CLIMATE IMPACTS – EASTERN UPPER PENINSULA AND NORTHERN LOWER MICHIGAN

From the Adaptation Workbook: www.adaptationworkbook.org/explore-impacts

Eastern Upper Peninsula and Northern Lower Michigan (Albert's Ecological Sections 7 and 8)

Summary of Climate Impacts (details and citations on subsequent pages):

Northern Michigan temperatures will increase between 2 °F and 8 °F by the end of the century, with more warming during winter.

Northern Michigan's winter snowpack will be reduced from 30-80% by the end of the century.

Northern Michigan will have 30-50 fewer days of frozen ground during the winter by the end of the century.

Northern Michigan's growing season will increase by 30 to 70 days by the end of the century.

Intense precipitation events will continue to become more frequent in northern Michigan.

Northern Michigan soil moisture patterns will change, with drier soil conditions later in the growing season.

Climate conditions will increase fire risks in northern Michigan by the end of the century.

Many invasive species, insect pests, and pathogens in northern Michigan forests will increase or become more damaging by the end of the century.

Northern Michigan's boreal species will face increasing stress from climate change.

Southern or temperate species in northern Michigan will be favored by climate change.

Northern Michigan's forest productivity will increase by the end of the century.

Low-diversity systems are at greater risk from climate change.

Species in fragmented landscapes will have less opportunity to migrate in response to climate change.

Systems that are limited to particular environments will have less opportunity to migrate in response to climate change.

Systems that are more tolerant of disturbance have less risk of declining on the landscape.

Table 19.—Vulnerability determination summaries for the forest systems considered in this assessment

Forest system	Potential impacts	Adaptive capacity	Vulnerability	Evidence	Agreement
Upland spruce-fir	Negative	Low	High	Medium-High	Medium-High
Jack pine (including pine-oak)	Moderate	Moderate-Low	High-Moderate	Medium	Medium-High
Red pine-white pine	Moderate	Moderate-Low	High-Moderate	Limited-Medium	Medium
Lowland conifers	Negative	Moderate-Low	High-Moderate	Medium	Medium
Aspen-birch	Moderate-Negative	Moderate	Moderate	Medium	Medium
Northern hardwoods	Moderate	Moderate-High	Moderate	Medium	Medium
Lowland-riparian hardwoods	Moderate-Negative	Moderate	Moderate	Medium	Low-Medium
Oak associations	Moderate	Moderate-High	Low-Moderate	Medium	Medium
Barrens	Moderate-Positive	Moderate-High	Low-Moderate	Limited-Medium	Medium

Table source: S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

Video presentation: Climate Change Impacts on Northwoods Forests

Northern Michigan temperatures will increase between 2 °F and 8 °F by the end of the century, with more warming during winter.

All global climate models project that temperatures will increase with continued increases in atmospheric greenhouse gas concentrations.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

Northern Michigan's winter snowpack will be reduced from 30-80% by the end of the century.

A variety of models project that across the Upper Midwest, more winter precipitation will be delivered as rain, more snow will melt between snowfall events, and the snowpack will not be as deep or consistent. Lake-effect snowfall may increase in the short-term, but these events may convert to rain as temperatures increase.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

D. Lorenz and M. Notaro. 2014. LCC Statistical Downscaling: Michigan. Nelson Center for Climatic Research - University of Wisconsin-Madison.

M. Notaro, D. Lorenz, and others. 2011. 21st century Wisconsin snow projections based on an operational snow model driven by statistically downscaled climate data. International Journal of Climatology.

T. Sinha and K. Cherkauer. 2010. Impacts of future climate change on soil frost in the midwestern United States. Journal of Geophysical Research: Atmospheres.

Northern Michigan will have 30-50 fewer days of frozen ground during the winter by the end of the century.

Cold-season soil temperatures are projected to increase between 1.8 and 5.4 °F by the end of the century, and total frost depth is projected to deline by 40 to 80 percent across northern Michigan by the end of the century. These conditions could increase water infiltration into the soil and reduce runoff, but they may also lead to greater soil water losses through increased evapotranspiration. The decrease in snowcover and frozen soil is expected to affect land management operations and a variety of ecosystem processes, including decomposition activity, nutrient cycling, the onset of the growing season, and other phenological factors.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

T. Sinha and K. Cherkauer. 2010. Impacts of future climate change on soil frost in the midwestern United States. Journal of Geophysical Research: Atmospheres.

Northern Michigan's growing season will increase by 30 to 70 days by the end of the century.

Evidence at both global and local scales indicates that growing seasons have been getting longer, and this trend is projected to become even more pronounced over the next century. As seasons shift so that spring arrives earlier and fall extends later into the year, phenology may shift for plant species that rely on temperature as a cue for the timing of leaf-out, reproductive maturation, and other developmental processes. Longer growing seasons could also result in greater growth and productivity of trees and other vegetation, but only if balanced by available water and nutrients.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

D. Wuebbles and K. Hayhoe. 2004. Climate Change Projections for the United States Midwest. Mitigation and Adaptation Strategies for Global Change.

Intense precipitation events will continue to become more frequent in northern Michigan.

Heavy precipitation events have been increasing in number and severity in the upper Midwest in general and for Michigan in particular, and many models agree that this trend will continue over the next century. Most heavy precipitation events occur during summer in Michigan. The magnitude or frequency of flooding could also potentially increase in the winter and spring due to increases in total runoff and peak stream flow during those times. Increases in runoff after heavy precipitation events could also lead to an increase in soil erosion.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

Northern Michigan soil moisture patterns will change, with drier soil conditions later in the growing season.

Large variation exists for projected changes in precipitation for Michigan and the Upper Midwest. Although individual model projections may differ, there is general agreement that annual precipitation is expected to remain consistent or increase slightly during the 21st century. Models also tend to agree that precipitation patterns between seasons may shift substantially. Precipitation increases are generally expected to be larger in winter and spring, while summer precipitation is projected to increase slightly or decrease sharply. As seasonal precipitation changes, it is reasonable to expect that soil moisture regimes will also change. Longer growing seasons and warmer temperatures may also result in greater evapotranspiration losses and lower soil-water availability later in the growing season. Model outputs indicate that forests in northern Michigan may become increasingly moisture-limited under climate change. This may be the case particularly in locations where soils and landforms do not allow precipitation from intense events to be retained. Model projections differ greatly, however, and it is also possible that the assessment area will have an increase in precipitation sufficient to offset increases in evapotranspiration.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

Climate conditions will increase fire risks in northern Michigan by the end of the century.

At a global scale, the scientific consensus is that fire risk will increase by 10 to 30 percent due to higher summer temperatures. For the early part of the 21st century, there is low agreement in this trend across climate models. By the end of the century, however, most models project an increase in wildfire probability, particularly for boreal forests, temperate coniferous forests, and temperate broadleaf forests. Studies from southern Canada also project more active wildfire regimes in the future. In addition to the direct effects of temperature and precipitation, increases in fuel loads from pest-induced mortality or blowdown events could increase fire risk, but the relationship between these factors can be complex. Forest fragmentation and unknown future wildfire management decisions also make fire projections more uncertain in parts of northern Michigan. Additionally, we do not have clear projections of how the timing or nature of the fire regimes in Michigan may change—the proportion of surface fires to crown fires, for example.

M. Moritz, M. Parisien, and others. 2012. Climate Change and Disruptions to Global Fire Activity. Ecosphere.
S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.
C. Dreyer, Y. Bergeron, and others. 2009. Effects of climate on occurrence and size of large fires in a northern hardwood landscape. Applied Vegetation Science.
M. Flannigan, B. Stocks, and others. 2009. Impacts of climate change on fire activity and fire management in the circumboreal forest. Global Change Biology.

Many invasive species, insect pests, and pathogens in northern Michigan forests will increase or become more damaging by the end of the century.

Evidence indicates that an increase in temperature and greater moisture stress will lead to increases in these kinds of stressors, but research to date has examined only a few species. Invasive species are already a persistent and growing challenge across much of the United States. Changes may exacerbate this problem, as warmer temperatures may allow some invasive plant species, insect pests, and pathogens to expand their ranges farther north. Northern Michigan may lose some of the protection offered by a traditionally cold climate and short growing season. Combinations of factors may also favor invasive species, such as exotic earthworms, and facilitation among several nonnative species. Pests and pathogens are generally more damaging in stressed forests, so there is high potential for these agents to interact with other climate-mediated stressors. Unfortunately, we lack basic information on the climatic thresholds that apply to many forest pests, and our ability to predict the mechanisms of infection, dispersal, and transmission for disease agents remains low. Furthermore, it is not possible to predict all future invasive species, pests, or pathogens that may enter northern Michigan during the 21st century.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.
J. Dukes, J. Pontius, and others. 2009. Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America. Canadian Journal of Forest Research.
N. Eisenhauer, N. Fisichelli, and others. 2012. Interactive effects of global warming and 'global worming' on the initial establishment of native and exotic herbaceous plants. Oikos.

Northern Michigan's boreal species will face increasing stress from climate change.

Impact models agree that boreal or northern species will experience reduced suitable habitat and biomass across northern Michigan, and that they may be less able to take advantage of longer growing seasons and warmer temperatures than temperate forest communities. Across northern latitudes, it is generally expected that warmer temperatures will be more favorable to species that are located at the northern extent of their range and less favorable to those at the southern extent. Climate impact models project a decline in suitable habitat and landscape-level biomass for northern species such as balsam fir, black spruce, tamarack, jack pine, paper birch, northern white-cedar, and white spruce. Boreal species may remain in areas with favorable soils, management, or landscape features. Additionally, northern species may be able to persist in northern Michigan if competitor species are unable to colonize these areas.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

Southern or temperate species in northern Michigan will be favored by climate change.

Impact models agree that many temperate species will experience increasing suitable habitat and biomass across northern Michigan, and that longer growing seasons and warmer temperatures will lead to productivity increases for temperate forest types. The list of species projected to increase includes American basswood, black cherry, green ash, white ash, white oak, and a variety of minor southern species. Models also indicate that deciduous forest types have the potential for large productivity increases across northern Michigan. In addition, suitable habitat may become available for species not currently found in northern Michigan (e.g., black hickory, hackberry, and post oak) by the end of the century. Habitat fragmentation and dispersal limitations could hinder the northward movement of southern species, despite the increase in habitat suitability. Most species can be expected to migrate more slowly than their habitats will shift. Pests and diseases such as emerald ash borer and Dutch elm disease are also expected to limit some species projected to increase.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

Northern Michigan's forest productivity will increase by the end of the century.

Model projections and other evidence support modest productivity increases for forests across northern Michigan under climate change, although there is uncertainty about the effects of carbon dioxide fertilization. Warmer temperatures are expected to speed nutrient cycling and increase photosynthetic rates for most tree species in the assessment area. Longer growing seasons could also result in greater growth and productivity of trees and other vegetation, but only if sufficient water and nutrients are available. It is expected that productivity will be reduced in localized areas, through disturbances such as fires, wind events, droughts, and pest outbreaks. In addition, lags in migration of species to newly suitable habitat may also reduce productivity until a new equilibrium is reached.

S. Handler, M. Duveneck, and others. 2014. Michigan Forest Ecosystem Vulnerability Assessment. USDA Forest Service Northern Research Station.

R. Norby and D. Zak. 2011. Ecological Lessons from Free-Air CO2 Enrichment (FACE) Experiments. Annual Review of Ecology Evolution and Systematics.

Low-diversity systems are at greater risk from climate change.

Studies have consistently shown that diverse systems have exhibited greater resilience to extreme environmental conditions and greater potential to recover from disturbance than less diverse communities. This relationship makes less diverse communities inherently more susceptible to future changes and stressors. The diversity of potential responses of a system to environmental change (response diversity), is a critical component of ecosystem resilience. Response diversity is generally reduced in less diverse ecological systems. Genetic diversity within species is also critical for the ability of populations to adapt to climate change, because species with high genetic variation have better odds of producing individuals that can withstand extreme events and adapt to changes over time.

T. Elmqvist, C. Folke, and others. 2003. Response diversity, ecosystem change, and resilience. Frontiers in Ecology and the Environment.

A. Hoffman and C. Sgrò. 2011. Climate change and evolutionary adaptation. Nature.

Species in fragmented landscapes will have less opportunity to migrate in response to climate change.

Habitat fragmentation can hinder the ability of tree species to migrate to more suitable habitat on the landscape, especially if the surrounding area is nonforested. Modeling results indicate that mean centers of suitable habitat for tree species will migrate between 60 and 350 miles by the year 2100 under a high emissions scenario and between 30 and 250 miles under milder climate change scenarios. Based on data gathered for seedling distributions, it has been estimated that many northern tree species could possibly migrate northward at a rate of 60 miles per century. Fragmentation makes this disparity even more challenging, because the landscape is essentially less permeable to migration.

L. Iverson, M. Schwartz, and others. 2004. How fast and far might tree species migrate in the eastern United States due to climate change? Global Ecology and Biogeography.

C. Woodall, C. Oswalt, and others. 2009. An indicator of tree migration in forests of the eastern United States. Forest Ecology and Management.

Systems that are limited to particular environments will have less opportunity to migrate in response to climate change.

Some species and forest types are confined to particular habitats on the landscape, whether through requirements for hydrologic regimes, soil types, or other reasons. Similar to species occurring in fragmented landscapes, isolated species and systems face additional barriers to migration. Widespread species may also have particular habitat requirements. For example, sugar maple is often limited to soils that are rich in nutrients like calcium, so this species may actually have less available suitable habitat than might be projected solely from temperature and precipitation patterns. Riparian forests are not expected to be able to migrate to upland areas because many species depend on seasonal flood dynamics for regeneration and a competitive advantage. Similarly, lowland conifer swamps contain a unique mix of species that are adapted to low pH values, peat soils, and particular water table regimes. These species face additional challenges in migration compared to more-widespread species with broad ecological tolerances.

A. Jump and J. Peñuelas. 2005. Running to stand still: adaptation and the response of plants to rapid climate change. Ecology Letters.

Systems that are more tolerant of disturbance have less risk of declining on the landscape.

Disturbances such as wildfire, flooding, and pest outbreaks are expected to increase in the future. Forests that are adapted to gap-phase disturbances, with stand-replacing events occurring over hundreds or thousands of years, may be less tolerant of more frequent widespread disturbances. Mesic hardwood forests can create conditions that could buffer against fire and drought to some extent, but these systems are not expected to do well if soil moisture declines significantly. Forest systems that are more tolerant of drought, flooding, or fire are expected to be better able to withstand climate-driven disturbances. This principle holds true only to a given point, because it is also possible for disturbance-adapted systems to experience too much disruption. For example, dry pine forests and woodlands might benefit from drier conditions with more frequent fire, but these systems might also convert to savannas or open grasslands if fire becomes too frequent or drought becomes too severe.

G. Nowacki and M. Abrams. 2008. The Demise of Fire and “Mesophication” of Forests in the Eastern United States. BioScience.

E. Gustafson and B. Sturtevant. 2013. Modeling Forest Mortality Caused by Drought Stress: Implications for Climate Change. Ecosystems.