Climate Change Vulnerability Assessment of Natural Features in Michigan's Coastal Zone – Phase I: Potential Changes to Natural Communities

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EXECUTIVE SUMMARY

Michigan's coastal zone contains rare and ecologically significant natural communities including the globally unique freshwater dune systems, drowned river mouths, and coastal wetlands such as Great Lakes marshes and coastal fens. These and other natural communities in the coastal zone provide habitat for many rare and declining plants and animals, including several species found nowhere else on Earth. Climate change can significantly impact the biodiversity in Michigan and the Great Lakes region. Scientists, resource managers, planners, conservationists, and policymakers have emphasized the need to identify and implement strategies for adapting or dealing with impacts of climate change. Understanding which species and habitats are most vulnerable and why is key to developing effective adaptation strategies.

To assist in climate change adaptation efforts, we initiated a two-year project to assess the vulnerability of natural features in Michigan's coastal zone to climate change, including plant and animal species and natural communities. This report summarizes our analysis and results and provides a preliminary assessment of the potential impacts of climate change on Michigan's natural communities. We selected eleven variables on which to assess the impacts of climate change on each of the 76 natural communities described for Michigan (Kost et al. 2007). Each variable was scored for vulnerability and confidence. Average vulnerability and confidence scores were calculated for each variable, natural community, and natural community group (e.g., upland forests, wetland forests, etc.).

Overall, results indicate that many wetland communities will be negatively impacted by climate change. Forested wetlands are predicted to be most impacted, with the greatest changes expected in the communities that support a significant conifer component such as poor conifer swamp, rich conifer swamp, rich tamarack swamp, and hardwood-conifer swamp. Fens and bogs are also likely to be negatively impacted. In addition to wetlands, several upland forest communities with significant conifer components are likely to be negatively impacted, especially boreal forest and mesic northern forest.

Unlike most wetlands, many upland community types have the potential to benefit through increased acreage resulting from colonization of former mesic to wet habitats. Upland natural communities that have the potential to benefit from a warmer and drier climate include prairies, savannas, open dunes, sand and gravel beach, Great Lakes cobble shores, bedrock grasslands and glades, and bedrock shorelines.

As climate changes, the assemblages of species that currently comprise Michigan's natural communities will also change. It is unlikely that whole communities will migrate northward along with climate. Instead, species will respond independently to the changes according to their ability to thrive or decline under the altered climate regime and associated stressors. In many cases, new species assemblages will arise to reflect the new environmental conditions.

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Introduction

Climate change can significantly impact biodiversity. Scientists, resource managers, planners, conservationists, and policymakers have emphasized the need to identify and implement strategies for adapting or dealing with impacts of climate change. The MI-Great Lakes Plan, the Michigan Climate Action Plan, the Michigan Wildlife Action Plan (WAP), and the Association of Fish and Wildlife Agencies' Climate Change Committee have all recommended that Michigan incorporate climate change into planning and management efforts. To do this, further analyses are needed to identify, prepare for, and respond to the effects of climate change on natural resources including fish and wildlife and their habitats. Some species and habitats will be more vulnerable to climate change than others. Understanding which species and habitats are most vulnerable and why is key to developing effective adaptation strategies.

Michigan's coastal zone contains rare and ecologically significant natural communities including the globally unique freshwater dune systems, drowned river mouths, and coastal wetlands such as Great Lakes marshes and coastal fens. These and other natural communities in the coastal zone provide habitat for many rare and declining plants and animals, including several species found nowhere else on Earth. These include globally rare and/or endemic species such as the Federal and state threatened Pitcher's thistle (*Cirsium pitcheri*), the Federal and state threatened dwarf lake iris (*Iris lacustris*), the state threatened Lake Huron locust (*Trimerotropis huroniana*), the Federal and state endangered Piping Plover (*Charadrius melodus*), and the state special concern Pleistocene catinella (*Catinella exile*) (i.e., a land snail known only from seven states and provinces globally and in Michigan only along the shoreline of Lakes Michigan and Huron). Over 25% of the documented natural features occurrences in Michigan's Natural Heritage Database occur within two miles of the shoreline (Michigan Natural Features Inventory 2011). Michigan's Wildlife Action Plan identifies 81 Species of Greatest Conservation Need (SGCN) and landscape features that are associated with the shoreline.

To assist in climate change adaptation efforts, the Michigan Natural Features Inventory (MNFI), in partnership with the Michigan Coastal Zone Management Program, Michigan Department of Natural Resources' (MDNR) Wildlife Division, NatureServe and The Nature Conservancy (TNC), initiated a two-year project to assess the vulnerability of natural features in Michigan's coastal zone to climate change. In addition to climate change vulnerability assessments of plant and animal species, this project includes assessing the vulnerability of natural communities found in Michigan's coastal zone to climate change by developing a general model or criteria for assessing vulnerability and using available climate change and natural community information and expertise. We identified natural communities that may be impacted by climate change and the factors or variables that could contribute to those impacts.

It is important to emphasize that a natural community is an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape, and is predominantly structured by natural processes rather than modern anthropogenic disturbances (Kost et al. 2007). Although soils and geology are critical factors for structuring the distribution of natural communities, climate is the primary driver. As environmental conditions change, individual species respond with increased or decreased growth and fecundity; new niches are carved out and others are vacated; competitive relationships are

altered, new ones arise, and old ones die out; symbiotic relationships are broken, forged, and changed. In summary, as climate changes, the assemblages of species that currently comprise Michigan's natural communities will also change. It is unlikely that whole communities will migrate northward along with climate. Instead, species will respond independently to the changes according to their ability to thrive or decline under the altered climate regime and associated stressors (e.g., changes in canopy cover, soil mycorrhizal associations, competitive relationships, natural disturbances, invasive species, etc.). These new species assemblages may not be easy to predict. The relatively slow pace of community change likely further complicates matters for biologists and land managers. For example, broad changes in plant species composition for most natural communities is likely to be a relatively slow process when compared to the average person's ability to notice these changes (e.g., longer than several decades, a career, a lifetime). Many of the dominant trees in our present forests have life spans of 200 to 300 years and some much longer.

This report is meant to serve as a preliminary assessment of the potential impacts of climate change on Michigan's natural communities. Although this report attempts to shed light on how different natural communities may respond to climate change and potential associated stressors, it is important to understand that, at the level of a natural community, many of the ecological changes resulting from climate change are difficult to predict, and observable changes will often lag considerably behind the current climate regime. In addition, this analysis is meant to be only a preliminary assessment of potential changes resulting from a warmer and drier climate. The results of this analysis would have been significantly different with a different set climate projections (e.g., warmer and wetter, cooler and drier, cooler and wetter, etc.). We will be conducting further review and refining this analysis during the second year of the project. We also will be seeking some external review of our analysis and results.

Methods

For this analysis, we selected eleven variables on which to assess the impacts of climate change on each of the 76 natural communities described for Michigan (Kost et al. 2007). Fifty-nine of these communities have occurrences documented in the MNFI Natural Heritage Database (MNFI 2011). The variables were drawn from our current understanding of the potential climate-related changes and associated stressors (see Table 1 for variables assessed). A review of the Massachusetts climate change report provided a helpful starting point for selecting several of the variables and structuring the analysis (Manomet Center for Conservation Sciences and Massachusetts Division of Fisheries and Wildlife 2010).

Each variable was scored for vulnerability and confidence. Vulnerability was scored with the following scale: +5, +3, +1, 0, -1, -3, -5. Positive numbers indicate the community is likely to benefit. Negative numbers indicate the community is likely to be negatively impacted. Zero indicates the effect of the variable is neutral overall. Larger numbers, positive or negative, indicate greater impact (positive or negative). The scoring range of 1, 3, and 5 was used to provide greater separation among composite scores. Confidence was scored using a scale of 1, 2, and 3, with higher numbers indicating greater confidence in the assignment of a vulnerability score. Average vulnerability and confidence scores were calculated for each variable, natural community, and natural community group (e.g., upland forests, wetland forests, etc.).

Table 1. Climate Change Variables Assessed for Natural Communities

1. Increased Air and Surface Temperatures
2. Longer Growing Season
3. Phenological Change
4. Latitude Range Expansion or Contraction
5. Intrinsic Ability to Disperse
6. Increased Frequency or Intensity of Extreme Events (e.g., fire, drought, windstorms, and floods)
7. Great Lakes Lower Water Levels
8. Reduction in Regional Groundwater and Surface Water Levels
9. Wetter Winters and Springs and Drier Summers and Falls
10. Overall Drier Climate (>evaporation and evapotranspiration and drier soils)
11. Increased Levels of Invasive Plants, Pests, Pathogens, Grazers, and Browsers

Results

Each climate change variable and the average vulnerability and confidence scores are discussed below. The vulnerability and confidences scores for each variable, natural community, and natural community group are included in Appendices 1 and 2.

Overall, results indicate that many wetland communities will be negatively impacted by climate change. Forested wetlands are predicted to be most impacted, with the greatest changes expected in the communities that support a significant conifer component such as poor conifer swamp, rich conifer swamp, rich tamarack swamp, and hardwood-conifer swamp. Fens and bogs are also likely to be negatively impacted. In addition to wetlands, several upland forest communities with significant conifer components are likely to be negatively impacted, especially boreal forest and mesic northern forest.

Unlike most wetlands, many upland community types have the potential to benefit through increased acreage resulting from colonization of former mesic to wet habitats. Upland natural communities that have the potential to benefit from a warmer and drier climate include prairies, savannas, open dunes, sand and gravel beach, Great Lakes cobble shores, bedrock grasslands and glades, and bedrock shorelines.

Explanation of Variables Assessed

1. Increased Air and Surface Temperatures

The effect of increased air and surface temperatures is likely to vary among natural community types. Community types comprised primarily of species that are most competitive in full sunlight or are well-adapted to hot, dry conditions are likely to benefit. This includes community types such as marshes, wet prairies, upland prairies and savannas, dry pine and oak forests, open dunes, and bedrock communities. An exception to this general trend may be open community types that are strongly dependent on cold groundwater such as fens. Unlike the other open wetland types, it is possible that fens may be negatively impacted by warmer surface

temperatures. Community types comprised of species well-adapted to moist, cool conditions such as mesic forests and those with mesic or wetland conifers may be negatively impacted by warmer air and surface temperatures. Negatively impacted community types may include mesic southern forest, mesic northern forest, poor conifer swamp, rich conifer swamp, rich tamarack swamp, hardwood conifer swamp, muskeg, and bog. This variable was consistently scored with a low level of confidence (1.1).

2. Longer Growing Season

Most natural communities are likely to benefit from a longer growing season. However, diversity in mixed hardwood-conifer systems may be detrimentally impacted. The present climate regime provides a competitive advantage to the conifers that retain their leaves throughout the year. While the broad-leaved deciduous trees are dormant, pine, hemlock, fir, spruce, cedar, juniper, and yew are able to continue to photosynthesize when temperatures are above freezing. If the period of dormancy for broad-leaved deciduous trees is shortened, the competitive advantage to the conifers will be reduced. Over time, a longer growing season may result in reductions in the frequency of conifers for some natural communities, especially those occurring near the floristic tension zone in mid Lower Michigan. Communities that may be detrimentally impacted include dry-mesic northern forest, mesic northern forest, boreal forest, hardwood-conifer swamp, rich tamarack swamp, rich conifer swamp, and poor conifer swamp. Many of the conifer species are very long-lived, and white pine reaches heights well above the hardwood canopy (i.e., it forms a super canopy above the hardwoods). Thus, a reduction in the abundance of conifers due to a longer growing season is likely to be a relatively slow process. Confidence scores for this variable ranged from low to high but were overall low (1.3).

3. Phenological Change

Because most of the dominant plants (i.e., trees, grasses, and sedges) in the natural communities are wind pollinated, this variable was consistently assessed as neutral (i.e., 0). Confidence scores for this variable were consistently low (1.0). A much more thorough review of the plant and animals pollinators and dispersers for each natural community would need to be conducted to increase the confidence score.

4. Latitude Range Expansion or Contraction

Many natural communities are restricted in their movement because the soils or bedrock they require are geographically limited. This is especially true for the bedrock natural communities. Natural communities such as alvar, northern bald, bedrock glades, bedrock shorelines, and bedrock cliffs, are all severely restricted in their movement. In addition, large water bodies such as the Great Lakes block their northward and southward movement, especially in the Upper Peninsula. Lastly, agricultural fields and development further limit opportunities for range expansion, especially in southern Lower Michigan. Confidence for this variable was scored as low or high for this variable but was low overall (1.4).

5. Intrinsic Ability to Disperse

This variable was difficult to apply consistently. The primary difficulty encountered was that many of the communities that have a very high intrinsic or natural ability to disperse, such as grasslands, are now extremely fragmented and rare. This is especially evident in southern Lower Michigan, where agricultural fields and development severely restrict natural dispersal

opportunities. Confidence scores for this variable ranged from low to high and were overall low to medium (1.6).

6. Increased Frequency or Intensity of Extreme Events (e.g., fire, drought, windstorms, and floods)

An increase in the frequency or intensity of extreme events (e.g., fire, drought, windstorms, and floods) is likely to lead to a decrease in the acreage of both upland and wetland forests and a subsequent increase in savanna and open lands (both uplands and wetlands). An increase in the frequency of downbursts, will lead to higher rates of windthrow, especially in forested wetlands where trees are shallowly rooted. The loss of canopy cover will favor shrubs and herbaceous species that are most competitive in conditions of mid and high levels of light. Similarly, an increase in the frequency of fire will result in reductions in forest canopy cover and provide a competitive advantage to open land species. Increases in the frequency of droughts and floods have the potential to negatively impact forest canopy cover and hasten the conversion to savanna and open natural communities. Confidence scores for this variable ranged from low to high and were overall medium (1.9).

7. Great Lakes Lower Water Levels

Lower water levels in the Great Lakes would lead to a direct expansion lakeward of the open natural communities that currently occupy the shoreline. This was widely observed when Great Lakes water levels dropped during the late 1990s and early to mid 2000s. Communities such as sand and gravel beach and open dunes are likely to expand lakeward where the newly exposed shoreline is comprised of sand. Current Great Lakes marshes are likely to expand as well. Bedrock shorelines will expand where retreating water levels expose fresh bedrock. Similarly, cobble shores will expand or arise where bedrock cobble is freshly exposed. The vertical face of lakeshore bedrock cliffs will increase as water levels drop and expose more of the cliff face. New lakeshore bedrock cliffs may also be exposed with retreating water levels. Alvar and bedrock glades will eventually come to dominate the landward portions of the bedrock lakeshore communities, and over a longer time period, forests will move lakeward. Confidence scores for this variable ranged from low to high and were overall low to medium (1.6).

One climate model suggests the potential for higher Great Lakes water levels but overall fluctuations are predicted to be within their normal range of variation (Lofgren 2002). Long-term rises in Great Lakes water levels beyond their normal range of variation will initially cause reductions in the acreage of many of the coastal natural communities but this change is likely to be temporary as wave, wind, ice, and storm disturbances facilitate the creation of open, primary communities along the lakeshore.

8. Reduction in Regional Groundwater and Surface Water Levels

Reductions in regional groundwater and surface water levels are likely to lead to a significant decrease in acreages of both open and forested wetlands. In many locations, the loss of wetlands will result in a subsequent expansion of adjacent upland natural communities. However, this conversion often may not be predictable. The soils of many wetlands are composed of organic soils (e.g., peat, muck). Reductions in ground and surface water levels will lead to an oxidation of the peat/organic soil, which will hasten its decomposition and significantly reduce its overall volume. The result would be a lowering of the land surface in these former wetlands. For

example, where there was once ten feet of peat overlaying mineral soil, there may be only a foot or less of organic material mixed with mineral soils due to compression, decomposition, and mixing by animals and plants. These soils are likely to have high organic content and thus high water holding capacity. Thus, the plant communities that develop on former peat soils will likely be comprised of a mix of wetland and upland plants. Some of the natural communities that could occupy former peatlands might include mesic prairie, mesic sand prairie, wet-mesic prairie, mesic southern forest, and mesic northern forest. Lastly, as these peatlands dry, they will be especially prone to catching fire, which would lead to the direct loss of organic material.

In addition to changes in wetlands, a reduction in regional ground and surface water levels is likely to result in significant declines in species diversity for both inland and lakeshore cliffs. Many cliffs have areas of groundwater seepage along their faces where mosses, lichens, liverworts, and ferns are abundant. In many cases, the cessation of groundwater seepage from the face of a cliff will lead to the loss of these species. Confidence scores for this variable ranged from low to high and were overall medium (1.8).

9. Wetter Winters and Springs and Drier Summers and Falls

This variable is not easy to accurately assess. The growth of most woody plants is concentrated during the spring and early summer. Consequently, wetter winters and springs followed by drier summers and falls may not significantly impact most woody species, and those that are already well-adapted to drier conditions, such as many oaks and pines, may benefit. However, drier summers and falls increases the chances of wildfires, which overtime could lead to significant reductions in forest canopy cover and an increase in the frequency of stand replacement events for boreal forest, dry northern forest, and dry-mesic northern forest. The scenario of wetter winters and springs followed by drier summers and falls will likely favor species well-adapted to drier conditions. Therefore, natural communities such as dry and dry-mesic prairies, oak barrens, oak opening, oak-pine barrens, pine barrens, alvar, bedrock shorelines, and bedrock glades may expand their acreages. Confidence scores for this variable ranged from low to medium but were overall low (1.1).

10. Overall Drier Climate (greater evaporation and evapotranspiration and drier soils)

The average annual precipitation in Michigan is approximately 30 inches, which favors the establishment and growth of trees. A drier climate is likely to result in a decrease in the overall acreage of all wetland communities (i.e., marshes, prairies, fens, bogs, shrublands, and forests). Mesic and boreal forests are also likely to be adversely impacted by an overall drier climate. Communities that are well adapted to drier conditions and which may expand in acreage include upland prairies, savannas, bedrock glades, open dunes, and oak and pine forests. Confidence scores for this variable ranged from low to high and were overall low to medium (1.6).

11. Increased Levels of Invasive Plants, Pests, Pathogens, Grazers, and Browsers

This attribute was especially difficult to score for several reasons. First, because of the large number of potential invasives plants, animals, and pathogens, we lacked the range of expertise needed to fully assess the potential threats posed by the potential expansion of these species resulting from climate change. Secondly, the potential for future, new introductions and their potential impacts is unknown. Thirdly, in many instances, an invasion may result in detrimental impacts for one community but indirectly benefit a different, adjacent community. For example,

a tree pathogen may severely reduce canopy cover, which may result in an expansion of an adjacent open community. There are numerous examples of this interaction in both wetlands and uplands but the interactions can be complex and hard to predict. For example, a tree pathogen in a dry-mesic northern forest or boreal forest on thin soils over bedrock may result in widespread tree mortality and a severe reduction of canopy cover. Consequently, the community would be especially vulnerable to a catastrophic fire event. In this example, the tree pathogen could cause a decrease in the acreage of dry-mesic northern forest or boreal forest and a subsequent increase in the acreage an adjacent bedrock glade. Confidence scores for this variable ranged from low to high but were overall low (1.1).

12. Average Vulnerability

The variables we selected for assessing climate change are not necessarily additive. Nonetheless, it may be helpful to review their composite scores. In general, our assessment indicates that most wetland communities will be negatively impacted by a change in climate that includes warmer and drier conditions. In particular, fens, bogs, and forested wetlands are predicted to be most impacted, with the greatest changes expected in the conifer-dominated wetlands. In addition to these wetlands, several upland forests are likely to be negatively impacted, especially boreal forest and mesic northern forest. Conversely, many other upland community types have the potential to expand in acreage, and thus, potentially benefit. Upland community types that have the potential to benefit from a warmer and drier climate include prairies, savannas, open dunes, sand and gravel beach, Great Lakes cobble shores, bedrock glades, and bedrock shorelines.

13. Average Confidence

In general, our confidence in assessing the various variables was scored low (1.4 on a scale of 1 to 3). The highest confidence scores on average were assigned for the variables of Increased Frequency or Intensity of Extreme Events (1.9) and Reduction in Regional Groundwater and Surface Water Levels (1.8). The lowest confidence scores were assigned to Phenological Change (1.0), Increased Air and Surface Temperatures (1.1), Wetter Winters and Springs and Drier Summers and Falls (1.1), and Increased Levels of Invasive Plants, Pests, Pathogens, Grazers, and Browsers (1.1). The overall low confidence scores is an indication that the there are far more unknowns than knowns when it comes to understanding the potential impacts of climate change.

Discussion

This analysis indicates that natural communities comprised of light-demanding, drought-tolerant species are likely to expand in acreage. This may include upland prairies, savannas, bedrock glades, bedrock shorelines, open dunes, and sand and gravel beaches. At least initially, Great Lakes marshes and cobble shores are also likely to expand in acreage, as water levels in the Great Lakes recede. Conversely, communities comprised of species that require constant moisture (i.e., wetlands) or constant moisture and shade (i.e., forested wetlands) are likely to decline in acreage. In particular, bogs, fens, and forested wetlands, especially those in which conifers are a significant component, are likely to decline. Over time, mesic and wetland conifers are likely to be outcompeted by broad-leaved deciduous species, especially in the Lower

Peninsula. Reductions in mesic and wetland conifers will significantly reduce structural diversity in boreal forest, mesic northern forest, poor conifer swamp, rich conifer swamp, hardwood-conifer swamp, and rich tamarack swamp. Reductions in the abundance of mesic and wetland confers will result in significant reductions in overall landscape diversity.

The natural communities of Michigan represent species assemblages that share relatively similar environment requirements (e.g., temperature, moisture, light, soils, etc.). Changes in environmental conditions will result in changes in species composition. Some of the responses by species to environmental changes are well understood but many others are not. Although this report seems to suggest that whole communities may be able to migrate, in many cases, new species assemblages will arise to reflect the new environmental conditions. Thus, novel combinations of species may arise that do not well reflect our present understanding of Michigan natural community species composition. In many cases, these changes will appear slowly. For example, many of the dominant tree species can live several hundred years, and once well established, have relatively broad tolerances for changes in temperature and moisture. The most easily observable changes in the natural communities of Michigan are likely to be found along the shorelines of the Great Lakes. Changes in Great Lakes water levels can result in rapid changes in the acreages of coastal natural communities. If Great Lakes water levels drop, as some models predict, efforts to prevent the widespread colonization of invasive plants on the newly exposed sediments will be a critical step in facilitating the establishment of high-quality coastal natural communities, especially Great Lakes marsh.

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Financial assistance for this project was provided, in part, by the Michigan Coastal Management Program (MCMP), Department of Environmental Quality (DEQ), through a grant from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations provided in this report are those of the Michigan Natural Features Inventory and Michigan State University (MSU) and do not necessarily reflect the views of the DEQ and the NOAA. Michigan Natural Features Inventory provided match for this project. We would like to thank Lynda Krupansky, Project Manager with the MCMP, for her administration and assistance with this project. We also would like to acknowledge Nancy Toben and Sue Ridge with MNFI and the MSU Office of Sponsored Programs and Contract and Grant Administration for assistance with administering this project.

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Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Increased Air and Surface Temperatures		Longer Growing Season		Phenological Change	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
MARSH COMMUNITIES						
Submergent Marsh	1	1	1	1	0	1
Emergent Marsh	1	1	3	1	0	1
Great Lakes Marsh	1	1	3	1	0	1
Northern Wet Meadow	1	1	3	1	0	1
Southern Wet Meadow	1	1	3	1	0	1
Inland Salt Marsh	1	1	3	1	0	1
Intermittent Wetland	1	1	3	1	0	1
Coastal Plain Marsh	1	1	3	1	0	1
Interdunal Wetland	-1	1	3	1	0	1
WET PRAIRIE COMMUNITIES						
Wet Prairie	1	1	3	1	0	1
Wet-mesic Prairie	1	1	3	1	0	1
Wet-mesic Sand Prairie	1	1	3	1	0	1
Lakeplain Wet Prairie	1	1	3	1	0	1
Lakeplain Wet-mesic Prairie	1	1	3	1	0	1
FEN COMMUNITIES				1		
Prairie Fen	-1	1	3	1	0	1
Northern Fen	-1	1	3	1	0	1
Coastal Fen	-1	1	3	1	0	1
Patterned Fen	-1	1	3	1	0	1
Poor Fen	-1	1	3	1	0	1
BOG COMMUNITIES						
Bog	-1	1	-1	1	0	1
Muskeg	-1	1	-1	1	0	1
SHRUB WETLAND COMMUNITIES						
Northern Shrub Thicket	1	1	5	3	0	1
Southern Shrub-carr	1	1	5	3	0	1
Inundated Shrub Swamp	1	1	5	3	0	1
FORESTED WETLAND COMMUNITIES						
Poor Conifer Swamp	-1	1	-1	1	0	1
Rich Conifer Swamp	-1	1	-1	1	0	1
Rich Tamarack Swamp	-1	1	-1	1	0	1
Hardwood-Conifer Swamp	-1	1	-1	1	0	1
Northern Hardwood Swamp	1	1	1	2	0	1
Southern Hardwood Swamp	1	1	1	2	0	1
Floodplain Forest	1	1	3	2	0	1
Wet-mesic Flatwoods	1	1	1	2	0	1
PALUSTRINE/TERRESTRIAL COMMUNITIES						
Wooded Dune and Swale Complex	0	1	0	1	0	1
TERRESTRIAL COMMUNITIES						
PRAIRIE COMMUNITIES						
Dry Sand Prairie	0	1	1	2	0	1
Dry-mesic Prairie	1	1	1	2	0	1
Mesic Sand Prairie	1	1	1	2	0	1
Mesic Prairie	1	1	1	2	0	1
Hillside Prairie	1	1	1	2	0	1
SAVANNA COMMUNITIES						
Pine Barrens	1	2	1	2	0	1
Oak-Pine Barrens	1	2	1	2	0	1
Oak Barrens	1	2	1	2	0	1
Oak Openings	1	2	1	2	0	1
Bur Oak Plains						
Lakeplain Oak Openings	1	1	3	2	0	1
FOREST COMMUNITIES						
Dry Northern Forest	1	1	0	1	0	1
Dry-mesic Northern Forest	1	1	-1	1	0	1
Mesic Northern Forest	-1	1	-1	1	0	1
Dry Southern Forest	1	1	1	1	0	1
Dry-mesic Southern Forest	1	1	1	1	0	1

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Increased Air and Surface Temperatures		Longer Growing Season		Phenological Change	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
Mesic Southern Forest	-1	1	3	2	0	1
Boreal Forest	-1	1	-1	1	0	1
PRIMARY COMMUNITIES						
COASTAL SAND COMMUNITIES						
Sand and Gravel Beach	0	1	0	1	0	1
Open Dunes	1	1	1	1	0	1
Great Lakes Barrens	1	1	1	1	0	1
BEDROCK GRASSLAND AND GLADE COMMUNITIES						
Alvar	1	1	1	1	0	1
Limestone Bedrock Glade	1	1	-1	1	0	1
Granite Bedrock Glade	1	1	-1		0	1
Volcanic Bedrock Glade	1	1	-1	1	0	1
Northern Bald	1	1	-1	1	0	1
COBBLE SHORE COMMUNITIES						
Limestone Cobble Shore	1	1	1	1	0	1
Sandstone Cobble Shore	1	1	1	1	0	1
Volcanic Cobble Shore	1	1	1	1	0	1
BEDROCK LAKESHORE COMMUNITIES						
Limestone Bedrock Lakeshore	1	1	1	1	0	1
Sandstone Bedrock Lakeshore	1	1	1	1	0	1
Granite Bedrock Lakeshore	1	1	3	1	0	1
Volcanic Bedrock Lakeshore	1	1	1	1	0	1
LAKESHORE CLIFF COMMUNITIES						
Limestone Lakeshore Cliff	1	1	1	1	0	1
Sandstone Lakeshore Cliff	1	1	1	1	0	1
Granite Lakeshore Cliff	1	1	1	1	0	1
Volcanic Lakeshore Cliff	1	1	1	1	0	1
INLAND CLIFF COMMUNITIES						
Limestone Cliff	1	1	1	1	0	1
Sandstone Cliff	1	1	1	1	0	1
Granite Cliff	1	1	1	1	0	1
Volcanic Cliff	1	1	1	1	0	1
SUBTERRANEAN/SINK COMMUNITIES						
Cave	0	3	0	3	0	1
Sinkhole	0	1	1	1	0	1
Average	**0.5**	**1.1**	**1.3**	**1.3**	**0.0**	**1.0**

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Latitude Range Expansion or Contraction		Intrinsic Ability to Disperse		Increased Frequency or Intensity of Extreme Events (e.g., fire, drought, windstorms, and floods)	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
MARSH COMMUNITIES						
Submergent Marsh	0	1	5	3	0	1
Emergent Marsh	0	1	5	3	0	1
Great Lakes Marsh	0	1	5	3	0	1
Northern Wet Meadow	-5	3	3	1	3	2
Southern Wet Meadow	5	3	3	1	3	2
Inland Salt Marsh	0	1	-5	3	1	2
Intermittent Wetland	0	1	5	2	3	3
Coastal Plain Marsh	3	1	-3	1	1	2
Interdunal Wetland	0	1	-1	1	0	1
WET PRAIRIE COMMUNITIES						
Wet Prairie	1	1	1	1	3	2
Wet-mesic Prairie	1	1	1	1	3	2
Wet-mesic Sand Prairie	1	1	1	1	3	2
Lakeplain Wet Prairie	1	1	1	1	3	1
Lakeplain Wet-mesic Prairie	1	1	1	1	3	1
FEN COMMUNITIES						
Prairie Fen	1	1	-3	1	3	1
Northern Fen	-1	1	-3	1	3	1
Coastal Fen	0	1	-3	1	3	1
Patterned Fen	-1	1	-3	1	3	1
Poor Fen	-1	1	-3	1	3	1
BOG COMMUNITIES						
Bog	-1	1	-3	1	1	1
Muskeg	-1	1	-3	1	1	1
SHRUB WETLAND COMMUNITIES						
Northern Shrub Thicket	-1	1	5	3	3	2
Southern Shrub-carr	1	1	5	3	3	2
Inundated Shrub Swamp	1	1	3	1	3	2
FORESTED WETLAND COMMUNITIES						
Poor Conifer Swamp	-1	1	-1	1	-3	2
Rich Conifer Swamp	-1	1	-1	1	-3	2
Rich Tamarack Swamp	-1	1	1	1	-5	2
Hardwood-Conifer Swamp	-1	1	-1	1	-3	2
Northern Hardwood Swamp	-1	1	1	1	-3	2
Southern Hardwood Swamp	1	1	1	1	-3	2
Floodplain Forest	0	1	0	1	-3	2
Wet-mesic Flatwoods	0	1	0	1	-3	2
PALUSTRINE/TERRESTRIAL COMMUNITIES		1				
Wooded Dune and Swale Complex	0	1	1	1	-1	1
TERRESTRIAL COMMUNITIES						
PRAIRIE COMMUNITIES						
Dry Sand Prairie	1	1	1	1	5	3
Dry-mesic Prairie	1	1	1	1	5	3
Mesic Sand Prairie	1	1	1	1	5	3
Mesic Prairie	1	1	1	1	5	3
Hillside Prairie	1	1	1	1	5	3
SAVANNA COMMUNITIES						
Pine Barrens	0	1	1	1	5	3
Oak-Pine Barrens	0	1	1	1	5	3
Oak Barrens	1	1	1	1	5	3
Oak Openings	1	1	1	1	5	3
Bur Oak Plains						
Lakeplain Oak Openings	1	1	1	1	3	1
FOREST COMMUNITIES						
Dry Northern Forest	0	1	1	1	1	1
Dry-mesic Northern Forest	0	1	1	1	1	1
Mesic Northern Forest	-1	1	3	2	-5	3
Dry Southern Forest	1	1	1	1	1	1
Dry-mesic Southern Forest	1	1	1	1	1	1

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Latitude Range Expansion or Contraction		Intrinsic Ability to Disperse		Increased Frequency or Intensity of Extreme Events (e.g., fire, drought, windstorms, and floods)	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
Mesic Southern Forest	3	3	5	3	-5	3
Boreal Forest	-5	3	-5	3	-3	2
PRIMARY COMMUNITIES						
COASTAL SAND COMMUNITIES						
Sand and Gravel Beach	0	1	5	3	5	3
Open Dunes	0	1	5	3	5	1
Great Lakes Barrens	1	1	1	1	0	1
BEDROCK GRASSLAND AND GLADE COMMUNITIES						
Alvar	0	3	1	1	3	2
Limestone Bedrock Glade	0	1	3	1	5	1
Granite Bedrock Glade	0	1	1	1	5	1
Volcanic Bedrock Glade	0	1	5	3	5	3
Northern Bald	0	1	3	1	5	2
COBBLE SHORE COMMUNITIES						
Limestone Cobble Shore	0	3	5	1	5	3
Sandstone Cobble Shore	0	1	5	3	5	3
Volcanic Cobble Shore	0	1	5	3	5	3
BEDROCK LAKESHORE COMMUNITIES						
Limestone Bedrock Lakeshore	0	3	5	1	5	3
Sandstone Bedrock Lakeshore	0	1	5	3	5	3
Granite Bedrock Lakeshore	0	1	1	1	3	1
Volcanic Bedrock Lakeshore	0	1	5	3	5	3
LAKESHORE CLIFF COMMUNITIES						
Limestone Lakeshore Cliff	0	3	1	1	0	2
Sandstone Lakeshore Cliff	0	3	1	1	0	2
Granite Lakeshore Cliff	0	3	1	1	0	2
Volcanic Lakeshore Cliff	0	3	1	1	0	2
INLAND CLIFF COMMUNITIES						
Limestone Cliff	0	3	0	3	0	2
Sandstone Cliff	0	3	0	3	0	2
Granite Cliff	0	3	0	3	0	2
Volcanic Cliff	0	3	0	3	0	2
SUBTERRANEAN/SINK COMMUNITIES						
Cave	0	3	0	3	0	3
Sinkhole	0	1	0	1	0	1
Average	**0.1**	**1.4**	**1.2**	**1.6**	**1.7**	**1.9**

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Great Lakes Lower Water Levels		Reduction in Regional Groundwater and Surface Water Levels		Wetter Winters and Springs and Drier Summers and Falls	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
MARSH COMMUNITIES						
Submergent Marsh	0	1	-3	1	0	1
Emergent Marsh	0	1	-3	1	0	1
Great Lakes Marsh	3	3	0	1	0	1
Northern Wet Meadow	0	1	-3	1	-1	1
Southern Wet Meadow	0	1	-3	1	-1	1
Inland Salt Marsh	0	1	-5	3	-1	1
Intermittent Wetland	0	1	-1	1	1	1
Coastal Plain Marsh	0	1	-5	3	1	1
Interdunal Wetland	-3	1	-5	3	0	1
WET PRAIRIE COMMUNITIES						
Wet Prairie	0	1	-3	2	0	1
Wet-mesic Prairie	0	1	-3	2	0	1
Wet-mesic Sand Prairie	0	1	-3	2	0	1
Lakeplain Wet Prairie	1	1	-5	1	1	1
Lakeplain Wet-mesic Prairie	1	1	-5	1	1	1
FEN COMMUNITIES						
Prairie Fen	0	1	-5	3	0	1
Northern Fen	-1	1	-5	3	0	1
Coastal Fen	3	1	-5	3	0	1
Patterned Fen	0	1	-5	3	0	1
Poor Fen	0	1	-5	3	0	1
BOG COMMUNITIES						
Bog	0	1	-5	3	-3	1
Muskeg	0	1	-5	3	-3	1
SHRUB WETLAND COMMUNITIES						
Northern Shrub Thicket	0	1	-3	1	1	1
Southern Shrub-carr	0	1	-3	1	1	1
Inundated Shrub Swamp	0	1	-3	1	1	1
FORESTED WETLAND COMMUNITIES						
Poor Conifer Swamp	0	1	-3	2	-1	1
Rich Conifer Swamp	-1	1	-5	3	-1	1
Rich Tamarack Swamp	0	1	-5	3	-1	1
Hardwood-Conifer Swamp	-1	1	-5	3	-1	1
Northern Hardwood Swamp	-1	1	-5	3	1	1
Southern Hardwood Swamp	0	1	-5	3	1	1
Floodplain Forest	-1	1	-3	2	0	1
Wet-mesic Flatwoods	0	1	-3	3	0	1
PALUSTRINE/TERRESTRIAL COMMUNITIES						
Wooded Dune and Swale Complex	0	1	-1	1	0	1
TERRESTRIAL COMMUNITIES						
PRAIRIE COMMUNITIES						
Dry Sand Prairie	0	3	0	1	1	2
Dry-mesic Prairie	0	3	-1	1	1	2
Mesic Sand Prairie	0	3	-1	1	1	2
Mesic Prairie	0	3	-1	1	1	2
Hillside Prairie	0	3	0	1	1	2
SAVANNA COMMUNITIES						
Pine Barrens	0	3	0	1	1	1
Oak-Pine Barrens	0	3	0	1	1	1
Oak Barrens	0	3	0	1	1	1
Oak Openings	0	3	0	1	1	1
Bur Oak Plains						
Lakeplain Oak Openings	0	1	0	1	3	1
FOREST COMMUNITIES						
Dry Northern Forest	0	2	-1	2	-1	1
Dry-mesic Northern Forest	0	1	-1	2	-1	1
Mesic Northern Forest	0	1	-1	2	-1	2
Dry Southern Forest	0	2	-1	2	-1	1
Dry-mesic Southern Forest	0	1	-1	2	-1	1

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Great Lakes Lower Water Levels		Reduction in Regional Groundwater and Surface Water Levels		Wetter Winters and Springs and Drier Summers and Falls	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
Mesic Southern Forest	0	1	-1	2	-1	2
Boreal Forest	0	1	0	1	-1	1
PRIMARY COMMUNITIES						
COASTAL SAND COMMUNITIES						
Sand and Gravel Beach	5	3	5	3	0	1
Open Dunes	5	3	0	1	0	1
Great Lakes Barrens	1	1	0	1	1	1
BEDROCK GRASSLAND AND GLADE COMMUNITIES						
Alvar	3	2	1	1	1	1
Limestone Bedrock Glade	5	1	0	1	3	1
Granite Bedrock Glade	5	1	0	1	3	1
Volcanic Bedrock Glade	5	1	0	1	3	1
Northern Bald	0	3	0	3	1	1
COBBLE SHORE COMMUNITIES						
Limestone Cobble Shore	5	3	0	1	1	1
Sandstone Cobble Shore	5	3	0	1	0	1
Volcanic Cobble Shore	5	3	-1	1	0	1
BEDROCK LAKESHORE COMMUNITIES						
Limestone Bedrock Lakeshore	5	3	0	1	1	1
Sandstone Bedrock Lakeshore	5	3	0	1	0	1
Granite Bedrock Lakeshore	3	1	0	3	0	1
Volcanic Bedrock Lakeshore	5	3	-1	1	0	1
LAKESHORE CLIFF COMMUNITIES						
Limestone Lakeshore Cliff	1	1	-1	2	0	1
Sandstone Lakeshore Cliff	1	1	-1	2	0	1
Granite Lakeshore Cliff	1	1	-1	2	0	1
Volcanic Lakeshore Cliff	1	1	-1	2	0	1
INLAND CLIFF COMMUNITIES						
Limestone Cliff	0	2	-1	2	0	1
Sandstone Cliff	0	2	-1	2	0	1
Granite Cliff	0	2	-1	2	0	1
Volcanic Cliff	0	2	-1	2	0	1
SUBTERRANEAN/SINK COMMUNITIES						
Cave	0	1	0	1	0	1
Sinkhole	0	1	0	1	0	1
Average	**0.9**	**1.6**	**-1.9**	**1.8**	**0.2**	**1.1**

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Overall Drier Climate (>evaporation and evapotranspiration and drier soils)		Increased Levels of Invasive Plants, Pests, Pathogens, Grazers, and Browsers		Average	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
MARSH COMMUNITIES					**-0.2**	**1.4**
Submergent Marsh	-3	1	-3	1	-0.3	1.2
Emergent Marsh	-3	1	-5	1	-0.3	1.2
Great Lakes Marsh	-1	1	-5	1	0.5	1.4
Northern Wet Meadow	-3	3	-1	1	-0.4	1.5
Southern Wet Meadow	-3	3	-1	1	0.5	1.5
Inland Salt Marsh	-5	3	-1	1	-1.2	1.6
Intermittent Wetland	-1	1	-1	1	0.8	1.3
Coastal Plain Marsh	-5	3	-1	1	-0.5	1.5
Interdunal Wetland	-3	1	-1	1	-0.9	1.2
WET PRAIRIE COMMUNITIES					**0.2**	**1.1**
Wet Prairie	-1	1	-1	1	0.3	1.2
Wet-mesic Prairie	-1	1	-1	1	0.3	1.2
Wet-mesic Sand Prairie	-1	1	-1	1	0.3	1.2
Lakeplain Wet Prairie	-1	1	-5	1	0.0	1.0
Lakeplain Wet-mesic Prairie	-1	1	-5	1	0.0	1.0
FEN COMMUNITIES					**-0.7**	**1.3**
Prairie Fen	-5	3	-1	1	-0.6	1.4
Northern Fen	-5	3	-1	1	-0.9	1.4
Coastal Fen	-1	1	-1	1	-0.2	1.2
Patterned Fen	-5	3	-1	1	-0.8	1.4
Poor Fen	-5	3	-1	1	-0.8	1.4
BOG COMMUNITIES					**-1.5**	**1.4**
Bog	-5	3	-1	1	-1.5	1.4
Muskeg	-5	3	-1	1	-1.5	1.4
SHRUB WETLAND COMMUNITIES					**0.7**	**1.5**
Northern Shrub Thicket	-3	2	-1	1	0.6	1.5
Southern Shrub-carr	-3	2	-1	1	0.8	1.5
Inundated Shrub Swamp	-3	2	-1	1	0.6	1.4
FORESTED WETLAND COMMUNITIES					**-1.5**	**1.4**
Poor Conifer Swamp	-5	2	-5	2	-1.8	1.4
Rich Conifer Swamp	-5	2	-3	2	-1.9	1.5
Rich Tamarack Swamp	-5	2	-5	2	-2.0	1.5
Hardwood-Conifer Swamp	-5	2	-5	2	-2.2	1.5
Northern Hardwood Swamp	-3	2	-3	1	-1.1	1.5
Southern Hardwood Swamp	-3	2	-3	1	-0.9	1.5
Floodplain Forest	-3	2	-3	1	-0.8	1.4
Wet-mesic Flatwoods	-3	2	-3	1	-1.0	1.5
PALUSTRINE/TERRESTRIAL COMMUNITIES					**-0.2**	**1.0**
Wooded Dune and Swale Complex	0	1	-1	1	-0.2	1.0
TERRESTRIAL COMMUNITIES						
PRAIRIE COMMUNITIES					**0.8**	**1.5**
Dry Sand Prairie	1	1	-1	1	0.9	1.5
Dry-mesic Prairie	1	1	-1	1	0.8	1.5
Mesic Sand Prairie	1	1	-1	1	0.8	1.5
Mesic Prairie	1	1	-1	1	0.8	1.5
Hillside Prairie	1	1	-1	1	0.8	1.5
SAVANNA COMMUNITIES					**1.0**	**1.5**
Pine Barrens	3	2	-1	1	0.9	1.6
Oak-Pine Barrens	3	2	-1	1	0.9	1.6
Oak Barrens	3	2	-1	1	1.0	1.6
Oak Openings	3	2	-1	1	1.0	1.6
Bur Oak Plains						
Lakeplain Oak Openings	3	1	-1	1	1.3	1.1
FOREST COMMUNITIES					**-0.4**	**1.5**
Dry Northern Forest	1	2		1	0.0	1.3
Dry-mesic Northern Forest	1	2		1	-0.1	1.2
Mesic Northern Forest	-3	2	-5	3	-1.2	1.7
Dry Southern Forest	1	2		1	0.3	1.3
Dry-mesic Southern Forest	1	2		1	0.4	1.2

Appendix 1. Natural Community Vulnerability and Confidence Scores for Eleven Climate Change Variables

NATURAL COMMUNITY GROUPS	Overall Drier Climate (>evaporation and evapotranspiration and drier soils)		Increased Levels of Invasive Plants, Pests, Pathogens, Grazers, and Browsers		Average	
Natural Communities	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**	**Vulnerability**	**Confidence**
Mesic Southern Forest	-3	2	-5	3	-0.3	2.1
Boreal Forest	-1	1	-5	1	-2.0	1.5
PRIMARY COMMUNITIES					**0.9**	**1.4**
COASTAL SAND COMMUNITIES					**1.3**	**1.4**
Sand and Gravel Beach	0	1	-1	1	1.7	1.7
Open Dunes	5	2	-1	1	1.8	1.5
Great Lakes Barrens	1	1	-1	1	0.4	1.0
BEDROCK GRASSLAND AND GLADE COMMUNITIES					**1.3**	**1.3**
Alvar	1	1	-1	1	0.8	1.4
Limestone Bedrock Glade	3	2	-1	1	1.5	1.1
Granite Bedrock Glade	3	1	-1	1	1.3	0.9
Volcanic Bedrock Glade	3	1	-1	1	1.7	1.4
Northern Bald	5	2	-1	1	1.1	1.5
COBBLE SHORE COMMUNITIES					**1.4**	**1.5**
Limestone Cobble Shore	0	1	-1	1	1.5	1.5
Sandstone Cobble Shore	0	1	-1	1	1.4	1.5
Volcanic Cobble Shore	1	1	-1	1	1.4	1.5
BEDROCK LAKESHORE COMMUNITIES					**1.4**	**1.5**
Limestone Bedrock Lakeshore	0	1	-1	1	1.5	1.5
Sandstone Bedrock Lakeshore	0	1	-1	1	1.4	1.5
Granite Bedrock Lakeshore	1	1	1	1	1.2	1.2
Volcanic Bedrock Lakeshore	1	1	-1	1	1.4	1.5
LAKESHORE CLIFF COMMUNITIES					**0.1**	**1.4**
Limestone Lakeshore Cliff	-1	1	-1	1	0.1	1.4
Sandstone Lakeshore Cliff	-1	1	-1	1	0.0	1.4
Granite Lakeshore Cliff	-1	1	-1	1	0.1	1.4
Volcanic Lakeshore Cliff	-1	1	-1	1	0.1	1.4
INLAND CLIFF COMMUNITIES					**-0.2**	**1.6**
Limestone Cliff	-1	1	-1	1	-0.1	1.6
Sandstone Cliff	-1	1	-1	1	-0.2	1.6
Granite Cliff	-1	1	-1	1	-0.3	1.6
Volcanic Cliff	-1	1	-1	1	-0.2	1.6
SUBTERRANEAN/SINK COMMUNITIES					**0.0**	**1.5**
Cave	0	1	0	1	0.0	1.9
Sinkhole	0	1	-1	1	0.0	1.0
Average	**-0.9**	**1.6**	**-1.6**	**1.1**	**0.1**	**1.4**

Appendix 2. Natural Community Group Vulnerability and Confidence Scores

Natural Community Groups	Average Vulnerability	Average Confidence
PALUSTRINE COMMUNITIES	-0.5	1.3
MARSH COMMUNITIES	-0.2	1.4
WET PRAIRIE COMMUNITIES	0.2	1.1
FEN COMMUNITIES	-0.7	1.3
BOG COMMUNITIES	-1.5	1.4
SHRUB WETLAND COMMUNITIES	0.7	1.5
FORESTED WETLAND COMMUNITIES	-1.5	1.4
PALUSTRINE/TERRESTRIAL COMMUNITIES	-0.2	1.0
TERRESTRIAL COMMUNITIES	0.7	1.5
PRAIRIE COMMUNITIES	0.8	1.5
SAVANNA COMMUNITIES	1.0	1.5
FOREST COMMUNITIES	-0.4	1.5
PRIMARY COMMUNITIES	0.9	1.4
COASTAL SAND COMMUNITIES	1.3	1.4
BEDROCK GLADE COMMUNITIES	1.3	1.3
COBBLE SHORE COMMUNITIES	1.4	1.5
BEDROCK LAKESHORE COMMUNITIES	1.4	1.5
LAKESHORE CLIFF COMMUNITIES	0.1	1.4
INLAND CLIFF COMMUNITIES	-0.2	1.6
SUBTERRANEAN/SINK COMMUNITIES	0.0	1.5