resulting from beech mortality), emerald ash borer, and pine and spruce budworm, but probably a decline over the long-term as these features deteriorate and are potentially not replaced (at least for currently for beech and maybe for ash).
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
See response to H2.
potential declines in snowpack could impact subnivian foraging behavior
Recent data on marten suggest that they can persist in a broader range of forest vegetation types than previoulsy thought.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
See response to H2.
snowpack decreases and decreased conifer components
Loss of snow cover (more precipitation in the form of rain during winter), and specifically snow that is fluffy and penetrable, will put marten at a competitive disadvantage with other forest mesocarnivores and raptors. Females that are energeticlaly stressed will likely experience reduced productivity.
Ability to colonize new areas: What is the potential for this species to disperse?
There's very little literature available on this topic for the upper Midwest. There is some literature from the NW and Rocky Mtn regions. I'm basing this primarily on knowledge about the present distribution of maten in MI relative to release sites several decades ago.
Michigan populations are mostly isolated from northern source populations in Canada and there is pretty good evidence that high-traffic roads and inhospitable vegetation cover types are effective movement barriers.
Physiological thresholds: Are limiting physiological conditions expected to change?
I'm aware of only one publications (Yoram et al. 2008) documenting increase in body size of maten in coastal AK.
very little information on physiological effects of climate
Pretty well-established that marten are poor thermoregulators, but little is known on the temperature/precipitation thresholds that compromise fitness
Sex ratio: Is sex ratio determined by temperature?
Not that I am aware of.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
There is some information that links decreased snowfall to decreased survival and reproduction in marten, but it is very limited. My answer reflects this, but I'm I think there needs to be more research on the topic.
Lower Peninsula populations may be more susceptible to large fires, droughts, etc.
As poor thermoregulators, winters with more rainfall may compromise fitness; Also may place marten at a competitive disadvantage with other predators, ultimately reducing fitness.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
Our recent telemetry data suggest that marten are active throughout the day, regardless of season, and their behaviors are not restricted by weather (at least how we are currently experiencing weather…who know in the future).
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?

Martes are generalists and can adapt to changing prey.
Borderline adequate information on this topic. Recent research suggests that marten exhibit greater habitat plastiity than previously thought, but they might not be able to compete effectively with other mesocarnivores if snow conditions are compromised.
Energy requirements: What is this species' metabolic rate?
Martes are on the higher end of moderate and need to feed frequently. However, there is ongoing research in MN that documents periods of winter torpor in fisher and possibly marten.
We know they carry low body fat throughout seasonally demanding periods, and that thermoregulation can be challenging (moderately effective fur, small bodied).
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
My response is general to mammals.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Survival and reproduction can fluctuate with temperal changes in small mammal abundance, but I'm not familiar with how small mammals are expected to respond to climate change.
The level of their dependence on larger-bodied prey during winter (e.g., snowshoe hare), and if those prey species negatively respond to climate change, winter could become a prey bottleneck.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Delayed implantation is an evolutionary trait that purposefyully allows this species to successfully impregnate even during period of low resource availability.
Food resources: Are important food resources for this species expected to change?
See my response to PH2 above.
The role of large-bodied winter prey (hare, red squirrels) in marten diets is pretty well-established, I'm just not sure how readily they can adapt to other prey sources.
Predators: Are important predator populations for this species expected to change?
Fisher will probably do better than marten in a warming climate scenario (thinking of how good fisher are doing in central WI right now), as long as forested habitats remain. Raptors (great-horned owls, red-tailed hawks) and other less snow adapted potential predators (e.g., coyotes) will increase.
Symbionts: Are populations of symbiotic species expected to change?
Not aware of any symbiotic species.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Preliminary data suggest that various diseases are prevalent, but effects of fitness are unknown.
Competitors: Are populations of important competing species expected to change?
I'm unaware of research on this topic, but projected changes to fisher may have influences on marten?
Pretty certain that a suite of other forest mesocarnivores that compete with marten will increase, but the long-term fitness consequences of that competition is not clearly understood.

Makwa || Black Bear || *Ursus americanus*

Species: Black Bear	
Overall Vulnerability	**Overall Uncertainty**
0.07	0.27
Habitat Vulnerability	**Habitat Uncertainty**
-0.08	0.24
Physiology Vulnerability	**Physiology Uncertainty**
-1.67	0.28
Phenology Vulnerability	**Phenology Uncertainty**
2.57	0.17
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0	0.4

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
The spatial distribution of black bears is strongly correlated to the extent of forest, not so much the forest type. As long as future climate scenarios do not result in a reduction of the extent of forest, I believe the distirbution of bear will remain relatively unchanged.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Same comment as for H1.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
I'm not aware of a specific habitat compoenent that limits bear breeding.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
The only thing I can think of is the potential climate ramifications that might influecne masting, for example warmer and drier conditions that might reduce soft mast crops.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Relationship between reproduction and masting is pretty well-established and accepted, but how changes in climate might affect masting is uncertain. I speculate that current soft mast crops (blueberries) would be negatively affected by climate change, but whether a different soft mast species would fill that void is uncertain.
Ability to colonize new areas: What is the potential for this species to disperse?
1. J. A. Moore, H. M. Draheim, D. Etter, S. Winterstein, K. T. Scribner, PLoS ONE. 9, e91168 (2014). 2. J. A. Moore, R. Xu, K. Frank, H. Draheim, K. T. Scribner, Molecular ecology. 24, 4010–4022 (2015).
Physiological thresholds: Are limiting physiological conditions expected to change?

I'm not sure about this one. Not aware of any physiological limitations that are climate driven.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
bears may benefit from increase fire disturbance
I believe that bears are pretty adapatable and resilient to disturbance.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
I believe that bears become less active when temperatures are hotter, but this is probably just a short-term behavioral response that likely doesn't affect long-term fitness.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Productivity fluctuates relative to condition of females heading into winter. Reduced litter sizes or reproductive success in respone to limited resources is likely an evolutionary adapatation to protect the health of the female. So, individually bears can adjust, but the popualtion over the long-term could suffer from lack of recruitment.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Black bear fitness is closely tied to masting (both soft and hard mast). Some studies have shown that masting relates to characteristics of the North Atlantic Oscillation (weather). II would predict that masting will be affected by climate change, but it is unclear what the resulting pattern might be.
Food resources: Are important food resources for this species expected to change?
See comment on masting above. Bears are pretty adapatable, but condition of the sow prior to hibernation is knowingly linked ot fecundity. In some areas, mast plays an important role in sow condition.
Predators: Are important predator populations for this species expected to change?
Really no major predators. Cubs might be lost to male bears.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Not sure.
Competitors: Are populations of important competing species expected to change?
Really no competitors.

Amik || North American Beaver || *Castor canadensis*

Species: North American Beaver	
Overall Vulnerability	**Overall Uncertainty**
2.69	0.39
Habitat Vulnerability	**Habitat Uncertainty**
0.71	0.52
Physiology Vulnerability	**Physiology Uncertainty**
0.28	0.28
Phenology Vulnerability	**Phenology Uncertainty**
1.67	0.17
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.33	0.53

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
Some climate projection modeling predicts that the southern distirbution of aspen in michigan may move northward. Beaver are pretty adapatable and are probably more limitaed by water availability and forest cover in general, but climate might drive a decrease in range.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
P. Collen, R. J. Gibson, The general ecology of beavers (Castor spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish–a review. Reviews in fish biology and fisheries. 10, 439–461 (2000).
Same comment as for H1.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Potential reduction of aspen (and maybe some species of willow?). Tag alder?
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
P. Collen, R. J. Gibson, The general ecology of beavers (Castor spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish–a review. Reviews in fish biology and fisheries. 10, 439–461 (2000).
Same comment as H3.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Fitness for beavers most closely linked to water conditions and availability of suitable forage. In so far as prefered tree species may be lost (e.g., aspen) there might be a negative impact on fitness.
Ability to colonize new areas: What is the potential for this species to disperse?

P. Collen, R. J. Gibson, The general ecology of beavers (Castor spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish–a review. Reviews in fish biology and fisheries. 10, 439–461 (2000).
Physiological thresholds: Are limiting physiological conditions expected to change?
I'm not aware of physiological thresholds for this species. They range down into Louisiana and Florida and up into Alaska so I suspect that they are not temperature restricted.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Flooding and fire are likley the two disturbance events that will affect beaver into the future. Beaver are pretty resilient to flooding. Low water levels during the winter can also have negative fitness consequences (e.g., if occupied wetlands "freeze out"). Fire creates early successional habitats that beavers seem to do well in.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
Literature indicates that activity is primarly related to time of day.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Beaver are pretty dapatable as long as they have water and food (they can survive on a diverse diet).
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Beaver may enter torpor during period of extreme cold, and will restrict their activity to below the ice at low temperatures.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Not sure on this one.
Food resources: Are important food resources for this species expected to change?
As potentially related to decline of aspen and maybe willow (discussed above), but not sure if the decline would be enough to limit beaver distirbution.
Predators: Are important predator populations for this species expected to change?
Wolf, coyote, bear, wolverine. P. Collen, R. J. Gibson, The general ecology of beavers (Castor spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish–a review. Reviews in fish biology and fisheries. 10, 439–461 (2000).
Symbionts: Are populations of symbiotic species expected to change?
Beavers are the classic examle of ecosystem engineers and as such, several species depend on the wetland habitat created by beavers. From the standpoint, if beaver distirbution is reduced, habitat for these species would also be reduced.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
I'm familiar with tuleremia, but I don’t think this disease is affected by climate.
Competitors: Are populations of important competing species expected to change?

Waawaashkeshi || White-tailed Deer || *Odocoileus virginianus*

Species: White-tailed Deer	
Overall Vulnerability	**Overall Uncertainty**
-4.23	0.06
Habitat Vulnerability	**Habitat Uncertainty**
-1.67	0
Physiology Vulnerability	**Physiology Uncertainty**
-1.67	0
Phenology Vulnerability	**Phenology Uncertainty**
0.14	0
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
-0.50	0.27

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
I don't foresee any major changes.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
I really don't see deer as being habitat limited, at least as related to climate change.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
C. L. Hoving, Michigan Journal of Sustainability. 3, 101–110 (2015).
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Might be some affect related to hard mast cycles and availbility of residual crops. Analysis in my lab suggests that yearling deer fitness in southern MI is negatively affected by deep snows and colder temperatures, so if the climate is warming there might be a slight positive effect in southern Michigan. Some climate models project deeper snows in portions of NLP and UP and in that case, survival may be directly impacted (negatively). So the answer to this question is "it depends"!
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Deer are pretty adapatable to change, so I do not envision any significant fitness consequences of altered disturbance regimes on deer populations.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Primarily driven by photoperiod.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Fawning corresponds to when the doe was bred, which is triggered by photoperiod so I don’t see any

major changes related to resource availability.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Does will enter second (and maybe a third?) estrous if not bred during the first estrous.
Food resources: Are important food resources for this species expected to change?
Maybe some affect of hard mast production, but that's probably it.
Predators: Are important predator populations for this species expected to change?
Wolves, cougars
Even though snow conditions limit the suite of deer predators, greater snow amounts in the UP should theoretically keep the non-snow adapted predators to the south.
Symbionts: Are populations of symbiotic species expected to change?
Would wolves in UP considered a symbiont?
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Not sure on this one. Dieases are a big deal (EHD - more weather driven than climate per se), CWD, TB; linkages to climate change are unclear.
Competitors: Are populations of important competing species expected to change?
Really no major competitors….

Bine || Ruffed Grouse || *Bonasa umbellus*

Species: Ruffed Grouse	
Overall Vulnerability	**Overall Uncertainty**
6.67	0.28
Habitat Vulnerability	**Habitat Uncertainty**
3	0.26
Physiology Vulnerability	**Physiology Uncertainty**
0.63	0.28
Phenology Vulnerability	**Phenology Uncertainty**
2.25	0.25
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.6	0.32

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
Aspen distribution will be impacted, and densities of ruffed grouse are highest in young aspen.
Needs early successional forest habitats for most of life cycle as well as mature forest habitats for wintering.
Pretty well documented in in the literature that aspen, a major component of the RUGR, habitat will be declining. Although they do exist in areas with low aspen they don't reach densities in areas without aspen.
Aspen-spruce-fir all likely to shift north and away from assessment area.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Same as H1
Nonmigratory so no difference between H1 and H2
Pretty well documented in in the literature that aspen, a major component of the RUGR, habitat will be declining. Although they do exist in areas with low aspen they don't reach densities in areas without aspen.
see H1
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Pretty well documented in in the literature that aspen, a major component of the RUGR, habitat will be declining.
However, southern ruffed grouse habitat could shift north. More insect and disease and windthrow for age-class diversity. More red maple and oak could mitigate some loss of aspen.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
Thermal cover in winter is obtained from conifers when snow roosting is not possible.
Aspen is a key winter food resources, as well as cover in conifer trees, also forecast to decline.

Less snowpack and more freezing rain in winter will result in poorer snow roosting habitat.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Can depend heavily on forest harvest and wildlife management actions.
Conifers, key winter cover, are forecast to decline.
Will be more difficult to maintain optimal age-class-distribution due to declining acreage of aspen-spruce-fir.
Ability to colonize new areas: What is the potential for this species to disperse?
Typically disperse a few miles. Females farther than males.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
They don't migrate.
Physiological thresholds: Are limiting physiological conditions expected to change?
Unclear how changes in opportunities to snow roost will be impacted and affect winter survival.
The potential effect of severe weather events is highly uncertain. The potential effects of changing snowpack dynamics, e.g. crusting, is uncertain.
Temps/precip not likely to exceed limits, as they occur in habitats much farther south. However, increasing winter temperatures that decrease the ability of RUGR to snow roost during extreme winter temperature events.
Sex ratio: Is sex ratio determined by temperature?
Like most other birds.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Blowdown may provide more coarse woody debris for drumming logs.
Cold wet weather in May/June may cause high losses among broods. Shallow snow cover or icy crust on snow may reduce survival in winter by precluding access to subnivean shelter.
Storms will likely increase in intensity, increasing the chance of chicks and nests being lost. Reduced ability to snow roost during extreme cold weather events.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
May be influenced by opportunities for snow roosting. Thermal cover in conifers is inferior to snow roosting for thermoregulating in temperature extremes.
Changes will not likely influence the daily activities of RUGR.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
This species has a typical boom/bust reproduction strategy. In good years, RUGR will have high reproduction. In poor years, poor reproduction.
Broad range may allow some flexibility to adjust for a period of years.
Energy requirements: What is this species' metabolic rate?
Studies in closely related taxa provide some information.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Drumming displays vary slightly among years depending on spring conditions.
Most grouse use photoperiod to initiate breeding season behaviors.

Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Breeding is presumably linked to resource availability for young.
There is a lack of information on hatch timing relating to key resources. This would be a key area to do some research.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
Not migratory.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Nest in spring
Spring weather is critical.
Increases in spring and summer rain events could decrease nest and brood survival.
Renest if first clutch fails.
Food resources: Are important food resources for this species expected to change?
Primary food sources include herbaceous plants, fruits, acorns, buds, twigs, catkins, flowers, ferns
Aspen, a key winter food component, is forecast to decline. There may be opportunities for adaptation, however. Other food sources appear to be stable.
Aspen buds will decrease but acorns could increase as oak migrates north. Eat a variety of vegetation.
Predators: Are important predator populations for this species expected to change?
Not clear how predators will be impacted by climate change.
Unknown, but may cause changes in distribution and occurrence of primary avian predators (GH Owl, Goshawk, etc.)
Everything wants to eat grouse, most predators will not likely decline.
If snowshoe hare are reduced due to coloration mismatch, predators may turn increasingly to ruffed grouse.
Symbionts: Are populations of symbiotic species expected to change?
Not likely applicable.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Not clear how diseases like West Nile Virus currently affect population. However, population data is pretty good (in Minnesota) and provides no indication that disease is currently impacting populations. Changes in moisture could impact mosquito-borne disease.
The potential effect of increased tick survival and prevalence is unknown.
Research need!
Competitors: Are populations of important competing species expected to change?
Not clear how competitors will be affected.
See B2.

Aagask || Sharp-tailed Grouse || *Tympanuchus phasianellus*

Species: Sharp-tailed Grouse	
Overall Vulnerability	**Overall Uncertainty**
4.83	0.33
Habitat Vulnerability	**Habitat Uncertainty**
1.86	0.17
Physiology Vulnerability	**Physiology Uncertainty**
0.3	0.26
Phenology Vulnerability	**Phenology Uncertainty**
2.69	0.5
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.2	0.55

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
More barrens habitat with increased fire and likely timber harvest. [L]ess jack and red pine. Same amount of fallow agriculture? More wetland with flooding.
A slight increase shrubland and openlands in the EUP and likely NLP
Distribution expected to shift north
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
See H1.
A slight increase shrubland and openlands in the EUP and likely NLP
Distribution expected to shift north
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Increased invasive species in openlands. Pine shift away, replaced by oak? Unknown insect changes - chick food.
A slight increase shrubland and openlands in the EUP and likely NLP
Hard to say- require early successional habitats and more disturbance (fire, blowdowns) would likely be good for this species. However, also area-sensitive, so large disturbances likely to be more beneficial than very localized events.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
Less snowpack and more freezing rain results in poorer snow roosting habitat. Loss of paper birch buds/catkins, a key food source.
Openlands and shrublands increase in core habitat
Same as H3

Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Increased blueberry with more fire. Variety of vegetation consumed.
No real changes to community. Relies on humans/disturbance to maintain core areas.
Ability to colonize new areas: What is the potential for this species to disperse?
Short-range dispersal. STGR are at very SE edge of range, in pretty low numbers, it's possible that habitat could shift out of the assessment area?
Sharp-tails can move, but response based on establishing a lek-based mating system in previously unoccupied available habitat.
Sharptails typically don't disperse very far (<6K from brood-rearing sites), but are capable of making very long movements (colonized an island in Lake Superior after a fire).
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
A resident species, doesn't migrate.
Physiological thresholds: Are limiting physiological conditions expected to change?
Occurs in warmer and colder climates.
Snow roosting opportunities may change which may impact overwinter survival.
Sex ratio: Is sex ratio determined by temperature?
Not usually in birds
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Increased fire could increase barren, agricultural or young pine habitats. Severe winter storms with less snowpack could increase winter mortality.
Could be an increase in storms/flooding which would decrease nest/chick survival. However, increased fire may open up habitat for this species
An increase in fire and blowdowns may create more habitat. This is a disturbance-dependent species that relies on early successional habitats.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
This species occurs in a wide variety habitats, precipitation regimes, and temperature regimes. It should be ok.
Not clear how the opportunities for snow roosting will change. Snow roosting reduces thermoregulatory costs in winter.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Lek fidelity and flocking, social behavior?
Able to move to new locations and disperse, has a typical boom/bust reproductive strategy.
Energy requirements: What is this species' metabolic rate?
Studies in closely related taxa provide some information.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Lek and courtship weather cues are not clear.
Lek behavior based on photoperiod
Most reproduction efforts likely related to photoperiod, however, egg hatch may have been historically aligned with new bug hatches. More research in this area could be beneficial

Annual variation in timing of peak lekking activity indicates that breeding is cued by temperature rather than photoperiod.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Chicks require insects (grasshoppers) food early in life. Warmer June could increase chick survival prior to thermoregulation.
See comment above. More research warranted. Earlier hatching insects could reduce chick survival
Presumably breeding is tied to peak food availability for young.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
See above.
Not migratory.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Renest if first clutch fails.
Will renest if first nest attempt fails.
Nest in spring
Food resources: Are important food resources for this species expected to change?
Variety of vegetation. Blueberry may be important.
Eats a variety of foods.
Consume bearberry, wild rosehips, buckwheat, oats, wheat, flax, berries, leaves, grasshoppers, clover, labrador tea, leatherleaf, birch buds and twigs, aspen and willow buds and twigs.
Predators: Are important predator populations for this species expected to change?
Many predators, not clear who wins/loses.
Unknown effects on avian predators.
Lots of predators eat STGR.
Not clear how predators will be impacted.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
West Nile may be an issue.
More information here would be important for the species now and into the future.
Not clear how disease currently impacts this population. Population data does not indicate patterns with disease. Mosquito-borne diseases could be impacted by climate change.
Competitors: Are populations of important competing species expected to change?
Not clear how competitors will be affected.

Mashkodese || Spruce Grouse || *Falcipennis canadensis*

Species: Spruce Grouse	
Overall Vulnerability	**Overall Uncertainty**
8.38	0.42
Habitat Vulnerability	**Habitat Uncertainty**
3.40	0.37
Physiology Vulnerability	**Physiology Uncertainty**
1.42	0.4
Phenology Vulnerability	**Phenology Uncertainty**
2.69	0.55
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.6	0.4

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
The southern limit of spruce-fir forests is expected to shift north. Spruce grouse rely on stands including black spruce, tamarack and/or jack pine, and to a lesser degree on other conifer types.
Conifers will decrease in 1836.
Jack pine-spruce-fir moving out of assessment area and is species primary habitat.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Same as question H1.
Conifers will decrease in 1836.
See H1. Species at south edge of boreal forest range.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Conifers will decrease in 1836.
Specific habitat components associated with boreal jack pine-spruce-fir will decline.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
Effects of climate change on forests in UP of MI are difficult to predict, but my guess is that it will be negative due to increased damage by inverts or other invasive pests
Conifers will decrease in 1836.
See H3.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Conifers are super important to the SPGR
Ability to colonize new areas: What is the potential for this species to disperse?

Home range size is extremely variable throughout spruce grouse range. I would expect dispersal distances to also vary widely, although less information is available on dispersal distances, than for home range.
Can fly to new areas if needed
Very short dispersal.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
Resident
Not migratory.
Physiological thresholds: Are limiting physiological conditions expected to change?
Snow roosting, which is a beneficial thermoregulatory activity, may be negatively impacted by changes in climate.
SPGR in the 1836 are at their furthest south extent. They could be subjected to temperature extremes in the summer.
Sex ratio: Is sex ratio determined by temperature?
Not usually in birds
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Severe storms may increase blowdown events and regeneration of black spruce is slow.
Could be an increase in storms/flooding which would decrease nest/chick survival. However, increased fire may open up habitat for this species
Increased fire could retain jack pine for a while, but jack pine is expected to eventually leave the assessment area.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
SPGR in the 1836 are at their furthest south extent. They could be subjected to temperature extremes in the summer.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Able to move to new locations and disperse, has a typical boom/bust reproductive strategy.
Energy requirements: What is this species' metabolic rate?
Available for closely related species, but not studied specifically for spruce grouse.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
The timing of responsiveness to the cantus call varies in the spring among years, which is consistent with temperature cues initiating breeding (rather than photoperiod). However, this has not been examined specifically.
Most reproduction efforts likely related to photoperiod, however, egg hatch may have been historically aligned with insect hatches. More research in this area could be beneficial
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Presumably breeding is timed to optimize food availability for precocial young, but this has not been verified.
See comment above. More research warranted. Earlier hatching insects could reduce chick survival
Chicks and insect hatch[e]s?

Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
Same as for PH2
See above.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Nests in spring.
Will renest if first nest attempt fails.
Food resources: Are important food resources for this species expected to change?
Eat invertebrates, shrubs, flowers, fruits, berries, fungi, etc.
Eats a variety of foods, but mainly conifer needles, if conifers decline, will likely lose some food source
Loss of boreal conifer needles that are an important winter food resource.
Predators: Are important predator populations for this species expected to change?
Diverse predators, but unclear how predator populations will be affected.
Unknown effects on avian predators
Lots of predators eat SPGR.
Not clear how suite of existing predators, or new predators, will impact species as climate changes.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
West Nile virus prevalence might change if mosquito population impacted by changing moisture levels, but not clear whether WNV has much impact at current levels. Population data for this species is sparse which makes identifying influential factors difficult.
More information here would be important for the species now and into the future.
Competitors: Are populations of important competing species expected to change?

Mizise || Wild Turkey || *Meleagris gallopavo*

Species: Wild Turkey	
Overall Vulnerability	**Overall Uncertainty**
-0.95	0.36
Habitat Vulnerability	**Habitat Uncertainty**
-2.50	0.38
Physiology Vulnerability	**Physiology Uncertainty**
0.08	0.28
Phenology Vulnerability	**Phenology Uncertainty**
2.5	0.38
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.33	0.4

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
Oaks will likely increase in Michigan, as well as more open forest lands.
Breeding and nesting habitat for Eastern Wild Turkeys (Meleagris gallopavo silvestris) is comprised of a variety of vegetation types. One of the most important components consistent with vegetation selected by nesting females is lateral cover roughly a meter in height with varying levels of overhead canopy cover (Porter 1992). Wild turkeys in Minnesota showed a change in nest site selection as time progressed further into the breeding season from primarily forested cover to open fields later in the Spring (Lazarus and Porter 1985). The effects of the amount of young forest cover and early successional habitat as an effect of increase in seasonal precipitation and temperature changes is unknown and more research is needed to discern the effects. Likely to see occupation in new areas and expansion of local populations based on the projection of milder winter weather and decreased levels of snowfall for the region.
Based on Audobon cliamte models
Turkey seems to respond positively to climate change
Oak shifting north and will be more common in the assessment area.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Open lands, oak forests, and deciduous forests will likely increase
The average home range of a wild turkey ranges from 370 to 1,360 acres (Brown 1980). Much of the range occupied during the breeding season will overlap with areas utilized during the non-breeding season if the resources exist. Primarily a decline in conifer species throughout this region would mean a decline in thermal cover during the winter periods, however this effect may be offset by increasing termperatures and reduced amounts of snowfall. More research is needed to understand the effects of these projected changes.
Same as H1

Northern portion of assessment area (UP) at or just beyond north edge of range. Oak habitat should increase with warming climate.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Open lands, oak forests, and deciduous forests will likely increase
See above comment H1 as it refers to habitat requirements for the breeding season. Wild turkeys are generalists and have adapted to a variety of different habitat types and vegetative communities. The effects of these changes due to climate change are unknown.
See H1 and H2.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
Open lands, oak forests, and deciduous forests will likely increase
See above comment H2 with regards to habitat requirements for the non-breeding season. Additional effects associated with increases in deer browse of hard mast species such as oak could impact mast production in this region negatively impacting mast production for wild turkeys. Increases in temperature and rainfall effects may impact the changes in forested communities and the dispersal of local populations, however more information is needed.
Breeding and non-breeding essentially the same vegetation type.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Forested cover and adjacent wildlife openings are critical habitat types associated with selection of breeding sites and impact breeding success of wild turkeys. Decline in aspen forest and regernation could have a negative effect on hen nest success in this region. Additionally, increases in precipitation and temperature coupled with a lack of active managment of openings habitat could reduce the amount of available habitat for breeding birds. Conversly, we may see an increase in growing degree days and conversion of lands for agricultural purposes throughout this region which may offset these effects.
More oak to north. More openland with increased fire. Less snow will increase winter forage opportunities and may
Ability to colonize new areas: What is the potential for this species to disperse?
WITU can fly into new locations, quite readily.
Wild turkeys have expanded greatly throughout the state compared to the historical range which included primarily the southern half of the lower penninsula prior to European settlement (Rusz 1986). Trap and transfer programs have dispersed wild turkeys into the northern lower penninsula and much of the upper penninsula and they occupy regions where favorable conditions and habitats exist. Much of the northern range of wild turkeys is dictated by snowfall amounts and less by cooler temperatures. Increase in annual temperatures and decrease in snowfall could greatly assist with expansion of the the ranges of wild turkeys and increase survival and abundance throughout this part of their range at local scales.
Relative to other resident game birds.
Strong flyer and walker.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
Resident species.
Physiological thresholds: Are limiting physiological conditions expected to change?
This species is currently at its northern extent of its range in the EUP. Climate change will likely allow this species to occur.

Northern range of wild turkeys found in northern Michigan is largely impacted by a combination of winter temperatures and snowfall depths. Snowfall greater than 12 inches increases the challenges associated for birds to locate food sources during the winter months. The nothern range and populations are most greatly affected where this is evident. Increased annual temperatures and reduced snowfall could posotively effect populations in this region and support increased breeding effort and success as condition of the the birds will be much greater and with increased fat reserves could support an increase in breeding success and recruitment.
Sex ratio: Is sex ratio determined by temperature?
Not common
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Fire can benefit WITU by maintaining and/or enhancing habitat, however fire and severe storms could lower nest and brood survival
Increased rainfall could have conflicting effects on reproduction of wild turkeys. First, increases in seasonal precipitation could support increased growth in vegetation and ground cover used as concelament for nesting hens and support increased nest success. However, increases in precipitation during the breeding season has shown to adversly effect breeding success of wild turkeys in multiple ways. Rainfall coupled with low spring temeratures have shown to decrease poult survival (Markley 1967). However, more information is needed to determine the effect of this and the combination effect of rainfall and temperature. Wild turkeys can also see decrease in nest survival with increased rainfall events and flooding as suitable habtiat for wild turkeys often exists along riparian areas within floodplains. Increased flooding and rainfall events could reduce nest success and impact recruitment. Severe or sudden changes of weather have the potential for the greatest negative impacts on breeding wild turkeys in this range. Some research has also suggested that increased precipitation in the breeding season increases predator effectiveness at location ground nesting birds including wild turkeys. The effects at the projected rate of change if volatile or sporadic have the greatest potential to negatively impact wild turkey populations, however they may be able to adapt to subtle changes in and increases. More reasearch is needed on this topic.
Increased likelihood of nests flooding.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
If anything, climate change will make winters more mild, and increase WITU survival.
Less snowpack and milder winters will benefit turkey - a current limiting factor in UP portion of assessment area.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Boom/bust survival strategy.
Wild turkeys are considered generalists and have adapted to using a variety of habitat types at varying compositions of forested cover and openings habitat. They are also well adapted at locating a variety of food sources including nuts, seeds, fruits, insects, grasses, leaves, and animal matter (Korschgen 1967).
Energy requirements: What is this species' metabolic rate?
The wild turkey like all birds is homeothermic. Metabolism for wild turkeys have been measured as a function of temperature during winter and summer months (Gray and Prince 1988:133). The basal metabolic rate did not differ between sexes within seasons but was higher for juveniles during the winter months and adults in the summer versus adults in the winter. Metabolic costs and response to thermoregulation has been shown to have greater impacts on females than males during all seasons

(Calder and King 1974:259). Adults are heaviest in the late winter and lightest in the late summer when changes in lipid reserves are greatest (Bailey and Rinell 1967: 85).
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
More research could inform if nest initiation is tied to insect hatches, etc. It appears to be photoperiod, but that is not well documented.
Breeding season for eastern wild turkeys is primarily driven by photoperiod (i.e., increased daylight hours in the spring), however seasonably warm or cold temperatures can impact the onset of breeding season (Healy 1992). Changes in temperatures in the Spring could initiate early breeding attempts which could be coupled with unseasonable weather events and have adverse effects on breeding success.
Photoperiod for breeding
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
More research could inform if nest initiation is tied to insect hatches, etc. It appears to be photoperiod, but that is not well documented.
Breeding season for wild turkeys takes place during the spring months April through May with the median nest initiation date for Michigan to April 19th on any given year (Michigan DNR personal communication). The timing is most closely associated with photoperiod changes. Wild turkeys can often re-nest if a nest is destroyed early within the nesting season offering an advantage for the species should an intial nest attempt fail due to predation or weather related events.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
Not migratory
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Will renest if first nest attempt fails.
Food resources: Are important food resources for this species expected to change?
Mostly a southern species, probably will see an increase in their food resources.
The food resources specific to the diet of wild turkeys is quite extensive and includes a variety of items including, nuts, seeds, insects, grasses, animal matter, fruits, and other plant matter (Korschegen 1967). Projected changes in increase prevalance of forest fires may support increased production of disturbance favored species such as Oak (Quercus spp.) providing important mast for wild turkeys. Conversely, an increase in deer browsing on regenerating oak species, would continue to stunt the growth and production of this important food source. Additional information on the effects on other important food sources for wild turkeys is lacking.
Acorns, a primary food expected to increase in assessment area. Suppl[e]mental feeding on agricultural lands?
Predators: Are important predator populations for this species expected to change?
What wouldn't want to eat a turkey, turkey chicks, or turkey eggs.
Predators of eastern wild turkeys include a variety of wildlife species including several mammal, bird, and reptile species. Information on the effects of climate change as it relates to a multitude of wildlife species specific to the effects of predator populations is lacking. Certain predator species may be positively impacted by the prejected changes and others may see no change or be negatively impacted. Many of these common predator species are generalists and omnivores (e.g., coyote, red and gray fox, rodents, ravens, skunks, opposums, and raccoons suggesting that there ability to adapt to changes in the availibility of food sources is likely greater than predators with restrictive diets (carnivores) and thus

likely to see fewer projected changes in populations (Miller and Leopold 1992: 121).
For mammalian predators
Game species - hunting regulations could change. Uncertain response by suite of predators and potential new predators if they expand to the north.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
More information could be beneficial
Mycoplasma gallisepticum has been shown to reduce production, hatchibility, and fertility of eggs on game-farm wild turkeys and these effects may be present in free ranging wild turkeys (Rocke et al. 1988:531). Gastrointestinal helminths also occur in wild turkeys in regions outside of Michigan, but the effects on reproduction are unknown (Maxfield et al 1963). There are a number of other viral and bacterial diseases that impact wild turkeys, however, none of which have shown to have any large scale population effects.
Some evidence to show that diseases are increasing
Competitors: Are populations of important competing species expected to change?

Badashka'anzhi || American Woodcock || *Scolopax minor*

Species: American Woodcock	
Overall Vulnerability	**Overall Uncertainty**
3.53	0.33
Habitat Vulnerability	**Habitat Uncertainty**
0.57	0.36
Physiology Vulnerability	**Physiology Uncertainty**
0.47	0.3
Phenology Vulnerability	**Phenology Uncertainty**
2.63	0.36
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.4	0.32

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
Alder is extensive and increasing and responds well to disturbance. Increased precipitation and flooding will increase alder and offset loss of aspen.
There may be some declines in the southern portion of the 1836; however, only aspen seems like it will decline. They will be far more likely to decline with a lack of young forest in the region, compared to climate change.
Breeding habitat supposed to decrease, while wintering habitat decreases.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Southern US winter vegetation expected to expand move north.
Uncertainty in precipitation makes assessment of some future foraging habitat, e.g. riparian alder and hydric forests, difficult.
Well researched and it seems they use quite a variety of habitats that seem unlikely to disappear.
Same as H1
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Increased alder and openland due to increased precipitation and disturbance from fire, flood, wind, insect/disease.
Aspen will likely decrease, but other components seem like they will be fine.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
See H2 comment.
It seems like there will be adequate habitat in the south. Major changes will likely result from human habitat manipulation more so than climate change.
Habitat quality: Within habitats occupied, are features of the habitat associated with better

reproductive success or survival expected to change?
They are a highly migratory species and capable of moving to new, more suitable habitats.
Ability to colonize new areas: What is the potential for this species to disperse?
Very broad range.
Sex bias dispersal may not be applicable.
Migratory
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
It will use other habitats, but it does use lots of early succesional forest throughout the year.
Physiological thresholds: Are limiting physiological conditions expected to change?
Broad range
This is an assumption. I don't think that the temps/precip will change to a degree that will negatively influence individuals or the population.
Sex ratio: Is sex ratio determined by temperature?
I'm assuming they are like other birds.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Spring flooding could reduce nest success and could increase alder and lowland shrub habitat.
The potential effect of severe weather incidents during migration is not adequately understood.
An increase in severe storms and flooding could decrease nest and brood survival.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
Courtship right at dusk and dawn?
The temps and precip should not affect daily activities.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Broad range
While site fidelity is quite high among adults, theoretically AMWO could migrate to another region, if resources are low/poor in a region.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Arrival/breeding is a bit of photoperiod and temperature cues.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Long migration timeframe.
I would assume that nest hatching would align with insect hatches, etc. It doesn't appear that there is any information on that.
Presumably breeding is timed to match availability [of] food for young.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
Will renest if first clutch fails.
Migratory
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?

Some evidence for 2 broods/yr
There are probably renest attempts, if a first nest attempt fails.
Food resources: Are important food resources for this species expected to change?
Drought could reduce earthworm availability - but increased precipitation and warming soil could increase earthworm population and extent.
Most of my responses are based on likely effects of climate change on woodcock primary food resources (i.e., earthworms)
I doubt there is much information on the effects of climate change on the AMWO food base. It seems that they have a broad food base, so they are probably OK.
earthworms, invertebrates, a few plants
Predators: Are important predator populations for this species expected to change?
Some predators are considered to be climate change 'winners.'
Most species that prey upon AMWO will likely remain stable.
Not clear how predators will be affected
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
There could be more data collected on this in the future.
Competitors: Are populations of important competing species expected to change?
This species doesn't have many directly competing species, given its unique life history. However, there could be a species or suite of species that could be become more prevalent and compete with AMWO.

Maang || Common Loon || *Gavia immer*

Species: Common Loon	
Overall Vulnerability	**Overall Uncertainty**
3.44	0.39
Habitat Vulnerability	**Habitat Uncertainty**
0.35	0.52
Physiology Vulnerability	**Physiology Uncertainty**
0.3	0.2
Phenology Vulnerability	**Phenology Uncertainty**
1.48	0.2
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
1.70	0.57

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
Will increase in growing season impact water quality in any way? How about shifts in precipitation...seems to be more precip. overall, but models are conflicting about when the increase will happen. If increase happens after initiation of nests, could nests be subjected to higher levels of inundation?
Lake environments suitable for breeding loons was determined by the last glaciation. Loons occupy a wide-spectrum of eutrophic and oligotrophic watebodies
Audubon climate endangered, with projected loss of 97.43% of habitat in Michigan by 2080. Dramatic northward shift predicted.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Unclear about what is projected in the wintering areas.
The winter ecology of loons on marine environments is poorly known. Previous work has not adequately evaluated offshore areas utilized by overwintering loons. Loons undergo a catastrophic molt followed by ~ 5 weeks of flightlessness. The physiological demands of this molt and resulting immobility issues for loons has not been investigated. Changes to the marine environment (e.g. increased turbidity of nearshore areas, hypoxic zones in the Gulf of Mexico) may have important consequences for overwintering loons.
Audubon climate endangered, with slightly more suitable winter conditions (projected to increase 14.35% by 2080). Species doesn't currently winter in any numbers in Michigan, contra Red-throated Loon.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Increased growing season could mean increases in invasive vegetation species including Phargmites and Narrow leaved cat-tail. These plants could grow along shoreline of the lakes and result in closed in

conditions that loons don't prefer.
Stable water/lake levels during the breeding season [I]s an important factor for successful productivity as is interannual variation which may be climate influenced.
More study will be needed to document this. The Audbon climate anlaysis simply looks at the microclimatic conditions the bird current breeds in, and where those are projected to occur in the future.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
Habitat components for non-breeding habitat unknown.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
No information on which to base decision.
Common Loon nesting success can be influenced by a host-specific blackfly (Simulium annulus) - observations suggest that in the Great Lakes region that abandonment of loon nests occur with a later onset of spring and lake ice-off.
Obligate fish eater (piscivore) in summer, with unknown climate impacts on relevant fish species. Slightly more flexible diet in winter, with crustaceans and other items occasionally taken.
Ability to colonize new areas: What is the potential for this species to disperse?
Both sexes move great distances for migration. Dispersal from natal sites is somewhat limited (3-4 km on average), but both sexes can move.
Sex-biased dispersal in young following three-years on the ocean; male offspring recruit to natal areas with female offspring dispersing longer distances. This likely limits the species ability to colonize and establish territories in new areas.
Very migratory and very strong flier.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
For our northern populations in the UP and NLP, loons migrate from breeding grounds to wintering grounds.
Long chick rearing period requires adult loons to molt during migration (body feathers) and on the wintering areas (flight feathers). The Great Lakes is an important site for body molt from August-December and the ocean (Gulf and Atlantic) for the flight feather molt (Jan-March). How climate changes in these areas may influence future survival of loons poorly known but potentially important given disease outbreaks such as Botulism E on the Great Lakes and periodic loon mortality events during the winter.
Physiological thresholds: Are limiting physiological conditions expected to change?
Ice cover in winter certainly a limiting factor which will be reduced in the northern parts of its winter range. But more study to identify mechanisms is recommended.
Sex ratio: Is sex ratio determined by temperature?
Sex ratio is 50:50, but no reference to how temp impacts. I guess if here was temp impacts perhaps that would have come out given several studies across broad geographic range.
i don't know.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
How would loons be impacted by more thunderstorms with associated wind/hail/etc? More frequent inundation from higher wave heights?
A predication of more frequent and intense storm systems in the Great Lakes during the loon breeding

season (April-August) has potential to negatively impact reproductive success as loons are vulnerable to sudden changes of water levels during incubation (28 days).
Species nests on floating platforms which could easily be affected by flooding and changes in habitat conditions due to climate, but the level of vulnerability is unclear. More study needed.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
As long as there is open water and sufficient fish availability the speices should be resilient, but there are plausible scenarios where the species could be affected, but to document these requires more study.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
This species may not be flexible to use other food sources. This should be monitored closely
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Species must have some sensitivity to tempertaure cues at the very least, but these appear to be poorly documented.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Changes to prey fish populations could have negative concequences for loons though the species can utilitze a wide variety of aquatic organisams for forage.
Like so many other mechanisms determining a species response to climate change, more information will be necessary. But availabiltiy of sufficient floating platforms and fish resources are the prime determinants of occupancy. Very sensitive to human disturbance too.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
Spring migration and molt from wintering areas are initiated independent of ice-off on northern inland lakes. Loons arriving prior to ice-off must stage on large waterbodies such as river systems or the Great Lakes.
i don't know.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Low clutch size (typically 2 eggs) and no double brooding. Renesting does occur if the brood is lost early enough.
Food resources: Are important food resources for this species expected to change?
How will small fish in relatively shallow areas be impacted by climate? What if water temp goes up…will fish need to move to deeper water? Also, aquatic invasives like milfoil (could increse), how might that impact fish species or loons ability to see and catch fish.
Loons are an obligate piscivore that can utilize a wide-spectrum of aquatic organisms. Changes to prey base could have important consequences for breeding loons and reproductive success.
I don't know the literature, but given how specific this species is to piscivory, it would be highly susceptible to fish shortages, which seem very plausible.
Predators: Are important predator populations for this species expected to change?
Seems like predation of adults in not frequent and limited to a few species. Eggs predated by coons, skunks, and other mammals (are those species going to increase?)
Primary predator of loons is the Bald Eagle though instances of eagle predation is relatively low. Nest predators such as raccoons are expected to increase with land use change and climate. The impact of eagle predation and distrubance to loon reproduction is inadequately known but could be signifcant in

some populations.
Adults rarely preyed upon in summer areas (annual survivorship near 96% in Upper Peninsula loons), but chicks vulnerable to snapping turtles and various fish species. The effect of climate on these predators is unknown to me.
Symbionts: Are populations of symbiotic species expected to change?
Evidence suggests that territorial disputes between Osprey and Bald Eagle provides protection to nesting loons that are located within an Ospreys territory. Unfortunately, in Michigan Osprey populations in the range of nesting loons has not recovered to historic levels from the DDT era.
No known symbionts.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Botulism prevelance in Great Lakes going up and loons have been impacted. Need to understand if botulism expected to change as result of warming temps/longer growing season associated with climate impacts. Water lake temps?
Since 2006, Botulism E outbreaks on the Great Lakes in the fall has become a substantial source of adult mortality for Common Loons. Though outbreaks are driven by invasive species the severity of mortality events is believed influenced by warmer lake water temperatures. Factors that influence mortality events, however, are still inadequately understood. Blood parasites area also known in loons but the influence of parasites on fitness or reproductive success is not known. Finally, periodic die-off of loons on wintering areas has been documeted on the AltaIntic and Gulf coast with the factors for this die-off still largely unknown but potientailly influenced by climate factors.
Botulism E on Lake MI, where late summer and early fall used as a major stopover, has become a major mortality source with unknown population level impacts. Additional pathogens, and many parasites, are known to infest loons. The impact of climate changes on these organisms is unclear to me.
Competitors: Are populations of important competing species expected to change?
Un[s]ure how waterfowl and grebes could be impacted due to projected changes.
Increasing population of Bald Eagles may influence future loon survival and reproductive success.
More study necessary.

Ininishib || Mallard || *Anas platyrhynchos*

Species: Mallard	
Overall Vulnerability	**Overall Uncertainty**
-1.92	0.23
Habitat Vulnerability	**Habitat Uncertainty**
-0.55	0.26
Physiology Vulnerability	**Physiology Uncertainty**
-1.19	0.18
Phenology Vulnerability	**Phenology Uncertainty**
-0.17	0.15
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.15	0.33

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
All types of wetland habitats including urban park ponds. Usually nest in adjacent uplands. Have much flexibility in their nesting habitat. So, I focused on whether wetlands would remain wet in spring and early summer under climate scenarios. Models B1 and A1F1 predicted different results for precip for spring right before nesting/incubation period. Thinking that precip will help fill up wetlands and provide adequate water for vegetation. B1 and A1F1 models increased rain in LP in spring . A1F1 increased rain in EUP...but B1 says less rainfall in UP in spring. Also snowmelt timing earlier and for wetlands expect that water would be absorbed and result in higher soil moisture (and adequate wetland recharge). Overall, this seems like maybe wetland areas will stay the same. T
The Michigan Breeding Bird Atlas II indicated the range of Mallard has not changed in the past 20 years. It remains the most abundant breeding duck in Michigan.
Continentally Climage Endanagered according to the Audubon Climate Analysis. Michigan breeding habitat projected to reduce by 15.87%.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
All types of wetland habitats including urban park ponds. Usually nest in adjacent uplands. Have much flexibility in their nesting habitat. So, I focused on whether wetlands would remain wet in spring and early summer under climate scenarios. Models B1 and A1F1 predicted different results for precip for spring right before nesting/incubation period. Thinking that precip will help fill up wetlands and provide adequate water for vegetation. B1 and A1F1 models increased rain in LP in spring . A1F1 increased rain in EUP...but B1 says less rainfall in UP in spring. Also snowmelt timing earlier and for wetlands expect that water would be absorbed and result in higher soil moisture (and adequate wetland recharge). Overall, this seems like maybe wetland areas will stay the same. T
Michigan habitat for wintering birds projected to be nearly the same (-2.87%) but will shift substantially northward.
Species is wintering farther north and will likely continue northward shift if climate continues warming.

Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Utilize a wide variety of vegetative cover for nesting...ag fields, woodlands, over wetlands, etc. Although projected changes could impact vegetation types at breeding sites, this may not impact mallard breeding as they use a wide variety of vegetation types.
Depends on the realized effect of climate change on marshes, flooded fields, bays, rivers, and lakes.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
So, assuming that winter temps in other parts of the country (including MI) are likely to go up...then winter habitat for the species might also increase. Since the species needs a small amount of open water and food. This could mean the species is found further to the north during non-breeding period (especially during winters when ponds/water does not freeze). Information on climate change impacts in non-breeding not provided so that is why I marked not adequate.
Less ice in winter presumably will mean more habitat for this generalist.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Expertise and information not available to answer definitely. Again, the flexibility of this species to nest in a wide range of habitats does not indicate that there are specific features needed to promote repro. success or survival. They survive and reproduce well in many habitats.
As a wetland species earlier and drier springs could have a negative impact to reproductive success through this species is highly adaptive and is adapted to nesting in upland grasslands.
Very adaptable species, breeding in urbanized environments often. More study needed though.
Ability to colonize new areas: What is the potential for this species to disperse?
Sexes disperse and move to other habitats seasonally.
Highly migratory, highly mobile species.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
Physiological thresholds: Are limiting physiological conditions expected to change?
Evidence provided suggest that ducklings and broods are sensitive to colder temperature. Predictions suggest that this geography will experience increase in temperatures. This might mean less mortality and higher productivity for mallards.
During winter conditions will not be exceeded as often due to milder temperatures.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Information lacking to determine if increased thunderstorms/hail , heavy precipitation events or tornadoes would impact the mallard population. I'd say impacts to population is unlikely...due to the size, magnitude, and geographic range of this species. The disturbance events being predicted would be a small, localized scale.
Food availability in wetlands is key to habitat quality. More study needed to clarify how that is affected.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Very adaptable and moves readily to take advantage of better resource conditions in other areas (or moves away from poor resource conditions). Does this overlap with dispersal question?
Adapts readily to changing ice conditions and food conditions, but more study needed.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?

Like other migratory birds, uses photoperiod to modulate migratory restlessness. But is a short distance migrant and excellent flier, so adjusting to changing conditions would be easy. More study needed.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Mallards eat a wide variety of food items...herbivores, insectivores, granivore. They can shift to where these food resources are more plentiful. They don't seem to be tied to discrete resource peaks.
Omnivorous and opportunistic so other than ice cover the species should be resilient. Eats more animal matter in summer than in winter.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
I don't know.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Emerging diseases may have important consequences for Mallard though not necessarily and climate related issue.
According to Birds of North America the species rarely renests after a failure (urban birds excepted), and renesting is highly dependent on temperatures, precipitation, and condition of wetlands, which are susceptible to climate change. Monitoring of productivity is recommended as climate changes.
Food resources: Are important food resources for this species expected to change?
Species utilized a very wide variety of food items found in both uplands and wetlands
Omnivorous and adaptable, with ice cover being the primary limiting factor most of the time. Still, monitoring of habitat quality and prey availability as climate changes will be important to documenting the mechanisms affecting food resources availability.
Predators: Are important predator populations for this species expected to change?
Wide variety of predators feed upon mallards.
Susceptible to disease which may be affected by climate. Wide variety of nest and chick predators, with adults captured by raptors and large mammals.
Symbionts: Are populations of symbiotic species expected to change?
I know of no symbionts in waterfowl.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Botulism outbreaks in the Great Lakes, especially in Northern Lower Peninsula and northern Lake Michigan shoreline has been observed over the last decade. There may be a link to climate impacts as well as invasive species presence (which is bringing the toxin in contact with fish and birds). Unsure, however, if mallard exposure is anticipated. Do they use the Great Lakes shoreline areas during migration in late summer/fall? I'm guessing at least a portion of the birds do. Do we have evidence of death of mallards via botulism outbreaks? Needs further investigation.
Like all waterfowl susceptible to a vareity of diseases and parasites. how these pathogens will respond to climate change is unclear and should be closely monitored.
Competitors: Are populations of important competing species expected to change?
I didn't look into black duck and whether some of the issues that are driving mallards breeding with or out competing that species could be climate related.
Interbreeds with American Black Duck in northern Michigan and appears to be displacing that spcies.
Unclear.

Jiwiiskwiiskiwe || Wilson's Snipe || *Gallinago delicata*

Species: Wilson's Snipe	
Overall Vulnerability	**Overall Uncertainty**
2.84	0.63
Habitat Vulnerability	**Habitat Uncertainty**
1.60	0.73
Physiology Vulnerability	**Physiology Uncertainty**
-0.33	0.53
Phenology Vulnerability	**Phenology Uncertainty**
1.21	0.6
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.25	0.61

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
In Michigan, potentially habitat sensitive due to avoidance of dense wetland habitat (i.e. Typha) and preference of wetland/upland edge with low herbaceous vegetation especially sedges. These habitats seem more vulnerable to changing climate conditions especially with reduced moisture predicted with a drier and warmer climate. Of concern, is a 40% decrease in the number of Townships reporting Wilson's Snipe during the Michigan Breeding Bird Atlas II. What is driving this decline is poorly understood and this species remains a relatively obscure wetland breeding species In addition, Steen et.al (2014) ranked Wilson's Snipe the most vulnerable of breeding waterbird species to climate change in the Prairie Pothole Region of the US.
Bog, swamp, peatlands used for breeding - non-treed. In north also associated with shrubs - alder and willow. Black willow expected to increase under NIACS. Wetland areas likely to be wet in early spring. Models B1 and A1F1 predicted different results for precip for spring right before nesting/incubation period. Thinking that precip will help fill up wetlands and provide adequate water for vegetation. B1 and A1F1 models increased rain in LP in spring . A1F1 increased rain in EUP...but B1 says less rainfall in UP in spring. Also snowmelt timing earlier and for wetlands expect that water would be absorbed and result in higher soil moisture (and adequate wetland recharge). Overall, this seems like maybe wetland areas will stay the same. There are some key uncertainties associated with which model results you utilize. No information on changes in herbaceous veg. due to climate which is a big part of this species breeding habitat (not trees).
Audubon Climate Analysis lists this species as stable, although a substantial northward shift in range is expected, constituting a 96.61% decline in breeding habitat suitability in Michigan by 2080.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Important habitat requirements of this species seems to be lacking from the wintering areas.

No information provided regarding climate change in wintering grounds. Is there a chance that wetland areas could dry up or become more vegetated by trees.
Audubon Climate Analysis projects a 150.85% increase in winter habitat in Michigan by 2080.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Educated guess based on if growing season increases by 30 -70 days species not native to the area could be more successful and native herbaceous and shrub vegetation will be outcompeted in and around wetlands. Also may allow for species such as cattails and phrag to move into these areas (which were specifically notes as problemmatic for this species...as the structure of these species are too tall and obstructs the birds view).
Breeds in sedge bog, fens, willow and alder swamp, and marshy edges of lakes and rivers. Commanilty is wet organic soils rich in food with clumps of cover. The effect on these habitats of climate change, is unknown and needs study.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
Components required for non-breeding unknown.
Similar habitats as breeding season: wet organic soils rich in food with clumps of cover.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
If non-native species are able to invade and out-compete native species then would expect that reproductive success or survival would be impacted. However, no information was provided on what habitat features impact reproductive success or survival.
Drying up soils in the habitats in which snipes breed would be problematic. More study needed.
Ability to colonize new areas: What is the potential for this species to disperse?
As a migrant probably has the ability to disperse but information seems to be lacking for this species.
Given the species long distance migration. It seems there is ability for both sexes to disperse and find new habitat areas. Site fidelity at breeding sites seems likely..but limited data exist.
Highly migratory and strong flier.
Physiological thresholds: Are limiting physiological conditions expected to change?
As an early migrant seems to be tolerant of a wide variery of climatic conditions.
Species is not utilizing excessively hot or dry climate. Temperature is expected to increase as result of climate change in summer...but seems like the temps should primarily remain within physiological thresholds. No data provided.
Definitely sensitive to cold temperatures. Unclear if sensitive to too much heat in summer.
Sex ratio: Is sex ratio determined by temperature?
Assuming that most bird species sex is not determined by temperature. No expertise or information to answer this question.
I don't know.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Literature provided suggest that drought can impact populations regionally. The NIACS paper doesn't mention drought in this geography as an issue. We are expecting to see increased precipitation.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
Nocturnal species that is not breeding in an excessively hot or dry environment. Unlikely to have to shift

or shorten daily activity period. Are active at coolest part of day.
Most likely it won't be affected because photoperiod modulates activity period.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Incomplete information.
No alternative life forms, irruptive migrations, explosive breeding or cooperative breeding.
I don't know.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Likely use photoperiod as cue for migration and breeding.
Primarily uses photoperiod, although temperature presumably has a smaller effect on initiation of breeding.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Species eats a variety of aquatic insects which would be available in wetlands where they nest year round. No evidence that their reproduction is timed to peaks in insect density or after any type of insect hatch.
Eats primarily insects, with some crustaceans and plants and small vertebrates. The effect on these species is unknown to me.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
No expertise or information provided on which to provide an answer.
unknown.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Only breed once a year.
Birds of North America suggests no evidence of double brooding.
Food resources: Are important food resources for this species expected to change?
A variety of aquatic arthropods in mud or on mud flats. Sometimes sedge or grass seed...but mainly insects. In our region, precipitation models are not predicting droughts but rather increased rain annually. Would not expect wetlands to dry up...if wetlands were to dry up then food base would also be diminished.
Prey are associated with wetlands, and would be affected by drying or acidification.
Predators: Are important predator populations for this species expected to change?
Northern Harriers are thought to be a primary predator (along with other raptor species). I don't havey understanding of how northern harriers are likely to be impacted by climate change.
Adults not predated on nests often. Nest depredation is common, and the effect of climate on these nest predators is unknown.
Symbionts: Are populations of symbiotic species expected to change?
Northern Harriers are thought to be a primary predator (along with other raptor species). I don't havey understanding of how northern harriers are likely to be impacted by climate change.
No known symbionts.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Botulism outbreaks in the Great Lakes, especially in Northern Lower Peninsula and northern Lake

Michigan shoreline has been observed over the last decade. There may be a link to climate impacts as well as invasive species presence (which is bringing the toxin in contact with fish and birds). Unsure, however, if snipe exposure is anticipated. Do they use Great Lakes shoreline areas during migration? If no, then unlikely to be exposed. If yes, then likely to be exposed during fall migration some years.
Susceptible to many parasites, and the effect of climate on these is unknown.
Competitors: Are populations of important competing species expected to change?
No competitive species known.
I don't know but am skeptical any such relationships will have major impacts on the species.

Ajijaak || Sandhill Crane || *Grus canadensis*

Species: Sandhill Crane	
Overall Vulnerability	**Overall Uncertainty**
3.47	0.28
Habitat Vulnerability	**Habitat Uncertainty**
1.10	0.2
Physiology Vulnerability	**Physiology Uncertainty**
0.38	0.21
Phenology Vulnerability	**Phenology Uncertainty**
1.40	0.35
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.65	0.4

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
The species utilizes a variety of wetland and adjacent upland habitats and has demonstrated to be adaptable as its population has increased dramatically in Michigan during the past twenty years.
Audubon climate analysis provides no data.
Wetlands (mostly open wetlands - bogs, fens, marsh areas) is critical for nesting habitat. Also adjoining or close by uplands/woods (but seems to be considerable variety utilized from ag fields, pastures to wooded). So, I focused on whether wetlands would remain wet in spring under climate scenarios. Models B1 and A1F1 predicted different results for precip for spring right before nesting/incubation period. Thinking that precip will help fill up wetlands and provide adequate water for vegetation. B1 and A1F1 models increased rain in LP in spring . A1F1 increased rain in EUP...but B1 says less rainfall in UP in spring. Also snowmelt timing earlier and for wetlands expect that water would be absorbed and result in higher soil moisture (and adequate wetland recharge). Overall, this seems like maybe wetland areas will stay the same. There is definitely variability in results depending on which model results you utilize.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Audubon climate analysis suggests a increase in habitat for Michigan, but the species is climate threatened continentally.
Speices may winter farther north if climate continues to warm.
I didn't really want to answer this question as I have no information or expertise on which to base my opinion. From perspective of predicted climate impacts in this part of the country.
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
The species benefits from stable water levels in wetlands. Extended dry periods may influence reproductive success through the species has increased significantly in the past 20 years during a time

declining lake levels.
Nests in open marshes, bogs, hay meadows, ponds and river edges.
Educated guess based on if growing season increases by 30 -70 days; species not native to the area could be more successful and native herbaceous and shrub vegetation will be out-competed in and around wetlands. Also NIACS summary suggests that many of the tree species associated with crane nesting sites in Seney and Northern Michigan could decrease due to climate impacts (Black spruce, tamarack, red pine, Eastern White Pine, Jack Pine, Red Maple). Questions: Is there a chance that climate change could impact habitat by shifting to more woody vegetation in wetlands.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
This species is adapted to feeding in a variety of upland habitats during migration including argicultural grains.
Winters in croplands, wetlands, and pastures near roosting sites. Check climate analysis for predictions.
Habitat components for non-breeding birds unknown.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Depends on what effect climate change has on bogs, vegetation, and the food sources therein. Cranes are omnivorous and flexible.
Mixed model results makes it hard to tell, but I'm thinking there could be a slight negative impact on reproductive success. Assuming that wetlands will remain similar in their location and extent based on H1. Not sure if there would be higher water levels or more stable water levels...which would improve nest success. High spring rainfall reduces productivity...increased spring rain in LP (both models) and EUP (A1F1)...suggest that across the geography there could be a decrease in reproductive success.
Ability to colonize new areas: What is the potential for this species to disperse?
A long-lived species with low reproductive output. Young migrate and are dependant on adults for learning migration routes. With hihg site fidelity colonization potientail is likely slow however during the past 20 years the species has demonstrated its ability to recolonized adeas were it was extripated including every county in Michigan and Isle Royale (where absent prior to 1996). Protection of wetlands and the adult population is paramount to the continued conservation success of this species.
Species is very mobile, highly migratory, and should be able to move to new areas if needed, so long as the habitat is appropriate.
Extremely high site fidelity; natal dispersal (for non-migratory population) also very small distance from site. Are there any studies that suggest birds move after repeated failed nesting attempts? Clearly birds are moving very large distances during migration.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
SHC are known to frequent different areas during migration to re-fuel and rest.
Physiological thresholds: Are limiting physiological conditions expected to change?
Species is highly resilient to cold temperatures and this may reduce pressure on wintering birds, or cause continued overwintered as is already occurring.
Answered question, but would have preferred not to as no expertise or information on which to base a decision.
Sex ratio: Is sex ratio determined by temperature?
I don't know.
Answered question, but would have refereed not to as no expertise or information on which to base a decision.

Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Floods could change the distribution of habitat, as could drying up, but the species is flexible so long as there is some wetland habitat.
Significant weather events have been shown to impact cranes (blizzards, hail storms, lightening)…perhaps due in part to the open nature of their habitat and lack of overhead cover? Model suggest a slight increase in severe storms and tornadoes on breeding grounds. I am saying it will have a negative impact on survival/reproduction, but think this could be small in magnitude.
Limitations to daily activity period: Are projected temperature or precipitation regimes that influence activity period of species expected to change?
Daily activity period moderated by food availability (time to fill the tank), which unless the food resource drops precipitously, shouldn't be grossly affected.
Diurnal species. Temperatures will likely be somewhat hotter in summer during breeding season. But seems that this might be buffered by habitat they use (wetland...moist) and next to wooded areas (shade).
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
This species benefits from adult longivity which can offset low reproductive potiential.
Flexible omnivorous diet and high ability to migrate should protect this species.
They have limited strategies to cope with variable resources (no alternative life forms, irruptive migration, explosive breeding or cooperative breeding).
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
Most annual activities are moderated by photoperiod. But it is clear that short-term adjustments to mild winters and early warm spells do allow the species to migrate north earlier or even stay the winter.
Photoperiod seems to be an important driver for many bird species.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
The effect of climate on breeding is unclear, but the efffect on winter survivorship should presumably be negligible or even advantageous.
Discrete resource peaks (food, breeding sites) don't seem to be a driver for SHC. Food may be more abundant later in the season but I due to the variety of food items, I don't think "discrete resource peaks" would affect this species.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
Amoung the first migrating birds to return in Michgian in early spring.
Needs study and monitoring
No specific information provided. Again, based on information provided the species doesn't seem to be tied to specific, discrete events that provide critical resources.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Species has the longest breeding season for any bird species in Michigan. Young are also dependant on adult for an extended period into fall migration and wintering areas.
The species doesn't double brood, but will renest after failed nesting. Needs study and monitoring
Food resources: Are important food resources for this species expected to change?
Species consumes variety of prey/forage species. Some of literature provided suggests that the species

has plasticity in what they eat…diet has likely change significantly due to loss of prairie systems.
Predators: Are important predator populations for this species expected to change?
Adults not eaten by much: coyotes and large mammals only. Chicks and eggs certainly predated by a variety of species.
Seems like there is a wide variety of species that prey on SHC. Could you cross walk this with the panel working on mammals...since several mammals were identified as predators of SHC.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Diesease risk probably increases climate change given this species propensity for staging during migration in very large aggregates.
Further study needed.
Botulism outbreaks in the Great Lakes, especially in Northern Lower Peninsula and northern Lake Michigan shoreline has been observed over the last decade. There may be a link to climate impacts as well as invasive species presence (which is bringing the toxin in contact with fish and birds). Unsure, however, if SHC exposure is anticipated. Do they use the shoreline areas during migration? If no, then unlikely to be exposed. If yes, then likely to be exposed during some years of fall migration.
Competitors: Are populations of important competing species expected to change?
Some preditors may increase with climate change however there's no indication that this would factor into a population level issues.

Mitigoningwiishib || Wood Duck || *Aix sponsa*

Species: Wood Duck	
Overall Vulnerability	**Overall Uncertainty**
-0.44	0.3
Habitat Vulnerability	**Habitat Uncertainty**
-0.07	0.29
Physiology Vulnerability	**Physiology Uncertainty**
-0.8	0.23
Phenology Vulnerability	**Phenology Uncertainty**
-0.19	0.35
Biotic Interactions Vulnerability	**Biotic Interactions Uncertainty**
0.6	0.36

Question/Comments
Area and distribution - breeding: Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?
In Michigan, Wood Ducks are more abundant in the Lower Peninsula but still well represented across the UP where habitat providing a mix of wetland and forest is abundant. Recent large scale loss of mature ash, elm, and beech due to invasive species/pathogens probably may have implications for this cavity nesting species.
Categorized at Threatened by Audubon Climate Analysis. Michigan summer habitat projected to decrease by 16.51% by 2080. Forested swamps and wetland edges are not, to my knowledge specifically threatened by climate.
Wide variety of habitats used. Also, the wetland habitats are likely to remain wet as a result of increased precipitation.
Area and distribution - non-breeding: Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?
Wood Ducks occupy a wide-range of wetland habitat types.
Michigan winter habitat projected to increase by 165.8% by 2080. During migration this species utilizes forested wetlands, but also a variety of additional habitats including rivers, lakes, sewage ponds, city parks, and open marshes. The species is absent from MI in winter, other than scattered rare individuals in local Mallard flocks, typically in urban areas and parks.
Species likely to winter farther north over time if winters continue to warm.
Unsure of projected changes in wintering grounds. Will there be widespread droughts that may impacted wetland habitats?
Habitat components - breeding: Are specific habitat components required for breeding expected to change within the associated vegetation type?
Again, implication of large-scale loss of mature of ash, elm, beech due to invasives may have implications for this cavity-nesting species. In general, changes in forest management and use projects maturing forests required for nesting to increase.

I am unaware what conditions are relevant here. Perhaps water levels, if they receded, or if wetlands dried up, you would have a negative impact. Need to see if that is predicted. If parastites increased in cavities that would present potential complications as well.
Streams are one of the most extensive habitats for this species and there is predictiond that flashiness of streams will increase. This flashiness could lead to increased nest inundation and decreased hatch rates.
Habitat components - non-breeding: Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?
This depends on the effect climate has on wetlands, the most obvious impact being any drying up, or change of food availabilty
No wintering grounds climate information on which to base decision.
Habitat quality: Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?
Loss of tree species associated with nesting such as ash and elm could be significant.
Nesting boxes may be the single most important factor associated with high nest success, with natural cavities a secondary contributing factor. If natural cavities become less available because of climate a negative impact on fitness is likely.
Need cavities for nesting (decidous forest species); many species listed are not on list to experience widespread declines in this geography.
Ability to colonize new areas: What is the potential for this species to disperse?
Highly migratory species, and should be very able to move to new areas.
Migratory or transitional habitats: Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?
This species utilizes a wide variety of wetland habitats during migration.
Physiological thresholds: Are limiting physiological conditions expected to change?
Wintering waterfowl should increase here with milder winters, as they are short distance migrants which can adjust to changing conditions readily.
Sex ratio: Is sex ratio determined by temperature?
Don't know.
Exposure to weather-related disturbance: Are disturbance events (e.g. severe storms, fires, floods, etc..) that affect survival or reproduction expected to change?
Floods that affect wetland habitat quality could plausibly impact the species reproductive success, but mechanisms need clarification. Food availability in wetlands is important to habitat quality.
Not much related to disturbance in the literature. Given the wide variety of habitat, increased disturbance of thunderstorms or rain events not likely to have widespread population level impacts.
Survival during resource fluctuation: Does this species have alternative life history pathways to cope with variable resources or climate conditions?
Capable of rearing two broods per season.
Highly migratory and should be able to change to new areas readily, assuming suitable ones exist. Whether there are geographic limitations which will not allow dispersal is dependent on which climate prediction comes true.
Mismatch potential - Cues: Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?
This question might be answered differently in summer and winter. In summer cues for migration and nest initiation are photoperiod driven. However, waterfowl adjust to changing ice conditions and temperature swings readily and can make drastic geographic adjustements. What the actual changes

would be remains to be seen.
Literature suggests that some climate (weather/temp) might be part of cue for some southern versus northern breeders. But I didn't read that this is PRIMARILY what initiates activities.
Mismatch potential - Event timing: Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?
Wood Ducks eat seeds, fruits, and aquatic and terrestrial invertebrates. I don't know whether these foods are expected to change, but I assume some changes will be inevitable. But since it's an omnivore and only nests near wetlands, I assume wetlands will always provide something of food value to the species.
Mismatch potential - Proximity: What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?
I don't know the answer to this without more study.
Resilience to timing mismatch: Does this species have more than one opportunity to time reproduction to important events?
Capable of two broods per season.
The species certainly double broods in some years, so some flexibilty exists.
This happens more frequently in souther portion of range. Could increased temps. result in two broods in northern MI?
Food resources: Are important food resources for this species expected to change?
I don't know what the projections for seeds, fruits, and aquatic and terrestrial invertebrates are, but given this is an omnivore it should be able to be flexible in its diet.
Predators: Are important predator populations for this species expected to change?
Appears that raccoon is an important preditor of this cavity nesting duck. Populations of raccoons have increased and moved north due to milder climatic conditions and land use changes that benefit this human commensal.
Primary nest predators are snakes, Fox Squirrels, and raccoons. I don't know if these are expected to change.
Symbionts: Are populations of symbiotic species expected to change?
I don't know of any symbionts in waterfowl.
Disease: Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?
Probably not adequately known -- infection rates for leucocytozoon is high amoung duck species and high suseptablity to avian influenza suggest this species vulunearable to emerging or new diesase pathogens.
Several parasites and pathogens infect Wood Ducks, including protozoans and microfilaria. Also avian influenza.
Unsure how temp increase and precip increase could impact prevelance of diseases listed.
Competitors: Are populations of important competing species expected to change?
Being an omnivore and accustomed to wetlands, I am not aware of imporant competing species. May compete for nest cavities with Hooded Merganser, Common Merganser, Eastern Screech-Owl, or other species.
Unclear what species are competing.