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## **Changing Climate, Changing Wildlife**

### **A Vulnerability Assessment of 400 Species of Greatest Conservation Need and Game Species in Michigan**

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## Executive Summary

Michigan's climate has been warming, and the warming trend is accelerating. The best available science indicates the acceleration is likely to continue, and warming in the next 40 years will be roughly 10 times as fast as the warming over the past 100 years in Michigan.

Michigan wildlife face myriad conservation challenges, including land use change and habitat loss, habitat fragmentation, competition from invasive exotic species, altered ecological processes, and a rapidly changing climate. This report focuses on the effect of a rapidly changing climate.

In 2010, the Michigan Natural Features Inventory (MNFI) received funding from the Michigan Department of Environmental Quality Coastal Management Program to assess vulnerability of 180 animal and plant species in the coastal zone using the Climate Change Vulnerability Index (CCVI) developed by NatureServe. MNFI assessed a total of 198 species including 131 animal species and 67 plant species. The Michigan Department of Natural Resources (DNR) Wildlife Division used State Wildlife Grants and Pittman-Robertson funds to assess vulnerability of 281 animal species using the same methods. Twelve animal species were assessed by both MNFI and the Michigan DNR. All resident terrestrial game species and all Species of Greatest Conservation Need (SGCN) (with enough life history data) were assessed. Vulnerable species are those expected to experience reductions in range extent or abundance by 2050 due to climate change.

**The CCVI analysis suggests that 17% of terrestrial game species and 61% of terrestrial and aquatic Species of Greatest Conservation Need (SGCN) are vulnerable.** Other conservation threats or programs aside, these species will likely experience range or population reductions due to climate change. Vulnerable species included important game species, such as moose (*Alces americanus*), American marten (*Martes americana*), snowshoe hare (*Lepus americanus*), and ruffed grouse (*Bonasa umbellus*). Vulnerable SGCN include conservation icons, such as the Karner blue butterfly (*Lycaeides melissa samuelis*) and common loon (*Gavia immer*). The full list of species' vulnerabilities is in the Appendices.

Other vulnerability analyses suggest that ecological communities in Michigan will change dramatically as species respond individually. Some characteristic northern species, such as spruce, fir, and birch may fade from the landscape. Quaking aspen (*Populus tremuloides*) is predicted not to regenerate and compete with the same health and vigor in a warmer and drier Michigan. Other species, such as red maple (*Acer rubrum*) and some oaks (*Quercus* spp.) and hickories (*Carya* spp.), are expected to do better in a warming climate. This analysis focuses on vulnerabilities of individual species, independent of changes in habitat or competitive interactions.

The CCVI predicts the strength and direction of the influence of a changing climate. Management action (or inaction) can offset or reinforce the climate influence. The CCVI is a useful first step in climate adaptation, but it is only one tool to use to develop climate adaptive management plans for species or habitats. Initial suggestions of management actions are provided to help managers begin thinking about how these adaptive plans can be formulated. However, adaptation (e.g., climate-smart management) will need to be context specific; it will depend on existing management goals, priorities, funds, and local site conditions.

## Introduction

Imagine eating a woodland caribou (*Rangifer tarandus caribou*) steak in Marquette County; or finding freshly shed caribou antlers in Bad Axe; or trapping American marten in Allegan; or finding the broad tracks of Canada lynx (*Lynx canadensis*) in the deep snow of northern Ohio. Imagine lake ice that stretches to the horizon, linking islands to mainland, peninsula to peninsula, every winter. This is not a picture of a boreal Great Lakes shortly after the glaciers melted. This is Michigan at statehood, even up to the early 1900s, based on historical records (Baker 1983). Mean air temperatures have warmed 1 degree F over the past 100 years (Andresen 2012), and many species have responded. **In the next 40 years, temperatures are projected to rise 7 to 12 times as fast. These future climate change projections raise important questions for fish and wildlife managers. How might current Michigan species respond to 3 to 5 degrees F change by 2050?** Which species are most vulnerable? Which species might increase in abundance or expand their range? And what should we do now?

Vulnerability to climate change is the likelihood that climate-induced changes will have an adverse impact on a given species, habitat, or ecosystem (Glick et al. 2011). Vulnerability is a function of the *sensitivity* of a species or system to climate changes and *exposure* to those changes (Schneider et al. 2007, Williams et al. 2008). A species or system's *capacity to adapt* to climate changes also contributes to its vulnerability (Schneider et al. 2007, Williams et al. 2008). Sensitivity is a measure of whether and how a species or system is likely to be affected by a given change in climate (Schneider et al. 2007, Williams et al. 2008, Glick et al. 2011). Exposure is a measure of how much of a change in climate and associated impacts a species or system is likely to experience (Glick et al. 2011). Adaptive capacity refers to a species or system's ability to improve, minimize, or manage

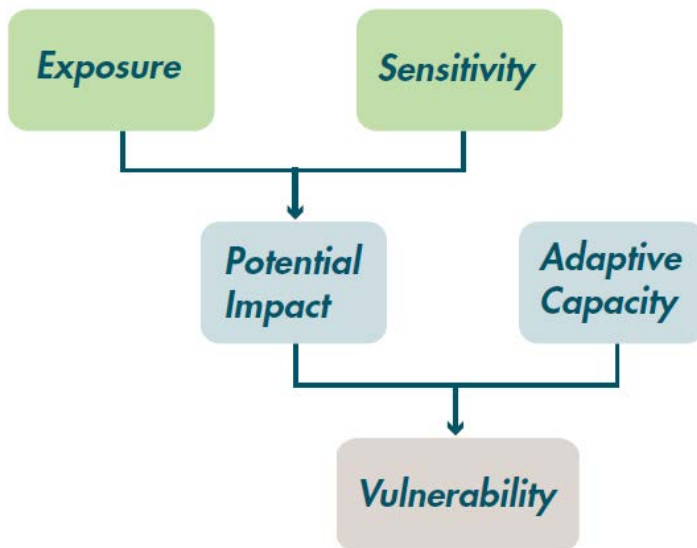


Figure 1. – The relationship of exposure, sensitivity, and adaptive capacity in determining vulnerability to climate change (Glick et al. 2011). All three elements were incorporated in the CCVI score.

its sensitivity or exposure to climate changes (Williams et al. 2008, Glick et al. 2011).

Vulnerability is like risk, and much can be learned from the field of risk management (Brooks 2003). **Risk management offers a different mental frame for understanding climate change and its potential to affect fish and wildlife resources.** Rather than seeking to control the threat, as a manager might control harvest levels or seasons, a more fruitful approach is to consider climate as a systemic stressor. Climate can be influenced by energy policies, but those are outside the decision-space of fish and wildlife managers. Instead, we should consider climate in the same category as other risks: new invasive species, new diseases, or demographic changes.

**A vulnerability assessment is a first step in climate adaptation, just as a risk assessment is an early step in risk management.** Risks are generally not eliminated, but rather they are managed by reducing exposure, decreasing sensitivity, or increasing adaptive capacity of a system. In the case of conservation, the systems are populations of species of fish and wildlife in the context of their habitats and ecosystems. First, we need to understand which species are most at risk. Then we need to understand why. Are they in a state or province where they could be exposed to more than average warming, or less? What makes them sensitive? Do they have limited dispersal abilities or require a narrow range of water temperatures? Once we know how climate threatens a species, then we can determine what can be done to manage those risks to reduce vulnerability. If feasible actions exist, they can then be prioritized and implemented.

A [Climate Change Vulnerability Index](#) (CCVI) score is a measure of the likelihood that climate change will cause a decrease in range or abundance of a species by 2050. The CCVI has been used in a number of states by a variety of agencies and organizations to conduct climate change vulnerability assessments including the natural resource departments and natural heritage programs in Nevada, West Virginia, Pennsylvania, New York, and Illinois (Byers and Norris 2011, Furedi et al. 2011, Schlesinger et al. 2011, Walk et al. 2011). The CCVI is designed to complement, and not duplicate, information contained in the NatureServe conservation status ranks (Master et al. 2012; see Appendix 1). Conservation status ranks are a standardized estimate of extinction risk. Species are ranked on a five point scale from 1 (critically imperiled) to 5 (secure) at the global (G) and the state (S) scale. The prairie vole, for example, is ranked G5 (secure) and S1 (critically imperiled). Managers can use output from the CCVI in conjunction with the conservation status ranks to identify priorities for adaptation efforts (Young et al. 2011). They may also use output from the CCVI to update future conservation status ranks to include the additional stressor of climate change (Byers and Norris 2011).

The CCVI focuses on changes in range or abundance. However, for game species, climate change adaptation is not only about avoiding extinction, but also about the effect that climate change may have on stakeholder values. As an example, ice fishermen create seasonal winter communities on larger lakes across the northern United States (Abbott 2005). The cultural heritage of these communities is likely threatened by ice loss: access may change even if the populations of fish on which they depend do not change. Similarly, **warmer temperatures will mean new or more virulent pests and diseases. Many diseases that could potentially occur in Michigan are limited by cold winter temperatures.** The link between Epizootic Hemorrhagic Disease (EHD) and weather has been well established (Ward 2005, Sleeman et al 2009, Xu et al. 2012). The 2012 outbreak of

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EHD in Michigan was largely a function of the abnormally hot and dry weather. Climate is weather over time, and EHD is expected to respond strongly to climate change (Wittmann and Baylis 2000). The increased frequency of EHD outbreaks in the past decade is an example of wildlife impacts from Michigan's changing climate. Although EHD had an insignificant effect on the statewide deer harvest, some local deer populations were heavily impacted in 2012. To hunters in those areas, climate change has had a significant impact on their hunting and wildlife viewing opportunities. It is important to understand that a simple analysis like CCVI will not capture impacts to cultural values or local populations. CCVI is a statewide, first approximation of vulnerability.

Finally, it should be noted that any assessment of vulnerabilities will have substantial uncertainty. Natural systems are dynamic and nonlinear. It is possible that some species will be less vulnerable than scored with this tool. However, the climate is changing faster than global climate models predicted. Global models of CO<sub>2</sub> rise, temperature rise, and sea level rise have under-predicted observed rates of change (Rahmstorf et al. 2007). Thus, it is likely that this assessment will more often underestimate than overestimate the climate risks to Michigan wildlife.

## Methods

We assessed the vulnerability of 400 animal species to climate change using the Climate Change Vulnerability Index (CCVI) developed by NatureServe (Young et al. 2011). The CCVI provides natural resource managers a practical, easy-to-use tool for rapid and science-based assessment of species vulnerability to climate change. The CCVI uses a Microsoft Excel<sup>®</sup> platform, which allows users to enter numerical or categorical responses to a series of questions about risk factors related to a species exposure and sensitivity to climate change. We initially performed the calculations using the NatureServe CCVI version 2.01, and subsequently transferred all results to version 2.1 following its release in April 2011. The complete CCVI v2.1 tool and supporting guidance and documentation are available on [NatureServe's website](#).

The CCVI tool determines the vulnerability of a species to climate change by assessing the exposure of the species to future projected climate change in the assessment area and the species sensitivity to climate change. Young et al. (2011) provides a more detailed summary and background on the CCVI. Adaptive capacity is incorporated under the sensitivity section of the CCVI tool.

CCVI classifies a species exposure to climate change as direct or indirect (Table 1). To measure direct exposure we examined the magnitude of predicted changes in temperature and moisture across the range of the species within the assessment area (Young et al. 2011). The direct exposure score is the percentage of the species' range within the assessment area that falls into categories of projected changes in temperature or moisture (Table 1). We downloaded projections for average annual temperature changes in Michigan for the year 2050 from The Nature Conservancy's [Climate Wizard](#) (Girvetz et al. 2009) and displayed these projections in a GIS format. We downloaded projections for changes in moisture by 2050 from NatureServe. These climate models or predictions represented a median of 16 global circulation models (GCMs) based on a "middle of the road" emissions scenario. Indirect exposure examines the species distribution relative to sea level rise, natural and

Table 1. Factors assessed with the NatureServe Climate Change Vulnerability Index tool developed by NatureServe (Young et al. 2011, Byers et al. 2011). Species had to be scored greatly increase, increase, slightly increase, neutral, slightly decrease, decrease, or unknown for each factor.

Aspect of Vulnerability	Factor	Description
Direct Exposure	Temperature Change	Predicted change in annual temperature by 2050, calculated over the range of the species in Michigan, ranged from 4.5 to >5.5°F increase.
	Moisture Change	Predicted net change in moisture based on the Hamon AET:PET Moisture Metric, calculated over the range of the species in Michigan, net drying ranging from -0.028 to -0.096.
Indirect Exposure	Sea Level Rise	Not a factor in Michigan. Great Lakes level changes were incorporated as a Disturbance regime factor.
	Natural Barriers	Geographical features of the landscape that may naturally restrict a species from dispersing to inhabit new areas. The Great Lakes were a natural barrier for many species.
	Anthropogenic Barriers	Anthropogenically altered landscapes that may hinder the dispersal of a species. Examples include urban or agricultural areas for terrestrial species and dams or culverts for aquatic species.
	Land Use Changes from Climate Change Mitigation	Strategies designed to mitigate greenhouse gases, such as creating large wind farms, plowing new cropland for biofuel production, or converting large tracts of land and the species that use these areas in both positive and negative ways.



Table 1. continued

Aspect of Vulnerability	Factor	Description
Sensitivity	Dispersal/Movement	Populations of species with poor dispersal abilities may not be able shift geographic range fast enough to stay in a suitable climate.
	Historical Thermal Niche	Species populations that have historically experienced high variation in temperature are expected to be less sensitive to future change. Populations that have experienced a narrow range of historical temperatures are expected to be more sensitive.
	Physiological Thermal Niche	Species requiring specific temperature regimes may be less likely to find similar areas as climates change and previously-associated temperature patterns uncouple.
	Historical Hydrological Niche	Species populations that have historically experienced high variation in precipitation historically are expected to be less sensitive to future change. Populations that have experienced a narrow range of historical precipitation extremes are expected to be more sensitive.
	Physiological Hydrological Niche	Species requiring specific moisture regimes may be less likely to find similar areas as climates change and previously-associated precipitation patterns uncouple.
	Disturbance	Dependence on a specific disturbance regime likely to be impacted by climate change: Species dependent on habitats such as jack pine forests, floodplain forests, and riparian corridors that are maintained by regular disturbances (e.g., fires or flooding) are vulnerable to changes in the frequency and intensity of these disturbances caused by climate change.
	Ice/snow	Dependence on ice, ice-edge, or snow-cover habitats: for example, spawning under Great Lakes ice, dependence on snow for camouflage or escape.
	Rarity of Physical Habitat	Restriction to uncommon geological features or derivatives: species requiring specific substrates, soils, or physical features such as caves, cliffs, or sand dunes may become vulnerable to climate change if their favored climate conditions shift to areas without these physical elements.

Table 1. continued

Aspect of Vulnerability	Factor	Description
Sensitivity	Dependence on Other Species for Habitat	Dependence on other species to generate habitat; because species react idiosyncratically to climate change, those with tight relationships with other species may be threatened.
	Diet Specialization	Dietary versatility (animals only); because species will react idiosyncratically to climate change, those with tight relationships with other species may be threatened.
	Pollinators Specialization	Pollinator versatility (plants only); because species react idiosyncratically to climate change, those with tight relationships with other species may be threatened. This was not a factor in our analysis because we only evaluated animals.
	Dependence on Other Species for Dispersal	Because species react idiosyncratically to climate change, those with tight relationships regarding propagule dispersal with other species may be threatened. Larvae of some mussels attach only to one or a few fish host species, for example.
	Dependence on Any Other Species Interaction	Species react idiosyncratically to climate change. This category captures species dependence not covered by the preceding four categories.
	Documented Genetic Variation	Measured genetic variation; because a species' ability to evolve adaptations to environmental conditions brought about by climate change is largely dependent on its existing genetic variation.
	Past Genetic Bottleneck	Occurrence of and recovery from bottlenecks in recent evolutionary history; because a species' ability to evolve adaptations to environmental conditions brought about by climate change is largely dependent on its existing genetic variation.



Table 1. continued

Aspect of Vulnerability	Factor	Description
Sensitivity	Documented Phenological Response	Phenology is the study of the timing of natural events. For example, recent research suggests that some species or populations are declining due to lack of response to changing annual temperature dynamics (earlier spring, longer growing season).
Documented or Modeled Response	Documented Response to Recent Climate Change	Although conclusively linking species declines to climate change is difficult, convincing evidence relating declines to recent climate patterns has begun to accumulate in a variety of species groups. This criterion incorporates the results of these studies.
	Modeled Change	This factor incorporates models of species vulnerability completed with other methods. This factor appeared to have a strong effect on the final score.
	Modeled Overlap with Current Range	A spatially disjunct predicted future range indicates the species will need to disperse in order to occupy the newly favored area, and geographical barriers or slow dispersal rates could prevent the species from getting there.
	Protected Areas in Modeled Range	For many species, future ranges may fall entirely outside of protected areas and therefore compromise their long-term viability. Because most protected area in Michigan is in the north, this factor was rarely scored high.

anthropogenic barriers to dispersal, and new land uses aiming to mitigate climate change (Table 1).

Sensitivity is based on a variety of factors, including dispersal capability; past climate regime and reliance on specific thermal and hydrological conditions; dependence on disturbance; dependence on snow or ice cover; restriction to certain geological types; reliance on interspecific interactions (e.g., herbivory and predator/prey relationships); genetic variation; and climate-related changes in phenology (Table 1). Each species is scored for each sensitivity factor from “decrease vulnerability” to “greatly increase vulnerability” (or a subset range of these categories), with three to six of these categories available for each factor. Some factors are optional, but a minimum number of factors in each group must be filled out to obtain a vulnerability score. We also incorporated documented or modeled responses to climate change from the peer-reviewed literature as a final factor (Table 1). “Adaptive capacity” was not considered separately in the CCVI. Instead, adaptive capacity

characteristics, such as genetic variation or historical population bottlenecks, were considered as aspects of sensitivity.

Our assessment area was the entire state of Michigan. For vulnerability assessment of listed or special concern species, we used the MNFI Natural Heritage Database, MNFI species abstracts, MNFI Rare Species Explorer, NatureServe Explorer, and other relevant literature and references (e.g., Michigan Breeding Bird Atlas, Michigan Fish Atlas) for species range, distribution and life history information. For listed species with few or no element occurrences in the MNFI database and for common or non-listed species, we relied on the NatureServe Explorer, Michigan GAP data, and other references and published literature for distribution information (e.g., Trautman 1981, Baker 1983, Brewer et al. 1991, Kurta 1995, Harding 1997, Scott and Crossman 1998, and Michigan Fish Atlas). When available we also used general habitat and life history descriptions from these references.

We obtained ranges of terrestrial gastropod species in Michigan from Hubricht (1985) and occurrence records in the Natural Heritage Database. We found additional taxa specific information for terrestrial and aquatic gastropods, including habitat preferences, in published literature (Burch 1988, Burch and Jung 1988, Burch and Jung 1993, and Nekola 1998). We estimated ranges of unionid mussels and aquatic gastropod species in Michigan using a GIS layer of occurrence records in the Natural Heritage Database. We overlaid species range distributions on the projected temperature and moisture maps/data layers and the historical precipitation variation data layer to rank the factors related to direct exposure and predicted sensitivity to temperature and moisture changes/niches. We also consulted with additional sources of information for the assessment including webinars (e.g., Ludsin 2011), theses, and dissertations.

After initial scores were calculated based on available literature, we interviewed a group of experts to ensure that the factors were scored accurately and that we did not miss any relevant literature or research results. Interviews were done on an individual basis, and not in a workshop setting. Most scores did not change after expert review. Those that did change usually increased in vulnerability. This suggests that for the CCVI tool there may be a bias toward underestimating climate vulnerability if expert opinion is not solicited.

Using CCVI we produced a climate change vulnerability score for each species along with a quantitative measure of confidence or uncertainty around the score. Young et al. (2011) provides a summary of how the vulnerability score and confidence measures were generated. Vulnerability scores, definitions, and abbreviations are provided below. Confidence scores range from low to very high (see Appendix 1).

- **Extremely Vulnerable (EV):** Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.
- **Highly Vulnerable (HV):** Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.
- **Moderately Vulnerable (MV):** Abundance and/or range extent within geographical area assessed likely to decrease by 2050.
- **Not Vulnerable/Presumed Stable (PS):** Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.

- **Not Vulnerable/Increase Likely (IL):** Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.
- **Insufficient Evidence (IE):** Available information about a species' vulnerability is inadequate to calculate a CCVI score.

## Climate Vulnerability and Conservation Status Ranks

NatureServe and the Michigan Natural Features Inventory rank species by conservation status. Conservation status incorporates many measures of rarity and population trends. Until recently, threats were considered as one measure of all conservation threats facing a species (Master et al. 2003). Climate change was not mentioned as a threat category. The new methodology does incorporate climate change explicitly, but not with the thoroughness of the CCVI (Master et al. 2012). The conservation ranks listed in this report were calculated prior to 2012, and did not use climate change as a threat. Thus, the conservation status ranks in this report apply to rarity, population trends, and other conservation threats. **The CCVI scores and conservation status together provide a conservation index for the species incorporating rarity, population trends, other threats, and climate change.** Biologists should use the two measures in conjunction to give a full understanding of each species conservation status in a rapidly changing climate. For example, the moose has a state conservation rank of S4, meaning that it is apparently secure, uncommon, but not rare within Michigan. However, the CCVI rank is Highly Vulnerable, meaning that abundance is likely to decrease significantly by 2050. The mink frog (*Rana semptontrionalis*) has a conservation rank of S3, meaning it is vulnerable and at risk in Michigan, but has a ranking of Extremely Vulnerable, meaning it is likely to substantially decrease or disappear by 2050. At the opposite end of the spectrum, wild turkey (*Meleagris gallopavo*) is an S5 (secure in Michigan), with a CCVI of Increase Likely.

**State conservation ranks and CCVI scores for each species are listed in Appendix A**, where species are organized alphabetically by scientific name within taxonomic groups. The other appendices rank species from most vulnerable to least vulnerable. In these appendices species are considered in four broad categories: climate-vulnerable rare species (n=145, Appendix B), climate-vulnerable common species (n=49, Appendix C), climate-stable rare species (n=73, Appendix D), climate-stable common species (n=93, Appendix E). Within these categories, species are ranked from most vulnerable to least vulnerable and most imperiled (S-rank 1) to most secure (S-rank 5). Readers who want to find the CCVI for a particular species should consult Appendix A. Readers who want to see which species are most or least at-risk should consult Appendices B-E.

### *Climate-Vulnerable Rare Species*

Most rare species (S3, S2, or S1) are also threatened by climate change (Moderately, Highly or Extremely Vulnerable). Some of these species already have recovery plans or conservation programs in place. Those programs may need to adapt to climate change, in addition to addressing other, existing conservation threats.

#### *Climate-Vulnerable Common Species*

Some common species are likely to be impacted by climate change. They are species that appear secure (S4 or S5), but climate may have a surprising negative impact by 2050. Further research in the sustainability of these species is needed, especially for game species. These may also be candidates for other conservation lists, such as the state threatened and endangered species list, MNFI's Species of Special Concern list, or Michigan's list of SGCN.

#### *Climate-Stable Rare Species*

Some rare species (S1, S2, and S3) have other conservation threats, but climate change may not be one of them (Stable or Increase Likely). In some cases, the climate may change to favor these species, but climate change may or may not offset other threats. Some rare prairie or savanna species in the southern part of the state are in this category.

#### *Climate-Stable Common Species*

Species that are common (S4 or S5), and not vulnerable to climate change (CCVI vulnerability is Stable or Increase Likely) are low priorities for conservation action. One possible exception would be overabundant species that are likely to increase with climate change. Another exception is discussed in the next section on geographic range shift.

### **Climate Vulnerability and Geographic Range Shift**

The CCVI handles population increases or declines due to geographic range shift in a very particular way. It is not intuitive for managers who work within fixed jurisdictions (those in the federal refuge system, national forest system, or state agencies). A species may be scored Presumed Stable, or even Increase Likely, and become extirpated from the refuge, forest, or state by 2050. Alternatively, a species may be Extremely Vulnerable, with a globally decreasing population, and the population within a jurisdiction may increase. This is because the CCVI focuses on the health of the population, and not its location.

An example of a vulnerable species that could increase in population in Michigan is the eastern box turtle (*Terrapene carolina carolina*). Box turtles are vulnerable for several reasons: they disperse slowly, are sensitive to temperature extremes, and do well only in a relatively narrow range of disturbance (too much or too little disturbance causes habitat degradation or direct mortality). Yet this species is at the northern edge of its distribution in Michigan. Suitable climate will exist statewide in the foreseeable future, and we could see local population increases even as it is extirpated from much of its southern range. Globally, it is expected to do poorly. In Michigan, box turtle populations might respond particularly well, but only if other significant conservation threats are addressed. These species are listed in Table 2 and footnoted in the Appendices.

A good example of a stable species that is projected to do well, yet decline within Michigan, is ruffed grouse. The species has natural history characteristics that make their populations less vulnerable: good dispersal ability, no need for a narrow temperature or hydrological regime, etc. Yet the species is at the southern edge of its range in Michigan, and with warming it is likely (although not certain) that the edge of the range will shift north.

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Thus, the ruffed grouse population will be able to adapt at the global or regional scale; however the numbers within Michigan are likely to decrease, especially if current trends in aspen decline continue as predicted (Worrall et al. *In Press*). The term “Presumed Stable” or “Increase Likely” are footnoted in the appendices where geographic range shift may cause reduced abundance as a stable or increasing population shifts out of Michigan. They are also listed in Table 3.

Table 2. The NatureServe Climate Change Vulnerability Index (CCVI) tool for these climate vulnerable species included the caveat that the "Species may expand range in assessment area." Populations of these species may decrease globally, but increase in Michigan if their populations shift northward. EV – Extremely Vulnerable, HV – Highly Vulnerable, MV – Moderately Vulnerable.

Species	English Name	CCVI	Confidence
<i>Acipenser fulvescens</i>	Lake sturgeon	HV	Moderate
<i>Acris crepitans blanchardi</i>	Blanchard's Cricket Frog	HV	Low
<i>Alasmidonta marginata</i>	Elktoe	HV	Low
<i>Alasmidonta viridis</i>	Slippershell	EV	Very High
<i>Ambystoma opacum</i>	Marbled salamander	HV	Low
<i>Ammocrypta pellucida</i>	Eastern sand darter	HV	Moderate
<i>Amybystoma texanum</i>	Smallmouth Salamander	EV	Moderate
<i>Basilodes pepita</i>	Gold moth	HV	Low
<i>Calephelis mutica</i>	Swamp metalmark	HV	Moderate
<i>Catocala dulciola</i>	Quiet underwing	MV	Moderate
<i>Catocala illecta</i>	Magdalen underwing	MV	Moderate
<i>Cicindela lepida</i>	Little white tiger beetle	HV	Moderate
<i>Clemmys guttata</i>	Spotted Turtle	HV	Low
<i>Clonophis kirtlandi</i>	Kirtland's Snake	HV	Low
<i>Emydoidea blandingii</i>	Blanding's Turtle	HV	Very High
<i>Epioblasma torulosa rangiana</i>	Northern riffleshell	EV	High
<i>Epioblasma triquetra</i>	Snuffbox	HV	Low
<i>Erimyzon claviformis</i>	Western creek chubsucker	HV	Moderate
<i>Erimyzon sucetta</i>	Lake chubsucker	MV	Low
<i>Erynnis persius persius</i>	Persius duskywing	MV	Moderate
<i>Falco peregrinus</i>	Peregrine Falcon	MV	Very High
<i>Fixsenia favonius Ontario</i>	Northern hairstreak	MV	Low
<i>Glyptemys insculpta</i>	Wood Turtle	MV	Moderate
<i>Hemileuca maia</i>	Barrens buckmoth	MV	Moderate
<i>Hiodon tergisus</i>	Mooneye	MV	Low
<i>Ixobrychus exilis</i>	Least Bittern	MV	Very High
<i>Lampsilis fasciola</i>	Wavy-rayed lampmussel	HV	Low
<i>Lepisosteus oculatus</i>	Spotted gar	HV	Moderate
<i>Merolonche dolli</i>	Doll's merolonche	MV	Moderate

Table 2. Range expanders...continued

Species	English Name	CCVI	Confidence
<i>Meropleon ambifusca</i>	Newman's brocade	HV	Moderate
<i>Moxostoma duquesnei</i>	Black redhorse	MV	Low
<i>Moxostoma erythrurum</i>	Golden redhorse	MV	Moderate
<i>Myotis sodalist</i>	Indiana bat	MV	Moderate
<i>Necturus maculosus</i>	Mudpuppy	MV	Moderate
<i>Neonympha mitchellii mitchellii</i>	Mitchell's satyr	EV	Very High
<i>Nerodia erythrogaster neglecta</i>	Copperbelly water snake	EV	Very High
<i>Notropis photogenis</i>	Silver shiner	HV	Low
<i>Noturus flavus</i>	Stonecat	MV	Moderate
<i>Noturus miurus</i>	Brindled madtom	MV	Moderate
<i>Noturus stigmosus</i>	Northern madtom	EV	Moderate
<i>Nycticeius humeralis</i>	Evening bat	MV	Very High
<i>Obovaria olivaria</i>	Hickorynut	HV	Low
<i>Oecanthus laricis</i>	Tamarack tree cricket	EV	High
<i>Oecanthus pini</i>	Pine tree cricket	MV	Low
<i>Opsopoeodus emiliae</i>	Pugnose minnow	HV	Moderate
<i>Pachypolia atricornis</i>	Three-horned moth	MV	Low
<i>Papaipema cerina</i>	Golden borer	MV	Moderate
<i>Papaipema speciosissima</i>	Regal fern borer	HV	Low
<i>Pleurobema clava</i>	Northern clubshell	EV	Very High
<i>Pleurobema coccineum</i>	Round pigtoe	HV	Low
<i>Prosapia ignipectus</i>	Red-legged Spittlebug	EV	Moderate
<i>Pygarctia spraguei</i>	Sprague's pygarctia	MV	Low
<i>Scudderia fasciata</i>	Pine katydid	HV	Low
<i>Setophaga cerulean</i>	Cerulean Warbler	MV	Very High
<i>Somatochlora hineana</i>	Hine's Emerald Dragonfly	EV	Very High
<i>Spartiniphaga inops</i>	Spartina borer moth	HV	Very High
<i>Speyeria idalia</i>	Regal fritillary	EV	High
<i>Terrapene carolina carolina</i>	Eastern Box Turtle	HV	Moderate
<i>Toxolasma lividus</i>	Purple lilliput	EV	Moderate
<i>Venustaconcha ellipsiformis</i>	Ellipse	EV	Moderate
<i>Villosa fabalis</i>	Rayed bean	HV	Low



Table 3. The NatureServe Climate Change Vulnerability Index (CCVI) tool for these climate stable species included the caveat that "Species range may shift and perhaps leave the assessment area." These species' populations may be stable globally, but may decrease in Michigan as populations shift across state/international boundaries. PS – Presumed Stable, IL – Increase Likely

Species	English Name	CCVI	Confidence
<i>Accipiter gentilis</i>	Northern Goshawk	PS	Very High
<i>Aeshna canadensis</i>	Canada damer	IL	Very High
<i>Ammodramus leconteii</i>	Le Conte's Sparrow	IL	High
<i>Bombus terricola</i>	Yellow banded bumble bee	PS	Very High
<i>Bonasa umbellus</i>	Ruffed Grouse	PS	Very High
<i>Canis lupus</i>	Gray Wolf	PS	Very High
<i>Colaptes auratus</i>	Northern Flicker	IL	Very High
<i>Contopus cooperi</i>	Olive-sided Flycatcher	IL	Very High
<i>Falco columbarius</i>	Merlin	PS	Very High
<i>Martes pennanti</i>	Fisher	PS	Very High
<i>Mustela erminea</i>	Ermine / Short-tailed Weasel	PS	Very High
<i>Ophiogomphus anomalus</i>	Extra-striped snaketail	PS	Very High
<i>Oporornis agilis</i>	Connecticut Warbler	PS	Moderate
<i>Pandion haliaetus</i>	Osprey	PS	Low
<i>Perisoreus canadensis</i>	Gray Jay	PS	Low
<i>Picoides arcticus</i>	Black-backed Woodpecker	IL	Very High
<i>Poecile hudsonica</i>	Boreal Chickadee	PS	Very High
<i>Regulus calendula</i>	Ruby-crowned Kinglet	PS	Very High
<i>Setophaga caerulescens</i>	Black-throated Blue Warbler	IL	Very High
<i>Setophaga kirtlandii</i>	Kirtland's Warbler	PS	Very High
<i>Setophaga palmarum</i>	Palm Warbler	PS	Very High
<i>Tympanuchus phasianellus</i>	Sharp-tailed grouse	PS	Moderate

## Featured Species and Climate Change

The Michigan DNR, Wildlife Division maintains a list of featured habitat species. The list is comprised of those species that are highly valued by Michigan citizens and limited by habitat. This list of 42 species represents high priority species for habitat management. Suitable climate is a component of species habitat, and that component of habitat is projected to deteriorate for some featured species. Considering the featured habitat species together, a couple patterns emerge.

**Populations of boreal species are unlikely to return to past levels.** American marten scored Moderately Vulnerable and snowshoe hare, common loon, and moose scored Highly Vulnerable. It is likely that these four species will experience population declines due



to direct and indirect impacts from on-going climate change. Ruffed grouse populations were scored stable, but the tool noted that those populations may shift partly or entirely out of Michigan by 2050. These species vulnerability results are consistent with vulnerability analyses of ecological communities, which show moderate to high vulnerability for aspen and conifer ecological communities (Worrall et al. *In Press*, Lee et al. *In Prep*, Handler et al. *In Prep*).

Wildlife managers often assume that population declines are correlated with changes in the biotic aspects of habitat quality or quantity. However, suitable habitat is not just suitable vegetation, but also suitable climate. For climate vulnerable species, the biotic aspects of habitat will become less of a limiting factor as the climate changes. For climate vulnerable species, habitat management may not result in the desired population responses in a warming, drying climate. For example, snowshoe hare populations may not respond to aspen clear-cuts if snowfall becomes less predictable. Similarly, brook trout (*Salvelinus fontinalis*) may not respond to in-stream habitat improvements if the water temperatures rise. As climate changes, we should expect that the climate aspect of habitat will become the limiting factor for vulnerable species.

**Some game species populations are likely to increase in a warming climate. Most common species will not experience climate-related population reductions in the next 40 years.** For example, abundance and distribution of white-tailed deer (*Odocoileus virginianus*, Presumed Stable) are unlikely to change by 2050 because of climate. Regional ecological and economic impacts, however, may be significant, even if the statewide abundance of deer does not change. Local populations may see temporary significant declines from EHD further north and more widespread than previously. Milder or more severe winters in the Upper Peninsula could change deer migration patterns and seasonal habitat use, with impacts to both wintering complexes and forest regeneration outside those complexes.

Wild turkeys are another valuable species that is likely to benefit from winters that are less severe. Habitat management for turkeys in regions where turkey populations were historically marginal due to climate will increasingly result in a positive population response.

**Most species of greatest conservation need (SCGN) are somewhat to extremely vulnerable to climate change by 2050.** For example, both the federally endangered Karner blue butterfly and federal candidate eastern Massasauga rattlesnake (*Sistrurus catenatus catenatus*) scored Highly Vulnerable. Both species already face significant conservation challenges, and climate is likely to cause further population declines, especially in southern areas and away from the moderating effects of the Great Lakes.

The rare species that scored Presumed Stable or Increase Likely were species that reach their northern range limit in Michigan, such as the blue racer (*Coluber constrictor foxi*) or evening bat (*Nycticeius humeralis*), or are associated with grasslands and other dry habitats, such as the Henslow's sparrow (*Ammodramus henslowii*), prairie warbler (*Setophaga discolor*), and Kirtland's warbler (*Setophaga kirtlandii*). Habitat management for these species may make up for habitat lost at the southern extremes of their current range in North America.

## Managing to Reduce Vulnerability

Identifying vulnerable species is a useful first step, but it is also important to understand why each species is vulnerable to climate change. **Why are 61% of Michigan’s SGCN species likely to experience population decreases due to climate change by 2050? Why are important game species like snowshoe hare and ruffed grouse so vulnerable?** The CCVI can be used to identify which factors increase vulnerability for the most species.

In the NatureServe tool, each species was scored on 24 factors. Several factors were always scored as Neutral in Michigan, including Sea Level Rise and Pollinators. The factors that most often increased vulnerability were related to Hydrological Niche, Natural Barriers, and Climate Mitigation (Table 4). The factors most often scored to decrease vulnerability

Table 4. Number of species for which each factor was scored to increase, decrease or not affect vulnerability. Factors are ranked from those that increased vulnerability for most species to those that increased vulnerability for the fewest number of species.

Factor	Increase	Neutral	Decrease
Historical Hydrological Niche	399	1	0
Natural Barriers	207	192	0
Physiological Hydrological Niche	195	185	20
Climate Change Land Use	183	200	9
Anthropogenic Barriers	132	268	0
Disturbance Regime Change	127	208	65
Dispersal/Movement	89	96	215
Physiological Thermal Niche	75	296	22
Diet Specialization	64	276	43
Rarity of Physical Habitat	60	146	194
Dependence on Other Species for Habitat	22	372	0
Modeled change	21	6	27
Past Genetic Bottleneck	16	14	0
Dependence on Other Species for Dispersal	14	367	0
Ice/snow Dependence	12	385	0
Documented Genetic Variation	9	10	3
Modeled Overlap with Current Range	9	41	0
Documented Response to Recent Climate Change	5	2	4
Dependence on Any Other Species Interaction	2	358	0
Documented Phenological Response	1	7	1
Protected Areas in Modeled Range	1	18	0
Sea Level Rise	0	400	0
Historical Thermal Niche	0	400	0
Pollinators Specialization	0	0	0

were related to Dispersal Ability and Habitat Rarity (Table 4). The effect of factors varied across taxonomic groups (Figures 2 and 3). Birds, for example, can cross natural barriers, such as the Great Lakes, but half are more vulnerable to land use related to climate change mitigation policies, such as an increased dependence on wind towers for energy. The factors that most often increased or decreased vulnerability are discussed in detail in the next section.

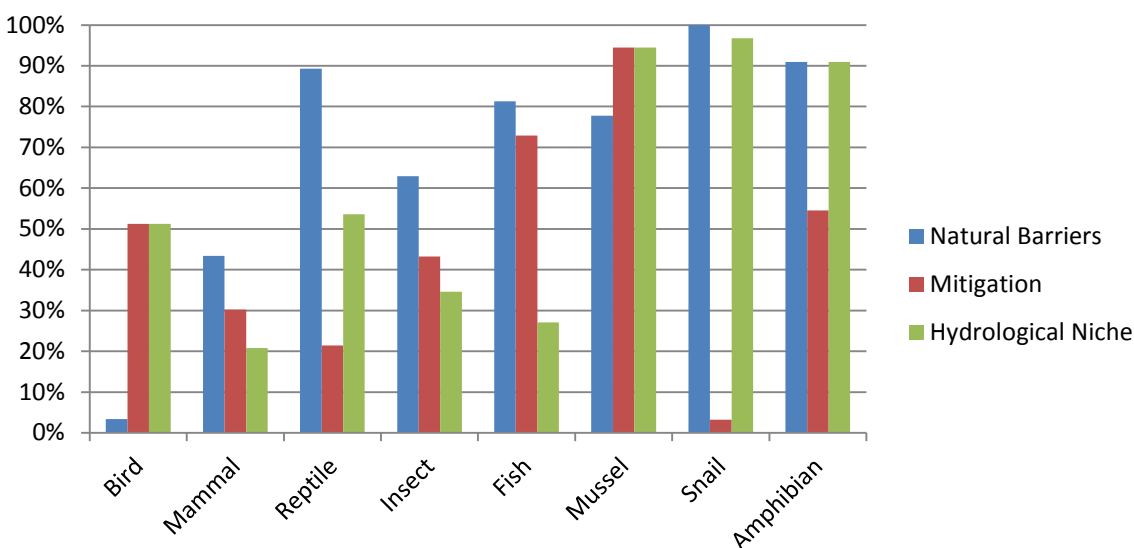


Figure 2. Percentage of each taxon ranked as more vulnerable to the top three factors that increased climate vulnerability for the most species.

### *Hydrological Niche*

The CCVI tool has two factors related to the dependence of a species on hydrology. One is the width of the historical hydrological niche of the species in the assessment area. This factor measures the range of mean annual precipitation that the species has experienced in Michigan from 1951-2006. Compared to other parts of the world, species in Michigan have experienced relatively little variation year-to-year in precipitation, which makes them more susceptible to future change. The other factor is the physiological hydrological niche. This factor measures the dependence of the species on a relatively narrow precipitation regime. Because the prediction for Michigan was for drier conditions, wetland species were disproportionately affected. Some prairie/barrens dependent species benefited, but the effect was negative for most species.

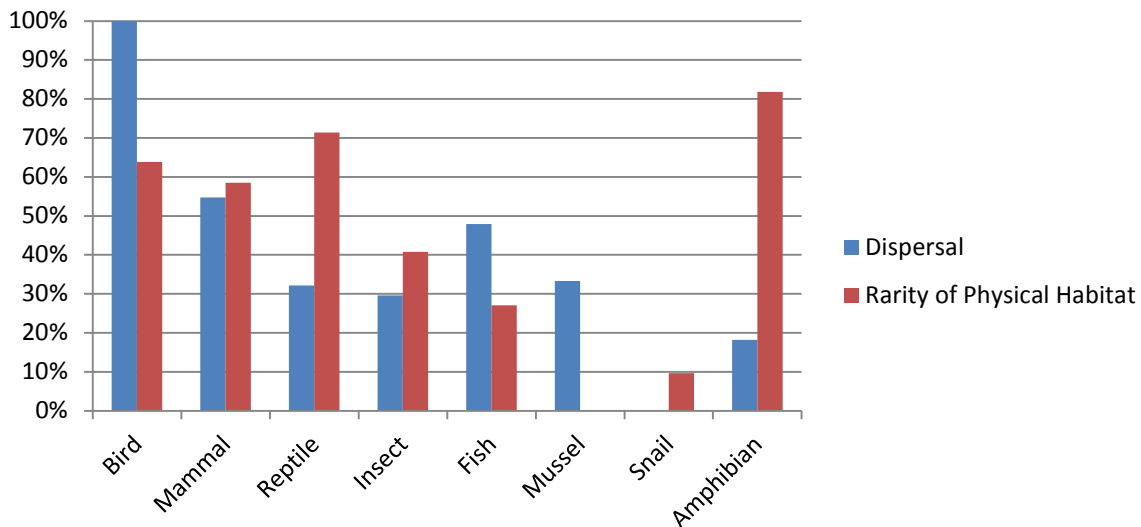


Figure 3. Percentage of each taxon ranked as less vulnerable to the top two factors that reduced vulnerability for the most species.

The CCVI results are based on one hydrological map, which is effectively one future scenario: the average of multiple models and moderate fossil fuel emissions. In this scenario, the slight increase in precipitation is offset by increased evaporation from soils for a drier future. However, the average hides significant variation among models: some models predict dryer, others predict wetter. In the face of uncertainty of this type, the most tempting response is to delay management actions. However, this uncertainty is unlikely to be reduced in the foreseeable future. Thus, delay may not be the best option. The best course of action is scenario planning, in which **management options that are robust under multiple scenarios are given preference over an option that is optimal in any single scenario**. The details of scenario planning are beyond the scope of this report. However, the importance of hydrology in CCVI scores and the variation among models suggest that future adaptation planning should stress scenario planning.

Potential hydrological adaptation strategies:

- Scenario planning to find optimum wetland protection and restoration strategies for a range of future precipitation regimes
- Preferentially monitor climate sensitive species in wetlands rather than in uplands
- Protect/restore wetlands that provide habitat to vulnerable species in drought and flood (e.g., watershed with intact floodplains and few impervious surfaces, groundwater maintained wetlands)
- Maintain ability to manage water levels at managed waterfowl areas and other important wetland complexes.

### *Natural Barriers*

As temperature regimes shift northward, many species will need to shift geographic distribution accordingly, if they can (Francl et al. 2010, Burrows et al. 2011). If geographic range shift is significantly blocked, populations south of the barrier will be more vulnerable. This factor “assesses the degree to which natural (e.g., topographic, geographic, or ecological) barriers limit a species’ ability to shift its range in response to climate change” (Young et al. 2011). If the species is not blocked and can disperse, then that species will be much less vulnerable to climate change.

Barriers vary by species and by geography. **The Great Lakes form a barrier to most terrestrial species in Michigan.** Furthermore, Michigan is oriented such that new competitors can enter either peninsula, either from the south or southwest, but existing populations are blocked to the north by Lake Michigan, Lake Huron, or Lake Superior. A small proportion of a population may be able to cross either the Straits of Mackinac or the St. Mary’s River, but most individuals of most populations are bounded by a wide lake. Temperature isotherms are shifting northward. In the Great Lakes, average January temperature isotherms will be shifting at a rate of 2.5 kilometers per year by 2020-2049, increasing to 4.5 kilometers per year by the end of the century (Francl et al. 2010). Another study using different climate variables and models estimated climate shifts of 2 – 5 kilometers per year (Burrows et al. 2011). At the rate of 2.5 kilometers per year, the isotherms in Michigan will have shifted 100 kilometers (60 miles) by 2050. The Upper Peninsula is less than 200 kilometers (125 miles) wide north-south in most places, and the Lower Peninsula is about 500 kilometers (300 miles) wide north-south. Because it is much narrower north-south, the Upper Peninsula will experience the effects of the Great Lakes as a natural barrier before the southern peninsula.

Aquatic species also face numerous natural and anthropogenic barriers, but the temperature gradients are different from terrestrial systems. Within large lakes, colder water is deeper than warmer water, at least during the stratified period. As lakes warm, the stratified period lasts longer, but the depth for optimum temperatures also increases. Inland lakes of moderate depths may experience oxygen depletion and anoxic thermoclines during stratification. As seasonal heating increases, there will be limited or no available thermal refugia. Cisco (lake herring) and northern pike would be vulnerable in these conditions. Small, shallow lakes may no longer stratify during ice-free periods. Within networks of streams and rivers, headwaters are colder than lower reaches of the watershed. As the entire system warms, cooler and colder water regimes migrate upstream. In both cases, temperature regimes shift away from hydrological connections.

Potential natural barrier adaptation strategies:

- Manage relocations by restricting movement of aggressive, often damaging species, while facilitating movement of ecologically or economically valuable species. Managed relocation has been the focus of heated discussion in the scientific literature (Schwartz et al. 2012).
- Continue to discourage or prohibit movement of firewood and other materials that transport invasive exotics between Michigan’s peninsulas

### *Climate Mitigation Driven Land Use*

Climate change affects the landscape through ecological changes, but it also affects how humans use landscapes. In Michigan, concerns over fossil fuel use and influence on climate have resulted in development of more wind energy facilities, which impact some species of bats and birds. These same concerns are increasing demands for more ethanol (and other biofuels), which raises corn prices, which results in conversion of wetlands, old fields, and hedgerows to intensive agriculture. This intensification of agricultural land use has negative implications for wildlife that use grasslands, wetlands, or edge habitats, especially in southern Michigan. **These climate-driven land use trends are underway, and we expect them to increase in intensity as society attempts to shift away from the production of greenhouse gases.**

Potential adaptation strategies to minimize the impacts of climate mitigation:

- Work with wind energy facilities to reduce impacts to bats and birds through wise site selection, operation, and monitoring.
- Modify incentives in the Farm Bill to keep pace with commodity prices, tiling practices, etc.
- Emphasize large landscapes of grasslands, wetlands, and other important habitat elements on state lands
- Create incentives and regulations to improve water quality in urban and agricultural landscapes.

### *Dispersal Ability*

The ability of a species to disperse improves its adaptive capacity to respond to climate change. In the CCVI tool, species are assessed separately on barriers and on dispersal ability. Barriers aside, most species we assessed can disperse and shift geographic range at the pace of climate change. Migratory birds or butterflies can expand their range quickly. Some species will not be able to disperse quickly. Earthworms and snails, for example, expand their range slowly. **In a perfectly connected world, most species that we assessed could theoretically shift geographic distributions to keep pace with climate change through 2050.** In reality, Michigan is fragmented by natural and human-caused barriers that will prevent populations from dispersing at their theoretical maximum speed.

Potential adaptation strategies to capitalize on dispersal abilities:

- Protect additional acres of linear corridors of natural vegetation, perhaps through partnerships with trails advocates. Manage linear corridors to discourage northward expansion of damaging invasive species.
- Protect “stepping stones” of natural areas across the full range of abiotic factors that correlate with current ecological communities.
- Restore and connect corridors, especially where relatively short corridors can connect large patches of natural vegetation and potential wildlife habitat.
- Protect funnel points for dispersing wildlife near edges of both peninsulas, especially near the Straights of Mackinac, the St. Clair River, St. Mary’s River, and along Great Lakes coastlines.

### *Rarity of Physical Habitat*

Another factor that works in favor of many (not all) conservation concern species in Michigan is that they are not specialists dependent on rare habitats. The factor is both the degree to which a species is restricted to a particular geological or landscape feature, and how rare that feature is on the landscape.

Although many species in Michigan are restricted to a certain habitat or landscape feature at some point in their life cycle, those features usually are not so rare to constitute climate vulnerability. Scoring of this factor often suggested a reduction in vulnerability, especially for vertebrate taxa.

Michigan is biologically-diverse. If the goal is to maintain diversity, the challenge will be to focus on many ecological communities rather than a small number. The many landscape features and ecological communities that occur throughout Michigan should be recognized as an asset to be protected.

Potential adaptation strategies to capitalize on existing habitat:

- Maintain or increase the amount of conservation land managed for sustainable natural resources on public and private property.
- Protect the diversity of landscape features and ecological communities throughout their ranges in Michigan.

## **Comparing SGCN and Game Species**

We attempted to apply the CCVI to all of the animal species that are targets of conservation in Michigan. This includes all game species (except game fish, which are defined and regulated differently than vertebrate wildlife), all Species of Greatest Conservation Need, and all statewide DNR Featured Habitat Species. Overall, data were insufficient to assess 158 game species and SGCN. Most often the Most important was a lack of information on a species' geographic distribution.

Assessing game species and SGCN with the same tool was a useful exercise. Overall, the pattern was that rare species were more vulnerable (61% MV, HV, or EV) than the more common game species (17% MV, HV, or EV). This is not surprising. The natural history traits that make harvest of game species sustainable are similar to those that reduce climate vulnerability: habitat generalists with high reproductive rates and robust population sizes. **That we identified nearly one-fifth of game species as vulnerable is noteworthy and cause for management concern.**

The CCVI scores for game species only indicate if climate change is a threat to the viability of that population by 2050. The CCVI is a poor tool to assess other climate impacts, which might include impacts to:

- access (e.g., changes in space or time of waterfowl migration),
- health (diseases that have local or highly visible impacts, such as EHD), or
- method of take (the disintegration of ice fishing communities, lack of snow for tracking).

Similarly, vulnerability scores do not capture significant shifts in indirect impacts caused by wildlife species. For instance, white-tailed deer were assessed as Presumed Stable. However, when snow persists for fewer days on average, deer in the Upper Peninsula will likely



migrate shorter distances and spend less time in coniferous wintering complexes. This could significantly impact forestry and hunting, not to mention tourism, agriculture, and the forest products industry.

Finally, a quirk of the CCVI approach is that some vulnerable species could increase in the assessment area (Table 2), and some stable species may leave the assessment area (Table 3). Considering the scores themselves, there are no vulnerable game birds and only three vulnerable game mammals (moose, American marten, and snowshoe hare). However, **the CCVI tool has an additional note on three other game species: fisher (*Martes pennati*), ermine (*Mustela erminea*), and ruffed grouse. The note states that although these species are scored as Stable, they “may shift and perhaps leave the assessment area.”** Presumably, the species are adaptable, but populations may not persist in Michigan.

## Comparing Taxa

In the CCVI tool, the same factors are considered in the same way across taxonomic groups. This allows managers to compare the relative vulnerabilities of birds to fish to plants. **In Michigan, amphibians, mollusks, fish, and insects are the most vulnerable groups; mammals are among the least vulnerable (Figure 3).** Penskar (2013) has conducted a similar analysis for plants in Michigan, but those results are not included in this report.

Vulnerability of migratory birds is not captured well by the CCVI. This analysis only shows vulnerability for Michigan, but many migratory species spend most their life cycle outside Michigan. This assessment for migratory species is at best overly optimistic, and at worst misleading. These results apply to Michigan and vulnerability to climate change while in Michigan. Migratory birds and bats should be considered over their entire life cycle, which may require a revision of this tool or the creation of an entirely new tool.

Migratory birds and bats aside, some patterns are evident when comparing taxa. **Taxa associated with water were more vulnerable** than fully terrestrial species or species associated with sand and other xeric landscapes. Also, **ectotherms (cold-blooded species) were more vulnerable** than endotherms (warm-blooded species.)

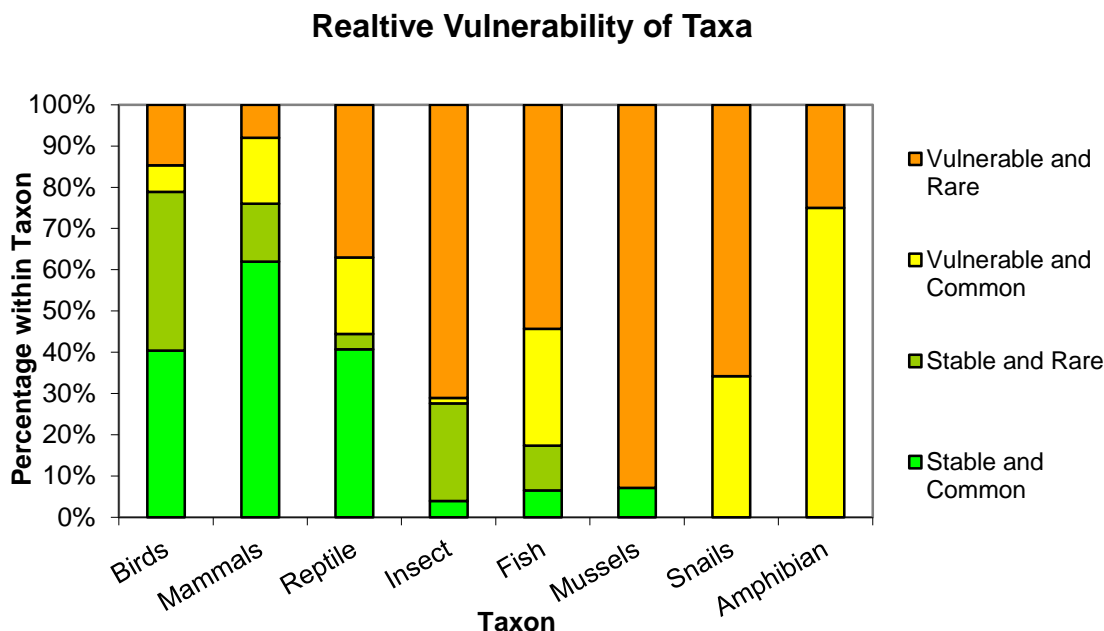


Figure 3. The relative climate vulnerability of 400 game and SCGN in Michigan, organized by taxa groups, using NatureServe CCVI.

## The Many Uses of a Vulnerability Assessment

Vulnerability assessments are useful in a variety of contexts. They provide a common language for discussions of species vulnerability across multiple states. If a SGCN in one state (for example, Franklin’s ground squirrel, *Poliocitellus franklinii*, in Illinois) is predicted to potentially leave that state, states or provinces to the north should be aware.

The CCVI scores and other factors could be useful in prioritizing scarce conservation staff and money. Between 15% and 37% of all species globally may be in danger of extinction because of climate change (Thomas et al. 2004). Without significant increases in conservation funding, agencies may have to decide which suites of recovery programs are likely to minimize the number of extinctions. Implicit in that decision is determining which species are too rare and too vulnerable to conserve in their current range in Michigan. Similarly, the data in the tool on vulnerability, geographic range position, dispersal ability, and conservation status are all potential inputs when assessing the wisdom or need to translocate species over natural or anthropogenic barriers.

CCVI vulnerability is a measure of the likelihood that climate change will cause a decrease in range or abundance of a species. It can be used when revising lists of SGCN for State Wildlife Action Plans, when amending state or federal lists of threatened or endangered species, or whenever conservation groups need to create a list of priority conservation species for a forest, park, sanctuary or easement.

Similarly, **CCVI scores can help managers prioritize which game management plans or species recovery plans need revision to include information on climate threats.** Given the significant amount of time and energy needed to revise species plans, it is

important to start with those most vulnerable to projected climate change. That does not mean that most resources should go to managing the most climate vulnerable species. The plan may be revised to put fewer resources toward very vulnerable species, especially if available staff and funding are no longer expected to be sufficient to meet long-term conservation goals. However, the plans for the most vulnerable are those plans that need to be reviewed and revised most urgently.

Finally, the CCVI scores can be useful in raising awareness of the impacts of climate change in Michigan. The prediction of a several degree temperature increase by 2100 is academic to most people. Impacts by 2050 are more immediate. The loss of opportunity to hunt grouse, fish through ice, or hear loons while “up north” makes the impact more tangible to those who most value fish, wildlife, and natural places.

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## Changing Climate, Changing Wildlife

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Appendix A. NatureServe Climate Change Vulnerability Index (CCVI) scores for Michigan game species and Species of Greatest Conservation Need (SGCN). G rank and S rank are conservation status derived from rarity, population trends, and threats other than climate change at the global and state scale, respectively. Ranks range from five (secure) to one (critically imperiled.) In this Appendix, species are sorted by taxa and scientific names.

### Mammals

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Alces americanus</i>	Moose	HV	Very High	5	4
<i>Canis latrans</i>	Coyote	IL	Very High	5	5
<i>Canis lupus</i>	Gray Wolf	PS <sup>b</sup>	Very High	4	3
<i>Castor canadensis</i>	American Beaver	PS	Very High	5	5
<i>Cervus elaphus</i>	Elk	PS	Very High	5	3
<i>Cryptotis parva</i>	Least shrew	PS <sup>a</sup>	Very High	5	1
<i>Didelphis virginiana</i>	Virginia Opossum	IL <sup>a</sup>	Very High	5	5
<i>Glaucomys sabrinus</i>	Northern flying squirrel	MV <sup>b</sup>	Very High	5	5
<i>Glaucomys volans</i>	Southern flying squirrel	PS <sup>a</sup>	Very High	5	5
<i>Lasionycteris noctivagans</i>	Silver-haired bat	PS	Very High	5	4
<i>Lasiurus borealis</i>	Red bat	PS	Very High	5	5
<i>Lasiurus cinereus</i>	Hoary bat	PS	Very High	5	3
<i>Lepus americanus</i>	Snowshoe hare	HV	Very High	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix A. Mammals... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Lontra canadensis</i>	Northern River Otter	PS	Very High	5	4
<i>Lynx canadensis</i>	Lynx	HV <sup>b</sup>	Very High	5	1
<i>Lynx rufus</i>	Bobcat	IL	Very High	5	4
<i>Marmota monax</i>	Woodchuck	IL	Very High	5	5
<i>Martes americana</i>	American marten	MV	Low	5	3
<i>Martes pennanti</i>	Fisher	PS <sup>b</sup>	Very High	5	4
<i>Mephitis mephitis</i>	Striped Skunk	IL	Very High	5	5
<i>Microtus orchrogaster</i>	Prairie vole	PS <sup>a</sup>	Very High	5	1
<i>Microtus pinetorum</i>	Woodland vole	PS <sup>a</sup>	Very High	5	3
<i>Mustela erminea</i>	Ermine / Short-tailed Weasel	PS <sup>b</sup>	Very High	5	5
<i>Mustela frenata</i>	Long-tailed Weasel	PS <sup>a</sup>	Very High	5	5
<i>Mustela nivalis</i>	Least Weasel	PS	Very High	5	5
<i>Myodes gapperi</i>	Southern red-backed vole	MV <sup>b</sup>	Very High	5	5
<i>Myotis septentrionalis</i>	Northern bat or Northern myotis	PS	Very High	4	NR
<i>Myotis sodalis</i>	Indiana bat	MV <sup>a</sup>	Moderate	2	1
<i>Napaeozapus insignis</i>	Woodland jumping mouse	MV <sup>b</sup>	High	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Mammals... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Neotamias minimus</i>	Least chipmunk	MV <sup>b</sup>	Very High	5	5
<i>Neovison vison</i>	American Mink	PS	Very High	5	5
<i>Nycticeius humeralis</i>	Evening bat	MV <sup>a</sup>	Very High	5	NA
<i>Odocoileus virginianus</i>	White-tailed deer	PS	Very High	5	5
<i>Ondatra zibethicus</i>	Muskrat	PS	Very High	5	5
<i>Perimyotis subflavus</i>	Eastern pipistrelle or Tri-colored bat	PS <sup>a</sup>	Very High	5	2
<i>Peromyscus maniculatus</i>	Deer mouse	PS	Very High	5	5
<i>Procyon lotor</i>	Raccoon	IL	Very High	5	5
<i>Puma concolor</i>	Cougar	IL	Very High	5	H
<i>Sciurus carolinensis</i>	Eastern Gray Squirrel	PS <sup>a</sup>	Very High	5	5
<i>Sciurus niger</i>	Eastern Fox Squirrel	PS <sup>a</sup>	Very High	5	5
<i>Sorex arcticus</i>	Arctic shrew	PS	Moderate	5	5
<i>Sorex fumeus</i>	Smoky shrew	HV	Very High	5	1
<i>Sorex hoyi</i>	American pygmy shrew	MV	Low	5	5
<i>Sorex palustris</i>	Water shrew	MV	Very High	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Mammals... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Spermophilus tridecemlineatus</i>	Thirteen-lined Ground Squirrel	PS <sup>a</sup>	Very High	5	5
<i>Sylvilagus floridanus</i>	Eastern Cottontail	PS	Very High	5	5
<i>Synaptomys cooperi</i>	Southern bog lemming	PS	Very High	5	5
<i>Tamias striatus</i>	Eastern chipmunk	PS <sup>a</sup>	Very High	5	5
<i>Tamiasciurus hudsonicus</i>	Red Squirrel	PS	Very High	5	5
<i>Taxidea taxus</i>	American Badger	PS <sup>a</sup>	Very High	5	4
<i>Urocyon cinereoargenteus</i>	Gray Fox	PS <sup>a</sup>	Very High	5	4
<i>Ursus americanus</i>	Black bear	PS	Very High	5	5
<i>Vulpes vulpes</i>	Red Fox	IL	Very High	5	5

**Birds**

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Accipiter cooperii</i>	Cooper's Hawk	PS <sup>a</sup>	Very High	5	3
<i>Accipiter gentilis</i>	Northern Goshawk	PS <sup>b</sup>	Very High	5	3
<i>Actitis macularia</i>	Spotted Sandpiper	MV	Moderate	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Aix sponsa</i>	Wood Duck	PS	Moderate	5	5
<i>Ammodramus henslowii</i>	Henslow's sparrow	PS <sup>a</sup>	Very High	4	2
<i>Ammodramus leconteii</i>	Le Conte's Sparrow	IL <sup>b</sup>	High	4	1
<i>Ammodramus savannarum</i>	Grasshopper Sparrow	PS <sup>a</sup>	Moderate	5	3
<i>Anas acuta</i>	Northern Pintail	PS	High	5	NRN
<i>Anas americana</i>	American Widgeon	PS	Very High	5	1
<i>Anas clypeata</i>	Northern Shoveler	PS	Very High	5	NRN
<i>Anas crecca</i>	Green-winged Teal	PS	Very High	5	3
<i>Anas discors</i>	Blue-winged Teal	PS	Very High	5	5
<i>Anas platyrhynchos</i>	Mallard	PS	Very High	5	5
<i>Anas rubripes</i>	American Black Duck	PS	Very High	5	3
<i>Anas strepera</i>	Gadwall	PS	Very High	5	NRN
<i>Ardea herodias</i>	Great Blue Heron	PS	Moderate	5	5
<i>Asio flammeus</i>	Short-eared Owl	PS	Moderate	5	1
<i>Asio otus</i>	Long-eared Owl	PS	High	5	2
<i>Aythya affinis</i>	Lesser Scaup	MV	Moderate	5	NRN

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Aythya americana</i>	Redhead	MV	Very High	5	3
<i>Aythya collaris</i>	Ring-necked Duck	MV	Low	5	4
<i>Aythya marila</i>	Greater Scaup	MV	Moderate	5	NRN
<i>Aythya valisineria</i>	Canvasback	MV	Very High	5	NRN
<i>Bartramia longicauda</i>	Upland Sandpiper	IL <sup>a</sup>	Very High	5	4
<i>Bonasa umbellus</i>	Ruffed Grouse	PS <sup>b</sup>	Very High	5	5
<i>Botaurus lentiginosus</i>	American Bittern	MV	Very High	4	3
<i>Branta canadensis</i>	Canada Goose	MV	Very High	5	5
<i>Branta hutchinsii</i>	Cackling Goose	PS	Very High	5	U
<i>Bucephala clangula</i>	Common Goldeneye	PS	Very High	5	3
<i>Buteo lineatus</i>	Red-shouldered Hawk	PS <sup>a</sup>	Very High	5	3
<i>Butorides virescens</i>	Green Heron	PS <sup>a</sup>	Low	5	5
<i>Caprimulgus vociferus</i>	Whip-poor-will	IL <sup>a</sup>	Low	5	5
<i>Cardellina canadensis</i>	Canada Warbler	MV <sup>b</sup>	Moderate	5	5
<i>Charadrius melodus</i>	Piping Plover	MV	Moderate	3	1
<i>Charadrius vociferus</i>	Killdeer	IL	Moderate	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Chilodonias niger</i>	Black tern	MV <sup>b</sup>	Very High	4	3
<i>Chordeiles minor</i>	Common Nighthawk	IL	Moderate	5	5
<i>Circus cyaneus</i>	Northern Harrier	MV	Moderate	5	3
<i>Cistothorus palustris</i>	Marsh Wren	PS	Very High	5	3
<i>Cistothorus platensis</i>	Sedge Wren	PS	Low	5	4
<i>Coccythraustes vesperinus</i>	Evening Grosbeak	IL	Very High	5	5
<i>Coccyzus americanus</i>	Yellow-billed Cuckoo	IL <sup>a</sup>	Very High	5	5
<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo	IL	Low	5	5
<i>Colaptes auratus</i>	Northern Flicker	IL <sup>b</sup>	Very High	5	5
<i>Colinus virginianus</i>	Northern Bobwhite	IL <sup>a</sup>	Very High	5	4
<i>Contopus cooperi</i>	Olive-sided Flycatcher	IL <sup>b</sup>	Very High	5	4
<i>Corvus brachyrhynchos</i>	American Crow	IL	Very High	5	5
<i>Coturnicops noveboracensis</i>	Yellow rail	MV <sup>b</sup>	Moderate	4	1
<i>Cygnus buccinator</i>	Trumpeter Swan	MV <sup>b</sup>	High	4	3
<i>Dolichonyx oryzivorus</i>	Bobolink	IL	Very High	5	5
<i>Dryocopus pileatus</i>	Pileated woodpecker	PS	Moderate	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



## Changing Climate, Changing Wildlife

### Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Empidonax minimus</i>	Least Flycatcher	MV	Moderate	5	5
<i>Empidonax virescens</i>	Acadian Flycatcher	IL <sup>a</sup>	Low	5	3
<i>Falciennes canadensis</i>	Spruce grouse	MV	Very High	5	2
<i>Falco columbarius</i>	Merlin	PS <sup>b</sup>	Very High	5	1
<i>Falco peregrinus</i>	Peregrine Falcon	MV <sup>a</sup>	Very High	4	1
<i>Fulica americana</i>	American Coot	PS	Very High	5	3
<i>Gallinula galeata</i> [ <i>G. chloropus</i> ]	Common Gallinule [Common Moorhen]	PS <sup>a</sup>	Very High	5	3
<i>Gavia immer</i>	Common Loon	HV <sup>b</sup>	Very High	5	3
<i>Grus canadensis</i>	Sandhill crane	PS	Very High	5	4
<i>Haliaeetus leucocephalis</i>	Bald Eagle	IL	Moderate	5	4
<i>Helmitheros vermivorus</i>	Worm-eating Warbler	PS <sup>a</sup>	Very High	5	NA
<i>Hylocichla mustelina</i>	Wood Thrush	IL	Low	5	4
<i>Icteria virens</i>	Yellow-breasted Chat	IL <sup>a</sup>	Very High	5	3
<i>Ixobrychus exilis</i>	Least Bittern	MV <sup>a</sup>	Very High	5	2
<i>Lanius ludovicianus migrans</i>	Migrant Loggerhead Shrike	PS <sup>a</sup>	Very High	5	1
<i>Lophodytes cucullatus</i>	Hooded Merganser	PS	Very High	5	3

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Loxia curvirostra</i>	Red Crossbill	PS	Very High	5	3
<i>Loxia leucoptera</i>	White-winged Crossbill	PS	Very High	5	2
<i>Melanerpes erythrocephalus</i>	Red-headed Woodpecker	IL <sup>a</sup>	Very High	5	5
<i>Meleagris gallopavo</i>	Wild Turkey	IL <sup>a</sup>	Moderate	5	5
<i>Mergus merganser</i>	Common Merganser	PS	Very High	5	3
<i>Mimus polyglottos</i>	Northern Mockingbird	IL <sup>a</sup>	High	5	4
<i>Nycticorax nycticorax</i>	Black-crowned Night-heron	IL <sup>a</sup>	Moderate	5	2
<i>Oporornis agilis</i>	Connecticut Warbler	PS <sup>b</sup>	Moderate	4	2
<i>Oxyura jamaicensis</i>	Ruddy Duck	PS	Low	5	NRN
<i>Pandion haliaetus</i>	Osprey	PS <sup>b</sup>	Low	5	4
<i>Parkesia motacilla</i>	Louisiana Waterthrush	PS <sup>a</sup>	Very High	5	2
<i>Passerculus sandwichensis</i>	Savannah Sparrow	IL	Low	5	5
<i>Perisoreus canadensis</i>	Gray Jay	PS <sup>b</sup>	Low	5	4
<i>Phalaropus tricolor</i>	Wilson's Phalarope	PS	Very High	5	2
<i>Phasianus colchicus</i>	Ring-necked Pheasant	PS <sup>a</sup>	Low	5	SNA
<i>Picoides arcticus</i>	Black-backed Woodpecker	IL <sup>b</sup>	Very High	5	2

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Pipilo erythrophthalmus</i>	Eastern Towhee	IL <sup>a</sup>	Moderate	5	5
<i>Podilymbus podiceps</i>	Pied-billed Grebe	PS <sup>a</sup>	Very High	5	4
<i>Poecile hudsonica</i>	Boreal Chickadee	PS <sup>b</sup>	Very High	5	3
<i>Pooecetes gramineus</i>	Vesper Sparrow	IL	High	5	5
<i>Porzana carolina</i>	Sora	MV	Moderate	5	4
<i>Progne subis</i>	Purple Martin	PS <sup>a</sup>	Very High	5	5
<i>Protonotaria citrea</i>	Prothonotary Warbler	IL <sup>a</sup>	Low	5	3
<i>Rallus elegans</i>	King Rail	PS <sup>a</sup>	Very High	4	1
<i>Rallus limicola</i>	Virginia Rail	PS	Moderate	5	3
<i>Regulus calendula</i>	Ruby-crowned Kinglet	PS <sup>b</sup>	Very High	5	4
<i>Scolopax minor</i>	American Woodcock	IL	Low	5	5
<i>Setophaga americana</i>	Northern Parula	PS	Very High	4	2
<i>Setophaga caerulescens</i>	Black-throated Blue Warbler	IL <sup>b</sup>	Very High	5	3
<i>Setophaga cerulea</i>	Cerulean Warbler	MV <sup>a</sup>	Very High	4	3
<i>Setophaga citrina</i>	Hooded Warbler	PS <sup>a</sup>	Very High	5	3
<i>Setophaga discolor</i>	Prairie Warbler	IL <sup>a</sup>	Very High	5	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Setophaga dominica</i>	Yellow-throated Warbler	IL <sup>a</sup>	Moderate	5	1
<i>Setophaga fusca</i>	Blackburnian Warbler	MV <sup>b</sup>	Moderate	5	5
<i>Setophaga kirtlandii</i>	Kirtland's Warbler	PS <sup>b</sup>	Very High	1	1
<i>Setophaga palmarum</i>	Palm Warbler	PS <sup>b</sup>	Very High	5	1
<i>Sialia sialis</i>	Eastern bluebird	PS <sup>a</sup>	Very High	5	5
<i>Spiza americana</i>	Dickcissel	IL <sup>a</sup>	Very High	5	3
<i>Spizella pusilla</i>	Field Sparrow	IL <sup>a</sup>	Moderate	5	5
<i>Sterna forsteri</i>	Forster's Tern	MV	Very High	5	2
<i>Sterna caspia</i>	Caspian Tern	MV	Moderate	5	2
<i>Sterna hirundo</i>	Common Tern	MV <sup>b</sup>	Moderate	5	2
<i>Sturnella magna</i>	Eastern Meadowlark	PS <sup>a</sup>	Very High	5	5
<i>Sturnella neglecta</i>	Western Meadowlark	PS	Very High	5	4
<i>Toxostoma rufum</i>	Brown Thrasher	IL	Very High	5	4
<i>Tympanuchus phasianellus</i>	Sharp-tailed grouse	PS <sup>b</sup>	Moderate	4	3
<i>Tyrannus tyrannus</i>	Eastern Kingbird	IL	Very High	5	4
<i>Tyto alba</i>	Barn Owl	PS <sup>a</sup>	Very High	5	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Birds... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Vermivora chrysoptera</i>	Golden-winged Warbler	IL <sup>a</sup>	Low	4	5
<i>Vermivora pinus</i>	Blue-winged Warbler	IL <sup>a</sup>	Very High	5	5
<i>Vireo griseus</i>	White-eyed Vireo	IL <sup>a</sup>	Very High	5	4
<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird	MV	Very High	5	2

Reptiles

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Apidoscelis sexlineatus</i>	Six-lined racerunner	HV	Very High	5	U
<i>Chelydra serpentina serpentina</i>	Snapping Turtle	PS	Very High	5	5
<i>Chrysemys picta</i>	Painted Turtle	PS	High	5	5
<i>Clemmys guttata</i>	Spotted Turtle	HV <sup>a</sup>	Low	5	2
<i>Clonophis kirtlandi</i>	Kirtland's Snake	HV <sup>a</sup>	Low	2	1
<i>Coluber constrictor foxi</i>	Blue racer	PS	Very High	5	5
<i>Diadophis punctatus edwardsii</i>	Northern Ring-necked Snake	HV	Very High	5	5
<i>Elaphe vulpina vulpina</i>	Western fox snake	PS	Very High	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Reptiles... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Emydoidea blandingii</i>	Blanding's Turtle	HV <sup>a</sup>	Very High	4	3
<i>Eumeces fasciatus</i>	Five-lined skink	MV	Low	5	3
<i>Glyptemys insculpta</i>	Wood Turtle	MV <sup>a</sup>	Moderate	3	2
<i>Graptemys geographica</i>	Common map turtle	PS <sup>a</sup>	Very High	5	5
<i>Heterodon platirhinos</i>	Eastern Hognose Snake	MV	Moderate	5	3
<i>Lampropeltis triangulum</i>	Eastern milk snake	PS	Very High	5	5
<i>Liochlorophis vernalis</i>	Smooth green snake	PS	Low	5	5
<i>Nerodia erythrogaster neglecta</i>	Copperbelly water snake	EV <sup>a</sup>	Very High	5	1
<i>Nerodia sipedon sipedon</i>	Northern water snake	PS <sup>a</sup>	Very High	5	5
<i>Pantherophis gloydi</i>	Eastern Fox Snake	MV	Low	3	2
<i>Pantherophis spiloides</i>	Gray Ratsnake/ Central Ratsnake	PS <sup>a</sup>	Moderate	5	3
<i>Regina septemvittata</i>	Queen Snake	EV	Moderate	5	4
<i>Sistrurus catenatus catenatus</i>	Eastern Massasauga	HV	High	3	3
<i>Sternotherus odoratus</i>	Common musk turtle	MV	Low	5	5
<i>Storeria dekayi</i>	Brown snake	PS	Moderate	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Reptiles... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Storeria occipitomaculata occipitomaculata</i>	Northern red-bellied snake	PS	Very High	5	5
<i>Terrapene carolina carolina</i>	Eastern Box Turtle	HV <sup>a</sup>	Moderate	5	2
<i>Thamnophis butleri</i>	Butler's garter snake	MV	Low	4	4
<i>Thamnophis sauritus septentrionalis</i>	Northern ribbon snake	MV	Low	5	5
<i>Thamnophis sirtalis sirtalis</i>	Eastern garter snake	PS	Very High	4	4

**Amphibians**

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Acris crepitans blanchardi/ Acris blanchardi</i>	Blanchard's Cricket Frog	HV <sup>a</sup>	Low	5	2
<i>Ambystoma opacum</i>	Marbled salamander	HV <sup>a</sup>	Low	5	1
<i>Amybstoma laterale</i>	Blue-spotted Salamander	EV	Very High	5	5
<i>Amybstoma maculatum</i>	Spotted Salamander	HV	Low	5	5
<i>Amybstoma texanum</i>	Smallmouth Salamander	EV <sup>a</sup>	Moderate	5	1
<i>Anaxyrus fowleri/ Bufo fowleri</i>	Fowler's Toad	MV	Moderate	5	5
<i>Bufo americanus americanus</i>	Eastern American toad	MV	Low	5	NR

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



Changing Climate, Changing Wildlife

Appendix A. Amphibians... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Hemidactylium scutatum</i>	Four-toed Salamander	EV	High	5	5
<i>Hyla chrysoscelis</i>	Cope's gray treefrog	MV	Moderate	5	5
<i>Hyla versicolor</i>	Eastern gray treefrog	MV	Low	5	5
<i>Lithobates pipiens</i>	Northern Leopard Frog	HV	Very High	5	5
<i>Lithobates sylvaticus</i>	Wood Frog	HV	Moderate	5	5
<i>Necturus maculosus</i>	Mudpuppy	MV <sup>a</sup>	Moderate	5	5
<i>Notophthalmus viridescens louisianensis</i>	Central newt	HV	Very High	5	5
<i>Notophthalmus viridescens viridescens</i>	Red-spotted newt	HV	Low	5	5
<i>Plethodon cinereus</i>	Redback Salamander	HV	Very High	5	5
<i>Pseudacris crucifer crucifer</i>	Northern spring peeper	MV	Low	5	5
<i>Pseudacris maculata</i>	Boreal Chorus Frog	EV	Very High	5	1
<i>Pseudacris triseriata triseriata</i>	Western chorus frog	MV	Low	5	5
<i>Rana palustris</i>	Pickerel frog	MV	Moderate	5	5
<i>Rana septentrionalis</i>	Mink frog	EV	Moderate	5	3
<i>Siren intermedia nettingi</i>	Western lesser siren	EV	Moderate	5	H

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Fish... continued

**Fish**

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Acipenser fulvescens</i>	Lake sturgeon	HV <sup>a</sup>	Moderate	3	2
<i>Ameiurus nebulosus</i>	Brown bullhead	IL	Moderate	5	4
<i>Ammocrypta pellucida</i>	Eastern sand darter	HV <sup>a</sup>	Moderate	3	1
<i>Aphredoderus sayanus</i>	Pirate perch	PS <sup>a</sup>	High	5	4
<i>Clinostomus elongatus</i>	Redside dace	EV	High	3	1
<i>Coregonus artedi</i>	Lake herring	MV	Low	5	3
<i>Coregonus bartlettii</i>	Siskiwit lake cisco	EV	Very High	3	H
<i>Coregonus hubbsi</i>	Ives lake cisco	EV	Low	1	1
<i>Coregonus kiyi</i>	Kiyi	EV	Moderate	3	3
<i>Coregonus zenithicus</i>	Shortjaw cisco	EV	Low	3	2
<i>Cottus cognatus</i>	Slimy sculpin	HV	Very High	5	5
<i>Cottus ricei</i>	Spoonhead sculpin	HV	Moderate	5	3
<i>Erimyzon claviformis</i>	Western creek chubsucker	HV <sup>a</sup>	Moderate	5	1
<i>Erimyzon sucetta</i>	Lake chubsucker	MV <sup>a</sup>	Low	5	4
<i>Esox americanus</i>	Grass pickerel (redfin pickerel)	MV	Low	5	5
<i>Etheostoma flabellare</i>	Fantail darter	HV	Moderate	5	4

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Fish... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Etheostoma microperca</i>	Least darter	MV	Moderate	5	5
<i>Etheostoma spectabile</i>	Orangethroat darter	HV	Moderate	5	3
<i>Etheostoma zonale</i>	Banded darter	MV	Moderate	5	1
<i>Fundulus dispar</i>	Starhead topminnow	PS	Very High	4	2
<i>Hiodon tergisus</i>	Mooneye	MV <sup>a</sup>	Low	5	2
<i>Hybognathus hankinsoni</i>	Brassy minnow	EV	High	5	2
<i>Hypophthalmichthys nobilis</i>	Big head carp	PS <sup>a</sup>	Very High	5	
<i>Ictiobus niger</i>	Black buffalo	PS <sup>a</sup>	Very High	5	3
<i>Lepisosteus oculatus</i>	Spotted gar	HV <sup>a</sup>	Moderate	5	2
<i>Luxilus chrysocephalus</i>	Striped shiner	MV	Moderate	5	5
<i>Macrhybopsis storeriana</i>	Silver chub	EV	Moderate	5	2
<i>Minytrema melanops</i>	Spotted sucker	PS <sup>a</sup>	High	5	3
<i>Moxostoma carinatum</i>	River redhorse	PS <sup>a</sup>	Very High	4	1
<i>Moxostoma duquesnei</i>	Black redhorse	MV <sup>a</sup>	Low	5	3
<i>Moxostoma erythrurum</i>	Golden redhorse	MV <sup>a</sup>	Moderate	5	4
<i>Myoxocephalus thompsonii</i>	Deepwater sculpin	HV	Low	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Fish... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Nocomis micropogon</i>	River chub	MV	Moderate	5	4
<i>Notropis anogenus</i>	Pugnose shiner	HV	Moderate	3	3
<i>Notropis dorsalis</i>	Bigmouth shiner	MV	Moderate	5	4
<i>Notropis photogenis</i>	Silver shiner	HV <sup>a</sup>	Low	5	1
<i>Noturus flavus</i>	Stonecat	MV <sup>a</sup>	Moderate	5	4
<i>Noturus gyrinus</i>	Tadpole madtom	PS <sup>a</sup>	Low	5	5
<i>Noturus miurus</i>	Brindled madtom	MV <sup>a</sup>	Moderate	5	2
<i>Noturus stigmosus</i>	Northern madtom	EV <sup>a</sup>	Moderate	3	1
<i>Opsopoeodus emiliae</i>	Pugnose minnow	HV <sup>a</sup>	Moderate	5	1
<i>Percina copelandi</i>	Channel darter	HV	Moderate	4	1
<i>Percina shumardi</i>	River darter	HV	Moderate	5	1
<i>Phoxinus erythrogaster</i>	Southern redbelly dace	MV	Low	5	1
<i>Phoxinus neogaeus</i>	Finescale dace	EV	Moderate	5	5
<i>Prosopium coulterii</i>	Pygmy whitefish	EV	Low	5	4
<i>Sander canadensis</i>	Sauger	HV	Low	5	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Mussels... continued

**Mussels**

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Alasmidonta marginata</i>	Elktoe	HV <sup>a</sup>	Low	4	2
<i>Alasmidonta viridis</i>	Slippershell	EV <sup>a</sup>	Very High	4	2
<i>Anodontoides ferussacianus</i>	Cylindrical papershell	PS	Moderate	5	4
<i>Cyclonaias tuberculata</i>	Purple wartyback	MV	Low	5	2
<i>Dreissena polymorpha</i>	Zebra mussel	PS	Very High	5	SNA
<i>Epioblasma torulosa rangiana</i>	Northern riffleshell	EV <sup>a</sup>	High	2	1
<i>Epioblasma triquetra</i>	Snuffbox	HV <sup>a</sup>	Low	3	1
<i>Lampsilis fasciola</i>	Wavy-rayed lampmussel	HV <sup>a</sup>	Low	5	2
<i>Lasmigona compressa</i>	Creek heelsplitter	HV	Moderate	5	SNR
<i>Ligumia nasuta</i>	Eastern pondmussel	MV	Low	4	NSR
<i>Obliquaria reflexa</i>	Threehorn wartyback	EV	High	5	NSR
<i>Obovaria olivaria</i>	Hickorynut	HV <sup>a</sup>	Low	4	2
<i>Pleurobema clava</i>	Northern clubshell	EV <sup>a</sup>	Very High	1	1
<i>Pleurobema coccineum</i>	Round pigtoe	HV <sup>a</sup>	Low	4	2

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

*Appendix A. Mussels... continued*

<b>Species</b>	<b>English Name</b>	<b>Climate Vulnerability</b>	<b>Confidence</b>	<b>G Rank</b>	<b>S Rank</b>
<i>Simpsonaias ambigua</i>	Salamander mussel	EV	High	3	1
<i>Toxolasma lividus</i>	Purple lilliput	EV <sup>a</sup>	Moderate	2	1
<i>Venustaconcha ellipsiformis</i>	Ellipse	EV <sup>a</sup>	Moderate	3	2
<i>Villosa fabalis</i>	Rayed bean	HV <sup>a</sup>	Low	2	1

**Snails**

<b>Species</b>	<b>English Name</b>	<b>Climate Vulnerability</b>	<b>Confidence</b>	<b>G Rank</b>	<b>S Rank</b>
<i>Acella haldimani</i>	Spindle lymnaea	EV	Moderate	3	3
<i>Anguispira kochi</i>	Banded globe	EV	Moderate	NR	U
<i>Appalachina sayana</i>	Spike-lip crater	HV	Low	4	U
<i>Catinella exile</i>	Pleistocene catinella	EV	Moderate	2	2
<i>Discus patulus</i>	Domed disc	EV	Moderate	5	U
<i>Euconulus alderi</i>	a land snail	EV	Moderate	4	2
<i>Fontigens nickliniana</i>	Watercress snail	EV	Very High	5	SU
<i>Gastrocopta holzingeri</i>	Lambda snaggletooth	EV	Very High	5	1
<i>Guppya sterkii</i>	Sterki's granule	HV	Low	5	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix A. Snails... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Helisoma anceps</i>	Two-ridge rams-horn	MV	Moderate	5	SU
<i>Hendersonia occulta</i>	Cherrystone drop	EV	Low	4	1
<i>Mesodon elevatus</i>	Proud globe	HV	Moderate	5	SU
<i>Mesomphix cupreus</i>	Copper button	HV	Moderate	5	U
<i>Philomycus carolinianus</i>	Carolina mantleslug	PS	Moderate	5	U
<i>Planogyra asteriscus</i>	Eastern flat-whorl	EV	Low	4	3
<i>Planorbella smithi</i>	aquatic snail	HV	Low	5	2
<i>Pomatiopsis cincinnatiensis</i>	Brown walker	HV	Low	4	SU
<i>Potamopyrgus antipodarum</i>	New Zealand mudsnail	MV	Low	5	SU
<i>Pupilla muscorum</i>	Widespread column	MV	Low	5	U
<i>Pyrgulopsis letsoni</i>	Gravel pyrg	HV	Low	5	U
<i>Stagnicola contracta</i>	Deepwater pondsnail	HV	Very High	1	1
<i>Vallonia gracilicosta albula</i>	terrestrial snail	HV	Moderate	4	1
<i>Vertigo bollesiana</i>	Delicate vertigo	HV	Moderate	4	2
<i>Vertigo cristata</i>	Crested vertigo	EV	High	5	3
<i>Vertigo elatior</i>	Tapered vertigo	HV	Moderate	5	3

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



## Changing Climate, Changing Wildlife

### Appendix A. Snails... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Vertigo hubrichti</i>	Hubricht's vertigo	EV	Moderate	3	2
<i>Vertigo modesta parietalis</i>	a land snail	EV	High	5	1
<i>Vertigo morsei</i>	Six-whorl vertigo	EV	Low	3	2
<i>Vertigo nylanderi</i>	Deep-throat vertigo	EV	Moderate	3	1
<i>Vertigo paradoxa</i>	Mystery vertigo	HV	Low	4	3
<i>Vertigo pygmaea</i>	Crested vertigo	MV	Low	5	U

### Insects

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Acronicta falcata</i>	Corylus dagger moth	MV	Low	U	2
<i>Aeshna canadensis</i>	Canada darner	IL <sup>b</sup>	Very High	5	NR
<i>Appalachia arcana</i>	Secretive locust	MV	Very High	2	2
<i>Atrytonopsis hianna</i>	Dusted skipper	MV	Low	4	2
<i>Basilodes pepita</i>	Gold moth	HV <sup>a</sup>	Low	4	1
<i>Battus philenor</i>	Pipevine swallowtail	PS <sup>a</sup>	Low	5	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix A. Insects... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Boloria freija</i>	Freija fritillary	HV	Low	5	3
<i>Boloria frigga</i>	Frigga fritillary	HV	Low	5	3
<i>Bombus affinis</i>	Rusty-patched bumble bee	PS <sup>a</sup>	Very High	U	NR
<i>Bombus terricola</i>	Yellow banded bumble bee	PS <sup>b</sup>	Very High	U	NR
<i>Brachionycha borealis</i>	Boreal fan moth	PS	High	4	1
<i>Brychius hungerfordi</i>	Hungerford's crawling water beetle	HV	Very High	1	1
<i>Calephelis mutica</i>	Swamp metalmark	HV <sup>a</sup>	Moderate	3	1
<i>Callophrys henrici</i>	Henry's elfin	PS	Moderate	5	2
<i>Callophrys irus</i>	Frosted elfin	HV	Moderate	3	2
<i>Catocala amestris</i>	Three-staff underwing	EV	Very High	4	1
<i>Catocala dulciola</i>	Quiet underwing	MV <sup>a</sup>	Moderate	3	1
<i>Catocala illecta</i>	Magdalen underwing	MV <sup>a</sup>	Moderate	5	2
<i>Catocala robinsonii</i>	Robinson's underwing	PS <sup>a</sup>	Very High	4	2
<i>Chlosyne gorgone carlota</i>	Gorgone checkerspot	HV	High	5	2
<i>Cicindela lepida</i>	Little white tiger beetle	HV <sup>a</sup>	Moderate	4	4
<i>Cicindela limbalis</i>	a tiger beetle	PS <sup>a</sup>	Very High	5	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Insects... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Cicindela macra</i>	a tiger beetle	PS <sup>a</sup>	High	5	5
<i>Cordulegaster erronea</i>	Tiger spiketail	PS <sup>a</sup>	Very High	4	1
<i>Dorydiella kansana</i>	Leafhopper	HV	Very High	NR	1
<i>Eacles imperialis pini</i>	Pine imperial moth	MV <sup>b</sup>	Low	5	2
<i>Erebia discoidalis</i>	Red-disked alpine	MV <sup>b</sup>	Low	5	2
<i>Erora laeta</i>	Early hairstreak	MV	Low	U	2
<i>Erynnis baptisiae</i>	Wild indigo duskywing	PS <sup>a</sup>	Low	5	2
<i>Erynnis persius persius</i>	Persius duskywing	MV <sup>a</sup>	Moderate	5	3
<i>Euchloe ausonides</i>	Large marble	EV	Very High	5	1
<i>Euxoa aurulenta</i>	Dune cutworm	PS	Very High	5	1
<i>Fixsenia favonius ontario</i>	Northern hairstreak	MV <sup>a</sup>	Low	4	1
<i>Flexamia delongi</i>	Leafhopper	PS	Very High	NR	1
<i>Flexamia huroni</i>	Huron River leafhopper	EV	Very High	NR	1
<i>Flexamia reflexus</i>	Leafhopper	PS	Very High	NR	1
<i>Gomphus lineatifrons</i>	Splendid clubtail	PS <sup>a</sup>	Very High	4	2
<i>Gomphus quadricolor</i>	Rapids clubtail	PS <sup>a</sup>	Very High	3	2

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix A. Insects... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Hemileuca maia</i>	Barrens buckmoth	MV <sup>a</sup>	Moderate	5	2
<i>Hesperia ottoe</i>	Ottoe skipper	MV	Moderate	3	1
<i>Heterocampa subrotata</i>	Small heterocampa	MV	Very High	4	1
<i>Heteropacha rileyana</i>	Riley's lappet moth	HV	Moderate	4	1
<i>Lepyronia angulifera</i>	Angular spittlebug	EV	Very High	3	1
<i>Lepyronia gibbosa</i>	Great plains spittlebug	HV	Moderate	3	1
<i>Liodessus cantralli</i>	Cantrall's bog beetle	MV	Low	NR	1
<i>Lycaeides idas nabokovi</i>	Northern blue	HV	Very High	5	2
<i>Lycaeides melissa samuelis</i>	Karner blue	HV	Very High	5	2
<i>Merolonche dolli</i>	Doll's merolonche	MV <sup>a</sup>	Moderate	3	1
<i>Meropleon ambifusca</i>	Newman's brocade	HV <sup>a</sup>	Moderate	3	1
<i>Neonympha mitchellii mitchellii</i>	Mitchell's satyr	EV <sup>a</sup>	Very High	2	1
<i>Oarisma poweshiek</i>	Poweshiek skipperling	EV	Very High	2	1
<i>Oecanthus laricis</i>	Tamarack tree cricket	EV <sup>a</sup>	High	1	1
<i>Oecanthus pini</i>	Pine tree cricket	MV <sup>a</sup>	Low	NR	1
<i>Oeneis macounii</i>	Macoun's arctic	EV	Moderate	2	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix A. Insects... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Oncocnemis piffardi</i>	Three-striped oncocnemis	HV	Moderate	4	1
<i>Ophiogomphus anomalus</i>	Extra-striped snaketail	PS <sup>b</sup>	Very High	4	1
<i>Ophiogomphus howei</i>	Pygmy snaketail	PS <sup>a</sup>	Very High	3	1
<i>Pachypolia atricornis</i>	Three-horned moth	MV <sup>a</sup>	Low	3	1
<i>Papaipema aweme</i>	Aweme borer	MV <sup>b</sup>	Moderate	1	H
<i>Papaipema cerina</i>	Golden borer	MV <sup>a</sup>	Moderate	4	2
<i>Papaipema speciosissima</i>	Regal fern borer	HV <sup>a</sup>	Low	4	2
<i>Phyciodes batesii</i>	Tawny crescent	PS	Low	4	4
<i>Polygonia gracilis</i>	Hoary comma	HV <sup>b</sup>	Low	5	3
<i>Prosapia ignipectus</i>	Red-legged Spittlebug	EV <sup>a</sup>	Moderate	1	1
<i>Proserpinus flavofasciata</i>	Yellow-banded day-sphinx	HV <sup>b</sup>	Moderate	5	3
<i>Pygarctia spraguei</i>	Sprague's pygarctia	MV <sup>a</sup>	Low	5	2
<i>Schinia indiana</i>	Phlox moth	EV <sup>b</sup>	Very High	2	1
<i>Schinia lucens</i>	Leadplant flower moth	HV	Very High	4	1
<i>Scudderia fasciata</i>	Pine katydid	HV <sup>a</sup>	Low	NR	1
<i>Somatochlora hineana</i>	Hine's Emerald Dragonfly	EV <sup>a</sup>	Very High	2	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix A. Insects... continued

Species	English Name	Climate Vulnerability	Confidence	G Rank	S Rank
<i>Somatochlora incurvata</i>	Incurvate emerald	MV	Very High	4	1
<i>Spartiniphaga inops</i>	Spartina borer moth	HV <sup>a</sup>	Very High	3	1
<i>Speyeria idalia</i>	Regal fritillary	EV <sup>a</sup>	High	3	H
<i>Stenelmis douglasensis</i>	Douglas stenelmis riffle beetle	EV	Low	1	1
<i>Stylurus amnicola</i>	Riverine snaketail	PS	Very High	4	1
<i>Stylurus laurae</i>	Laura's snaketail	PS <sup>a</sup>	Very High	4	1
<i>Stylurus notatus</i>	Elusive snaketail	PS <sup>a</sup>	Very High	3	1
<i>Stylurus plagiatus</i>	Russet-tipped clubtail	PS <sup>a</sup>	Very High	5	1
<i>Tachopteryx thoreyi</i>	Grey petaltail	PS <sup>a</sup>	Moderate	4	1
<i>Trimerotropis huroniana</i>	Lake Huron locust	MV	Very High	2	2
<i>Williamsonia fletcheri</i>	Ebony Boghaunter	MV <sup>b</sup>	Low	4	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

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Appendix B. Climate-vulnerable (EV, HV, and MV) rare (S1, S2, and S3) species. NatureServe Climate Change Vulnerability Index (CCVI) scores for Michigan game species and Species of Greatest Conservation Need (SGCN). S rank is conservation status derived from rarity, population trends, and threats other than climate change at the state scale. Ranks range from five (secure) to one (critically imperiled.) Relative vulnerability is a combination of rarity, other conservation threats and climate vulnerability. Species with the same rank order are tied (same S-rank and same CCVI).

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Amybstoma texanum</i>	Smallmouth Salamander	1	EV <sup>a</sup>	1
<i>Catocala amestris</i>	Three-staff underwing	1	EV	1
<i>Clinostomus elongatus</i>	Redside dace	1	EV	1
<i>Coregonus hubbsi</i>	Ives lake cisco	1	EV	1
<i>Epioblasma torulosa rangiana</i>	Northern riffleshell	1	EV <sup>a</sup>	1
<i>Euchloe ausonides</i>	Large marble	1	EV	1
<i>Flexamia huroni</i>	Huron River leafhopper	1	EV	1
<i>Gastrocopta holzingeri</i>	Lambda snaggletooth	1	EV	1
<i>Hendersonia occulta</i>	Cherrystone drop	1	EV	1
<i>Lepyronia angulifera</i>	Angular spittlebug	1	EV	1
<i>Neonympha mitchellii mitchellii</i>	Mitchell's satyr	1	EV <sup>a</sup>	1
<i>Nerodia erythrogaster neglecta</i>	Copperbelly water snake	1	EV <sup>a</sup>	1
<i>Noturus stigmosus</i>	Northern madtom	1	EV <sup>a</sup>	1
<i>Oarisma poweshiek</i>	Poweshiek skipperling	1	EV	1

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



## Changing Climate, Changing Wildlife

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### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Oecanthus laricis</i>	Tamarack tree cricket	1	EV <sup>a</sup>	1
<i>Oeneis macounii</i>	Macoun's arctic	1	EV	1
<i>Pleurobema clava</i>	Northern clubshell	1	EV <sup>a</sup>	1
<i>Prosapia ignipectus</i>	Red-legged Spittlebug	1	EV <sup>a</sup>	1
<i>Pseudacris maculata</i>	Boreal Chorus Frog	1	EV	1
<i>Schinia indiana</i>	Phlox moth	1	EV <sup>b</sup>	1
<i>Simpsonaias ambigua</i>	Salamander mussel	1	EV	1
<i>Somatochlora hineana</i>	Hine's Emerald Dragonfly	1	EV <sup>a</sup>	1
<i>Stenelmis douglasensis</i>	Douglas stenelmis riffle beetle	1	EV	1
<i>Toxolasma lividus</i>	Purple lilliput	1	EV <sup>a</sup>	1
<i>Vertigo modesta parietalis</i>	a land snail	1	EV	1
<i>Vertigo nylanderi</i>	Deep-throat vertigo	1	EV	1
<i>Alasmidonta viridis</i>	Slippershell	2	EV <sup>a</sup>	2
<i>Catinella exile</i>	Pleistocene catinella	2	EV	2
<i>Coregonus zenithicus</i>	Shortjaw cisco	2	EV	2
<i>Euconulus alderi</i>	a land snail	2	EV	2
<i>Hybognathus hankinsoni</i>	Brassy minnow	2	EV	2

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Macrhybopsis storeriana</i>	Silver chub	2	EV	2
<i>Venustaconcha ellipsiformis</i>	Ellipse	2	EV <sup>a</sup>	2
<i>Vertigo hubrichti</i>	Hubricht's vertigo	2	EV	2
<i>Vertigo morsei</i>	Six-whorl vertigo	2	EV	2
<i>Acella haldimani</i>	Spindle lymnaea	3	EV	3
<i>Coregonus kiyi</i>	Kiyi	3	EV	3
<i>Planogyra asteriscus</i>	Eastern flat-whorl	3	EV	3
<i>Rana septentrionalis</i>	Mink frog	3	EV	3
<i>Vertigo cristata</i>	Crested vertigo	3	EV	3
<i>Ambystoma opacum</i>	Marbled salamander	1	HV <sup>a</sup>	4
<i>Ammocrypta pellucida</i>	Eastern sand darter	1	HV <sup>a</sup>	4
<i>Basilodes pepita</i>	Gold moth	1	HV <sup>a</sup>	4
<i>Brychius hungerfordi</i>	Hungerford's crawling water beetle	1	HV	4
<i>Calephelis mutica</i>	Swamp metalmark	1	HV <sup>a</sup>	4
<i>Clonophis kirtlandi</i>	Kirtland's Snake	1	HV <sup>a</sup>	4
<i>Dorydiella kansana</i>	Leafhopper	1	HV	4
<i>Epioblasma triquetra</i>	Snuffbox	1	HV <sup>a</sup>	4

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Erimyzon claviformis</i>	Western creek chubsucker	1	HV <sup>a</sup>	4
<i>Guppya sterkii</i>	Sterki's granule	1	HV	4
<i>Heteropacha rileyana</i>	Riley's lappet moth	1	HV	4
<i>Lepyronia gibbosa</i>	Great plains spittlebug	1	HV	4
<i>Lynx canadensis</i>	Lynx	1	HV <sup>b</sup>	4
<i>Meropleon ambifusca</i>	Newman's brocade	1	HV <sup>a</sup>	4
<i>Notropis photogenis</i>	Silver shiner	1	HV <sup>a</sup>	4
<i>Oncocnemis piffardi</i>	Three-striped oncocnemis	1	HV	4
<i>Opsopoeodus emiliae</i>	Pugnose minnow	1	HV <sup>a</sup>	4
<i>Percina copelandi</i>	Channel darter	1	HV	4
<i>Percina shumardi</i>	River darter	1	HV	4
<i>Sander canadensis</i>	Sauger	1	HV	4
<i>Schinia lucens</i>	Leadplant flower moth	1	HV	4
<i>Scudderia fasciata</i>	Pine katydid	1	HV <sup>a</sup>	4
<i>Sorex fumeus</i>	Smoky shrew	1	HV	4
<i>Spartiniphaga inops</i>	Spartina borer moth	1	HV <sup>a</sup>	4
<i>Stagnicola contracta</i>	Deepwater pondsnail	1	HV	4

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Vallonia gracilicosta albula</i>	terrestrial snail	1	HV	4
<i>Villosa fabalis</i>	Rayed bean	1	HV <sup>a</sup>	4
<i>Acipenser fulvescens</i>	Lake sturgeon	2	HV <sup>a</sup>	5
<i>Acris crepitans blanchardi/ Acris blanchardi</i>	Blanchard's Cricket Frog	2	HV <sup>a</sup>	5
<i>Alasmidonta marginata</i>	Elktoe	2	HV <sup>a</sup>	5
<i>Callophrys irus</i>	Frosted elfin	2	HV	5
<i>Chlosyne gorgone carlota</i>	Gorgone checkerspot	2	HV	5
<i>Clemmys guttata</i>	Spotted Turtle	2	HV <sup>a</sup>	5
<i>Lampsilis fasciola</i>	Wavy-rayed lampmussel	2	HV <sup>a</sup>	5
<i>Lepisosteus oculatus</i>	Spotted gar	2	HV <sup>a</sup>	5
<i>Lycaeides idas nabokovi</i>	Northern blue	2	HV	5
<i>Lycaeides melissa samuelis</i>	Karner blue	2	HV	5
<i>Obovaria olivaria</i>	Hickorynut	2	HV <sup>a</sup>	5
<i>Papaipema speciosissima</i>	Regal fern borer	2	HV <sup>a</sup>	5
<i>Planorbella smithi</i>	aquatic snail	2	HV	5
<i>Pleurobema coccineum</i>	Round pigtoe	2	HV <sup>a</sup>	5
<i>Terrapene carolina carolina</i>	Eastern Box Turtle	2	HV <sup>a</sup>	5

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

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### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Vertigo bollesiana</i>	Delicate vertigo	2	HV	5
<i>Boloria freija</i>	Freija fritillary	3	HV	6
<i>Boloria frigga</i>	Frigga fritillary	3	HV	6
<i>Cottus ricei</i>	Spoonhead sculpin	3	HV	6
<i>Emydoidea blandingii</i>	Blanding's Turtle	3	HV <sup>a</sup>	6
<i>Etheostoma spectabile</i>	Orangethroat darter	3	HV	6
<i>Gavia immer</i>	Common Loon	3	HV <sup>b</sup>	6
<i>Notropis anogenus</i>	Pugnose shiner	3	HV	6
<i>Polygonia gracilis</i>	Hoary comma	3	HV <sup>b</sup>	6
<i>Proserpinus flavofasciata</i>	Yellow-banded day-sphinx	3	HV <sup>b</sup>	6
<i>Sistrurus catenatus catenatus</i>	Eastern Massasauga	3	HV	6
<i>Vertigo elatior</i>	Tapered vertigo	3	HV	6
<i>Vertigo paradoxa</i>	Mystery vertigo	3	HV	6
<i>Catocala dulciola</i>	Quiet underwing	1	MV <sup>a</sup>	7
<i>Charadrius melodus</i>	Piping Plover	1	MV	7
<i>Coturnicops noveboracensis</i>	Yellow rail	1	MV <sup>b</sup>	7
<i>Etheostoma zonale</i>	Banded darter	1	MV	7

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

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### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Falco peregrinus</i>	Peregrine Falcon	1	MV <sup>a</sup>	7
<i>Fixsenia favonius ontario</i>	Northern hairstreak	1	MV <sup>a</sup>	7
<i>Hesperia ottoe</i>	Ottoe skipper	1	MV	7
<i>Heterocampa subrotata</i>	Small heterocampa	1	MV	7
<i>Liodessus cantralli</i>	Cantrall's bog beetle	1	MV	7
<i>Merolonche dolli</i>	Doll's merolonche	1	MV <sup>a</sup>	7
<i>Myotis sodalis</i>	Indiana bat	1	MV <sup>a</sup>	7
<i>Oecanthus pini</i>	Pine tree cricket	1	MV <sup>a</sup>	7
<i>Pachypolia atricornis</i>	Three-horned moth	1	MV <sup>a</sup>	7
<i>Phoxinus erythrogaster</i>	Southern redbelly dace	1	MV	7
<i>Somatochlora incurvata</i>	Incurvate emerald	1	MV	7
<i>Williamsonia fletcheri</i>	Ebony Boghaunter	1	MV <sup>b</sup>	7
<i>Acronicta falcula</i>	Corylus dagger moth	2	MV	8
<i>Appalachia arcana</i>	Secretive locust	2	MV	8
<i>Atrytonopsis hianna</i>	Dusted skipper	2	MV	8
<i>Catocala illecta</i>	Magdalen underwing	2	MV <sup>a</sup>	8
<i>Cyclonaias tuberculata</i>	Purple wartyback	2	MV	8

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Eacles imperialis pini</i>	Pine imperial moth	2	MV <sup>b</sup>	8
<i>Erebia discoidalis</i>	Red-disked alpine	2	MV <sup>b</sup>	8
<i>Erora laeta</i>	Early hairstreak	2	MV	8
<i>Falcapennes canadensis</i>	Spruce grouse	2	MV	8
<i>Glyptemys insculpta</i>	Wood Turtle	2	MV <sup>a</sup>	8
<i>Hemileuca maia</i>	Barrens buckmoth	2	MV <sup>a</sup>	8
<i>Hiodon tergisus</i>	Mooneye	2	MV <sup>a</sup>	8
<i>Ixobrychus exilis</i>	Least Bittern	2	MV <sup>a</sup>	8
<i>Noturus miurus</i>	Brindled madtom	2	MV <sup>a</sup>	8
<i>Pantherophis gloydi</i>	Eastern Fox Snake	2	MV	8
<i>Papaipema cerina</i>	Golden borer	2	MV <sup>a</sup>	8
<i>Pygarctia spraguei</i>	Sprague's pygarctia	2	MV <sup>a</sup>	8
<i>Sterna forsteri</i>	Forster's Tern	2	MV	8
<i>Sterna caspia</i>	Caspian Tern	2	MV	8
<i>Sterna hirundo</i>	Common Tern	2	MV <sup>b</sup>	8
<i>Trimerotropis huroniana</i>	Lake Huron locust	2	MV	8
<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird	2	MV	8

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix B. Climate vulnerable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Aythya americana</i>	Redhead	3	MV	9
<i>Botaurus lentiginosus</i>	American Bittern	3	MV	9
<i>Chilodonias niger</i>	Black tern	3	MV <sup>b</sup>	9
<i>Circus cyaneus</i>	Northern Harrier	3	MV	9
<i>Coregonus artedi</i>	Lake herring	3	MV	9
<i>Cygnus buccinator</i>	Trumpeter Swan	3	MV <sup>b</sup>	9
<i>Erynnis persius persius</i>	Persius duskywing	3	MV <sup>a</sup>	9
<i>Eumeces fasciatus</i>	Five-lined skink	3	MV	9
<i>Heterodon platirhinos</i>	Eastern Hognose Snake	3	MV	9
<i>Martes americana</i>	American marten	3	MV	9
<i>Moxostoma duquesnei</i>	Black redhorse	3	MV <sup>a</sup>	9
<i>Setophaga cerulea [Dendroica cerulea]</i>	Cerulean Warbler	3	MV <sup>a</sup>	9

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



## Changing Climate, Changing Wildlife

Appendix C. Climate-vulnerable (EV, HV, and MV) common (S4 and S5) species. NatureServe Climate Change Vulnerability Index (CCVI) scores for Michigan game species and Species of Greatest Conservation Need (SGCN). S rank is conservation status derived from rarity, population trends, and threats other than climate change at the state scale. Ranks range from five (secure) to one (critically imperiled.) Species ranked from most vulnerable to least vulnerable. Relative vulnerability is a combination of rarity, other conservation threats and climate vulnerability. Species with the same rank order are tied (same S-rank and same CCVI).

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Prosopium coulterii</i>	Pygmy whitefish	4	EV	10
<i>Regina septemvittata</i>	Queen Snake	4	EV	10
<i>Amybstoma laterale</i>	Blue-spotted Salamander	5	EV	11
<i>Hemidactylium scutatum</i>	Four-toed Salamander	5	EV	11
<i>Phoxinus neogaeus</i>	Finescale dace	5	EV	11
<i>Alces americanus</i>	Moose	4	HV	12
<i>Cicindela lepida</i>	Little white tiger beetle	4	HV <sup>a</sup>	12
<i>Etheostoma flabellare</i>	Fantail darter	4	HV	12
<i>Amybstoma maculatum</i>	Spotted Salamander	5	HV	13
<i>Cottus cognatus</i>	Slimy sculpin	5	HV	13
<i>Diadophis punctatus edwardsii</i>	Northern Ring-necked Snake	5	HV	13
<i>Lepus americanus</i>	Snowshoe hare	5	HV	13
<i>Lithobates pipiens</i>	Northern Leopard Frog	5	HV	13
<i>Lithobates sylvaticus</i>	Wood Frog	5	HV	13
<i>Myoxocephalus thompsonii</i>	Deepwater sculpin	5	HV	13
<i>Notophthalmus viridescens louisianensis</i>	Central newt	5	HV	13
<i>Notophthalmus viridescens viridescens</i>	Red-spotted newt	5	HV	13

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

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### Appendix C. Climate vulnerable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Plethodon cinereus</i>	Redback Salamander	5	HV	13
<i>Aythya collaris</i>	Ring-necked Duck	4	MV	14
<i>Erimyzon sucetta</i>	Lake chubsucker	4	MV <sup>a</sup>	14
<i>Moxostoma erythrurum</i>	Golden redbhorse	4	MV <sup>a</sup>	14
<i>Nocomis micropogon</i>	River chub	4	MV	14
<i>Notropis dorsalis</i>	Bigmouth shiner	4	MV	14
<i>Noturus flavus</i>	Stonecat	4	MV <sup>a</sup>	14
<i>Porzana carolina</i>	Sora	4	MV	14
<i>Thamnophis butleri</i>	Butler's garter snake	4	MV	14
<i>Actitis macularia</i>	Spotted Sandpiper	5	MV	15
<i>Anaxyrus fowleri/ Bufo fowleri</i>	Fowler's Toad	5	MV	15
<i>Branta canadensis</i>	Canada Goose	5	MV	15
<i>Setophaga fusca</i>	Blackburnian Warbler	5	MV <sup>b</sup>	15
<i>Empidonax minimus</i>	Least Flycatcher	5	MV	15
<i>Esox americanus</i>	Grass pickerel (redfin pickerel)	5	MV	15
<i>Etheostoma microperca</i>	Least darter	5	MV	15
<i>Glaucomys sabrinus</i>	Northern flying squirrel	5	MV <sup>b</sup>	15
<i>Hyla chrysoscelis</i>	Cope's gray treefrog	5	MV	15

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix C. Climate vulnerable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Hyla versicolor</i>	Eastern gray treefrog	5	MV	15
<i>Luxilus chrysocephalus</i>	Striped shiner	5	MV	15
<i>Myodes gapperi</i>	Southern red-backed vole	5	MV <sup>b</sup>	15
<i>Napaeozapus insignis</i>	Woodland jumping mouse	5	MV <sup>b</sup>	15
<i>Necturus maculosus</i>	Mudpuppy	5	MV <sup>a</sup>	15
<i>Neotamias minimus</i>	Least chipmunk	5	MV <sup>b</sup>	15
<i>Pseudacris crucifer crucifer</i>	Northern spring peeper	5	MV	15
<i>Pseudacris triseriata triseriata</i>	Western chorus frog	5	MV	15
<i>Rana palustris</i>	Pickerel frog	5	MV	15
<i>Sorex hoyi</i>	American pygmy shrew	5	MV	15
<i>Sorex palustris</i>	Water shrew	5	MV	15
<i>Sternotherus odoratus</i>	Common musk turtle	5	MV	15
<i>Thamnophis sauritus septentrionalis</i>	Northern ribbon snake	5	MV	15
<i>Cardellina canadensis</i>	Canada Warbler	5	MV <sup>b</sup>	15

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

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Appendix D. Climate-stable, (PS and IL) rare (S1, S2, and S3) species. NatureServe Climate Change Vulnerability Index (CCVI) scores for Michigan game species and Species of Greatest Conservation Need (SGCN). S rank is conservation status derived from rarity, population trends, and threats other than climate change at the state scale. Ranks range from five (secure) to one (critically imperiled.) Species ranked from most vulnerable to least vulnerable. Relative vulnerability is a combination of rarity, other conservation threats and climate vulnerability. Species with the same rank order are tied (same S-rank and same CCVI).

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Anas americana</i>	American Wigeon	1	PS	16
<i>Asio flammeus</i>	Short-eared Owl	1	PS	16
<i>Battus philenor</i>	Pipevine swallowtail	1	PS <sup>a</sup>	16
<i>Brachionycha borealis</i>	Boreal fan moth	1	PS	16
<i>Cordulegaster erronea</i>	Tiger spiketail	1	PS <sup>a</sup>	16
<i>Cryptotis parva</i>	Least shrew	1	PS <sup>a</sup>	16
<i>Setophaga kirtlandii</i>	Kirtland's Warbler	1	PS <sup>b</sup>	16
<i>Setophaga palmarum</i>	Palm Warbler	1	PS <sup>b</sup>	16
<i>Euxoa aurulenta</i>	Dune cutworm	1	PS	16
<i>Falco columbarius</i>	Merlin	1	PS <sup>b</sup>	16
<i>Flexamia delongi</i>	Leafhopper	1	PS	16
<i>Flexamia reflexus</i>	Leafhopper	1	PS	16
<i>Lanius ludovicianus migrans</i>	Migrant Loggerhead Shrike	1	PS <sup>a</sup>	16
<i>Microtus orchrogaster</i>	Prairie vole	1	PS <sup>a</sup>	16

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix D. Climate stable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Moxostoma carinatum</i>	River redhorse	1	PS <sup>a</sup>	16
<i>Ophiogomphus anomalus</i>	Extra-striped snaketail	1	PS <sup>b</sup>	16
<i>Ophiogomphus howei</i>	Pygmy snaketail	1	PS <sup>a</sup>	16
<i>Rallus elegans</i>	King Rail	1	PS <sup>a</sup>	16
<i>Stylurus amnicola</i>	Riverine snaketail	1	PS	16
<i>Stylurus laurae</i>	Laura's snaketail	1	PS <sup>a</sup>	16
<i>Stylurus notatus</i>	Elusive snaketail	1	PS <sup>a</sup>	16
<i>Stylurus plagiatus</i>	Russet-tipped clubtail	1	PS <sup>a</sup>	16
<i>Tachopteryx thoreyi</i>	Grey petaltail	1	PS <sup>a</sup>	16
<i>Tyto alba</i>	Barn Owl	1	PS <sup>a</sup>	16
<i>Ammodramus henslowii</i>	Henslow's sparrow	2	PS <sup>a</sup>	17
<i>Asio otus</i>	Long-eared Owl	2	PS	17
<i>Callophrys henrici</i>	Henry's elfin	2	PS	17
<i>Catocala robinsonii</i>	Robinson's underwing	2	PS <sup>a</sup>	17
<i>Erynnis baptisiae</i>	Wild indigo duskywing	2	PS <sup>a</sup>	17
<i>Fundulus dispar</i>	Starhead topminnow	2	PS	17
<i>Gomphus lineatifrons</i>	Splendid clubtail	2	PS <sup>a</sup>	17

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix D. Climate stable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Gomphus quadricolor</i>	Rapids clubtail	2	PS <sup>a</sup>	17
<i>Loxia leucoptera</i>	White-winged Crossbill	2	PS	17
<i>Oporornis agilis</i>	Connecticut Warbler	2	PS <sup>b</sup>	17
<i>Setophaga americana</i>	Northern Parula	2	PS	17
<i>Perimyotis subflavus</i>	Eastern pipistrelle or Tri-colored bat	2	PS <sup>a</sup>	17
<i>Phalaropus tricolor</i>	Wilson's Phalarope	2	PS	17
<i>Parkesia motacilla</i>	Louisiana Waterthrush	2	PS <sup>a</sup>	17
<i>Accipiter cooperii</i>	Cooper's Hawk	3	PS <sup>a</sup>	18
<i>Accipiter gentilis</i>	Northern Goshawk	3	PS <sup>b</sup>	18
<i>Ammodramus savannarum</i>	Grasshopper Sparrow	3	PS <sup>a</sup>	18
<i>Anas crecca</i>	Green-winged Teal	3	PS	18
<i>Anas rubripes</i>	American Black Duck	3	PS	18
<i>Bucephala clangula</i>	Common Goldeneye	3	PS	18
<i>Buteo lineatus</i>	Red-shouldered Hawk	3	PS <sup>a</sup>	18
<i>Canis lupus</i>	Gray Wolf	3	PS <sup>b</sup>	18
<i>Cervus elaphus</i>	Elk	3	PS	18
<i>Cistothorus palustris</i>	Marsh Wren	3	PS	18

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix D. Climate stable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Fulica americana</i>	American Coot	3	PS	18
<i>Gallinula galeata</i> [ <i>G. chloropus</i> ]	Common Gallinule [Common Moorhen]	3	PS <sup>a</sup>	18
<i>Ictiobus niger</i>	Black buffalo	3	PS <sup>a</sup>	18
<i>Lasiurus cinereus</i>	Hoary bat	3	PS	18
<i>Lophodytes cucullatus</i>	Hooded Merganser	3	PS	18
<i>Loxia curvirostra</i>	Red Crossbill	3	PS	18
<i>Mergus merganser</i>	Common Merganser	3	PS	18
<i>Microtus pinetorum</i>	Woodland vole	3	PS <sup>a</sup>	18
<i>Minytrema melanops</i>	Spotted sucker	3	PS <sup>a</sup>	18
<i>Pantherophis spiloides</i>	Gray Ratsnake/ Central Ratsnake	3	PS <sup>a</sup>	18
<i>Poecile hudsonica</i>	Boreal Chickadee	3	PS <sup>b</sup>	18
<i>Rallus limicola</i>	Virginia Rail	3	PS	18
<i>Tympanuchus phasianellus</i>	Sharp-tailed grouse	3	PS <sup>b</sup>	18
<i>Setophaga citrina</i>	Hooded Warbler	3	PS <sup>a</sup>	18
<i>Ammodramus leconteii</i>	Le Conte's Sparrow	1	IL <sup>b</sup>	19
<i>Setophaga discolor</i>	Prairie Warbler	1	IL <sup>a</sup>	19
<i>Setophaga dominica</i>	Yellow-throated Warbler	1	IL <sup>a</sup>	19

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix D. Climate stable, rare species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Nycticorax nycticorax</i>	Black-crowned Night-heron	2	IL <sup>a</sup>	20
<i>Picoides arcticus</i>	Black-backed Woodpecker	2	IL <sup>b</sup>	20
<i>Setophaga caerulescens</i>	Black-throated Blue Warbler	3	IL <sup>b</sup>	21
<i>Empidonax virescens</i>	Acadian Flycatcher	3	IL <sup>a</sup>	21
<i>Icteria virens</i>	Yellow-breasted Chat	3	IL <sup>a</sup>	21
<i>Protonotaria citrea</i>	Prothonotary Warbler	3	IL <sup>a</sup>	21
<i>Spiza americana</i>	Dickcissel	3	IL <sup>a</sup>	21

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



## Changing Climate, Changing Wildlife

Appendix E. Climate-stable (PS and IL) common (S4 and S5) species. NatureServe Climate Change Vulnerability Index (CCVI) scores for Michigan game species and Species of Greatest Conservation Need (SGCN). S rank is conservation status derived from rarity, population trends, and threats other than climate change at the state scale. Ranks range from five (secure) to one (critically imperiled.) Species ranked from most vulnerable to least vulnerable. Relative vulnerability is a combination of rarity, other conservation threats and climate vulnerability. Species with the same rank order are tied (same S-rank and same CCVI).

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Anodontoides ferussacianus</i>	Cylindrical papershell	4	PS	22
<i>Aphredoderus sayanus</i>	Pirate perch	4	PS <sup>a</sup>	22
<i>Cistothorus platensis</i>	Sedge Wren	4	PS	22
<i>Grus canadensis</i>	Sandhill crane	4	PS	22
<i>Lasionycteris noctivagans</i>	Silver-haired bat	4	PS	22
<i>Lontra canadensis</i>	Northern River Otter	4	PS	22
<i>Martes pennanti</i>	Fisher	4	PS <sup>b</sup>	22
<i>Pandion haliaetus</i>	Osprey	4	PS <sup>b</sup>	22
<i>Perisoreus canadensis</i>	Gray Jay	4	PS <sup>b</sup>	22
<i>Phyciodes batesii</i>	Tawny crescent	4	PS	22
<i>Podilymbus podiceps</i>	Pied-billed Grebe	4	PS <sup>a</sup>	22
<i>Regulus calendula</i>	Ruby-crowned Kinglet	4	PS <sup>b</sup>	22
<i>Sturnella neglecta</i>	Western Meadowlark	4	PS	22
<i>Taxidea taxus</i>	American Badger	4	PS <sup>a</sup>	22

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix E. Climate stable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Thamnophis sirtalis sirtalis</i>	Eastern garter snake	4	PS	22
<i>Urocyon cinereoargenteus</i>	Gray Fox	4	PS <sup>a</sup>	22
<i>Aix sponsa</i>	Wood Duck	5	PS	23
<i>Anas discors</i>	Blue-winged Teal	5	PS	23
<i>Anas platyrhynchos</i>	Mallard	5	PS	23
<i>Ardea herodias</i>	Great Blue Heron	5	PS	23
<i>Bonasa umbellus</i>	Ruffed Grouse	5	PS <sup>b</sup>	23
<i>Butorides virescens</i>	Green Heron	5	PS <sup>a</sup>	23
<i>Castor canadensis</i>	American Beaver	5	PS	23
<i>Chelydra serpentina serpentina</i>	Snapping Turtle	5	PS	23
<i>Chrysemys picta</i>	Painted Turtle	5	PS	23
<i>Cicindela limbalis</i>	a tiger beetle	5	PS <sup>a</sup>	23
<i>Cicindela macra</i>	a tiger beetle	5	PS <sup>a</sup>	23
<i>Coluber constrictor foxi</i>	Blue racer	5	PS	23
<i>Dryocopus pileatus</i>	Pileated woodpecker	5	PS	23
<i>Elaphe vulpina vulpina</i>	Western fox snake	5	PS	23
<i>Glaucomys volans</i>	Southern flying squirrel	5	PS <sup>a</sup>	23

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix E. Climate stable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Graptemys geographica</i>	Common map turtle	5	PS <sup>a</sup>	23
<i>Lampropeltis triangulum</i>	Eastern milk snake	5	PS	23
<i>Lasiurus borealis</i>	Red bat	5	PS	23
<i>Liochlorophis vernalis</i>	Smooth green snake	5	PS	23
<i>Mustela erminea</i>	Ermine / Short-tailed Weasel	5	PS <sup>b</sup>	23
<i>Mustela frenata</i>	Long-tailed Weasel	5	PS <sup>a</sup>	23
<i>Mustela nivalis</i>	Least Weasel	5	PS	23
<i>Neovison vison</i>	American Mink	5	PS	23
<i>Nerodia sipedon sipedon</i>	Northern water snake	5	PS <sup>a</sup>	23
<i>Noturus gyrinus</i>	Tadpole madtom	5	PS <sup>a</sup>	23
<i>Odocoileus virginianus</i>	White-tailed deer	5	PS	23
<i>Ondatra zibethicus</i>	Muskrat	5	PS	23
<i>Peromyscus maniculatus</i>	Deer mouse	5	PS	23
<i>Progne subis</i>	Purple Martin	5	PS <sup>a</sup>	23
<i>Sciurus carolinensis</i>	Eastern Gray Squirrel	5	PS <sup>a</sup>	23
<i>Sciurus niger</i>	Eastern Fox Squirrel	5	PS <sup>a</sup>	23
<i>Sialia sialis</i>	Eastern bluebird	5	PS <sup>a</sup>	23

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix E. Climate stable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Sorex arcticus</i>	Arctic shrew	5	PS	23
<i>Spermophilus tridecemlineatus</i>	Thirteen-lined Ground Squirrel	5	PS <sup>a</sup>	23
<i>Storeria dekayi</i>	Brown snake	5	PS	23
<i>Storeria occipitomaculata occipitomaculata</i>	Northern red-bellied snake	5	PS	23
<i>Sturnella magna</i>	Eastern Meadowlark	5	PS <sup>a</sup>	23
<i>Sylvilagus floridanus</i>	Eastern Cottontail	5	PS	23
<i>Synaptomys cooperi</i>	Southern bog lemming	5	PS	23
<i>Tamias striatus</i>	Eastern chipmunk	5	PS <sup>a</sup>	23
<i>Tamiasciurus hudsonicus</i>	Red Squirrel	5	PS	23
<i>Ursus americanus</i>	Black bear	5	PS	23
<i>Ameiurus nebulosus</i>	Brown bullhead	4	IL	24
<i>Bartramia longicauda</i>	Upland Sandpiper	4	IL <sup>a</sup>	24
<i>Colinus virginianus</i>	Northern Bobwhite	4	IL <sup>a</sup>	24
<i>Contopus cooperi</i>	Olive-sided Flycatcher	4	IL <sup>b</sup>	24
<i>Haliaeetus leucocephalis</i>	Bald Eagle	4	IL	24
<i>Hylocichla mustelina</i>	Wood Thrush	4	IL	24
<i>Lynx rufus</i>	Bobcat	4	IL	24

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Changing Climate, Changing Wildlife

Appendix E. Climate stable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Mimus polyglottos</i>	Northern Mockingbird	4	IL <sup>a</sup>	24
<i>Toxostoma rufum</i>	Brown Thrasher	4	IL	24
<i>Tyrannus tyrannus</i>	Eastern Kingbird	4	IL	24
<i>Vireo griseus</i>	White-eyed Vireo	4	IL <sup>a</sup>	24
<i>Canis latrans</i>	Coyote	5	IL	25
<i>Caprimulgus vociferus</i>	Whip-poor-will	5	IL <sup>a</sup>	25
<i>Charadrius vociferus</i>	Killdeer	5	IL	25
<i>Chordeiles minor</i>	Common Nighthawk	5	IL	25
<i>Coccothraustes vespertinus</i>	Evening Grosbeak	5	IL	25
<i>Coccyzus americanus</i>	Yellow-billed Cuckoo	5	IL <sup>a</sup>	25
<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo	5	IL	25
<i>Colaptes auratus</i>	Northern Flicker	5	IL <sup>b</sup>	25
<i>Corvus brachyrhynchos</i>	American Crow	5	IL	25
<i>Didelphis virginiana</i>	Virginia Opossum	5	IL <sup>a</sup>	25
<i>Dolichonyx oryzivorus</i>	Bobolink	5	IL	25
<i>Marmota monax</i>	Woodchuck	5	IL	25
<i>Melanerpes erythrocephalus</i>	Red-headed Woodpecker	5	IL <sup>a</sup>	25

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix E. Climate stable, common species... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Meleagris gallopavo</i>	Wild Turkey	5	IL <sup>a</sup>	25
<i>Mephitis mephitis</i>	Striped Skunk	5	IL	25
<i>Passerculus sandwichensis</i>	Savannah Sparrow	5	IL	25
<i>Pipilo erythrophthalmus</i>	Eastern Towhee	5	IL <sup>a</sup>	25
<i>Pooecetes gramineus</i>	Vesper Sparrow	5	IL	25
<i>Procyon lotor</i>	Raccoon	5	IL	25
<i>Scolopax minor</i>	American Woodcock	5	IL	25
<i>Spizella pusilla</i>	Field Sparrow	5	IL <sup>a</sup>	25
<i>Vermivora chrysoptera</i>	Golden-winged Warbler	5	IL <sup>a</sup>	25
<i>Vermivora pinus</i>	Blue-winged Warbler	5	IL <sup>a</sup>	25
<i>Vulpes vulpes</i>	Red Fox	5	IL	25

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

Appendix F. Species without a numeric S-rank (Historic, Unknown, or Not Ranked), ranked by climate vulnerability.

Species	English Name	S Rank	CCVI	Relative Vulnerability
<i>Coregonus bartlettii</i>	Siskiwit lake cisco	H	EV	N/A
<i>Siren intermedia nettingi</i>	Western lesser siren	H	EV	N/A
<i>Speyeria idalia</i>	Regal fritillary	H	EV <sup>a</sup>	N/A
<i>Obliquaria reflexa</i>	Threehorn wartyback	NSR	EV	N/A
<i>Fontigens nickliniana</i>	Watercress snail	SU	EV	N/A
<i>Anguispira kochi</i>	Banded globe	U	EV	N/A
<i>Discus patulus</i>	Domed disc	U	EV	N/A
<i>Lasmigona compressa</i>	Creek heelsplitter	SNR	HV	N/A
<i>Mesodon elevatus</i>	Proud globe	SU	HV	N/A
<i>Pomatiopsis cincinnatiensis</i>	Brown walker	SU	HV	N/A
<i>Apidoscelis sexlineatus</i>	Six-lined racerunner	U	HV	N/A
<i>Appalachina sayana</i>	Spike-lip crater	U	HV	N/A
<i>Mesomphix cupreus</i>	Copper button	U	HV	N/A
<i>Pyrgulopsis letsoni</i>	Gravel pyrg	U	HV	N/A
<i>Papaipema aweme</i>	Aweme borer	H	MV <sup>b</sup>	N/A
<i>Nycticeius humeralis</i>	Evening bat	NA	MV <sup>a</sup>	N/A

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."

## Changing Climate, Changing Wildlife

### Appendix F. Species without state-level numeric conservation rank... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Bufo americanus americanus</i>	Eastern American toad	NR	MV	N/A
<i>Aythya affinis</i>	Lesser Scaup	NRN	MV	N/A
<i>Aythya marila</i>	Greater Scaup	NRN	MV	N/A
<i>Aythya valisineria</i>	Canvasback	NRN	MV	N/A
<i>Ligumia nasuta</i>	Eastern pondmussel	NSR	MV	N/A
<i>Helisoma anceps</i>	Two-ridge rams-horn	SU	MV	N/A
<i>Potamopyrgus antipodarum</i>	New Zealand mudsnail	SU	MV	N/A
<i>Pupilla muscorum</i>	Widespread column	U	MV	N/A
<i>Vertigo pygmaea</i>	Crested vertigo	U	MV	N/A
<i>Hypophthalmichthys nobilis</i>	Big head carp		PS <sup>a</sup>	N/A
<i>Helmitheros vermivorus</i>	Worm-eating Warbler	NA	PS <sup>a</sup>	N/A
<i>Bombus affinis</i>	Rusty-patched bumble bee	NR	PS <sup>a</sup>	N/A
<i>Bombus terricola</i>	Yellow banded bumble bee	NR	PS <sup>b</sup>	N/A
<i>Myotis septentrionalis</i>	Northern bat or Northern myotis	NR	PS	N/A
<i>Anas acuta</i>	Northern Pintail	NRN	PS	N/A
<i>Anas clypeata</i>	Northern Shoveler	NRN	PS	N/A
<i>Anas strepera</i>	Gadwall	NRN	PS	N/A

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."



Appendix F. Species without state-level numeric conservation rank... continued

Species	English Name	S Rank	Climate Vulnerability	Relative Vulnerability
<i>Oxyura jamaicensis</i>	Ruddy Duck	NRN	PS	N/A
<i>Dreissena polymorpha</i>	Zebra mussel	SNA	PS	N/A
<i>Phasianus colchicus</i>	Ring-necked Pheasant	SNA	PS <sup>a</sup>	N/A
<i>Branta hutchinsii</i>	Cackling Goose	U	PS	N/A
<i>Philomycus carolinianus</i>	Carolina mantleslug	U	PS	N/A
<i>Puma concolor</i>	Cougar	H	IL	N/A
<i>Aeshna canadensis</i>	Canada darner	NR	IL <sup>b</sup>	N/A

Vulnerability: EV Extremely Vulnerable, HV Highly Vulnerable, MV Moderately Vulnerable, PS Presumed Stable, IL Increase Likely

<sup>a</sup> The CCVI output included the caveat that "Species may expand range in assessment area."

<sup>b</sup> The CCVI output included the caveat that "Species range may shift and perhaps leave the assessment area."