

How the Climate Affects Forests

Forests are affected by the local climate, in addition to being affected by short-term weather events.

Michigan's climate has been changing over the past several decades, and continued climate change could result in many impacts to forests in our state.

The Earth's climate is changing. Many trends have been tracked, some reaching back tens of thousands of years. Trees and forests are sensitive to a range of environmental conditions, including the climate. In addition to climate, there are other factors to which forests respond, such as human activities and management, biological relationships, and invasive pests. All of this creates a dynamic within which forests grow and change.

How much do climate factors need to change before forests change in a significant way? This question is almost impossible to answer, although there is no doubt about impending change. Climate influences will vary between different forest types and will be complicated by ecological complexities.

Evidence of Change

Historical data goes back about one hundred years for some climate measures. There are a variety of ways climate factors can be inferred, such as pollen cores in bogs and the study of tree rings. Globally, some measures go back 100,000 years. Records over the past 100 years demonstrate some remarkable trends that cannot be attributed to natural causes. These trends vary somewhat across regions, but the overall picture points to a warming, more erratic climate.

Across the entire state, Michigan's average annual temperature increased over 2.4 °F from 1895-2013.¹ Winter temperatures have risen faster (3.3 °F) during the same time, particularly winter low temperatures (3.7 °F). Extreme high temperature periods have increased across the Midwest, including higher night temperatures and higher humidity.

Average annual precipitation has increased by 3.5 inches, with the greatest increases in the summer and fall.¹ There is variation across the state, with some areas experiencing significant droughts. The interaction of temperature, precipitation, and seasonality is important to forests.

Heavy rainfall events (+3 inches in a single event) have become more frequent in Michigan, as well as across the Midwest.² As a greater proportion of precipitation is delivered in large events, there can be longer periods between rain events.

Recent severe events, such as the burst of tornadoes across southern Michigan in 2012 and the northward migration of tornadoes suggest change but long-term records for these phenomena are limited.³

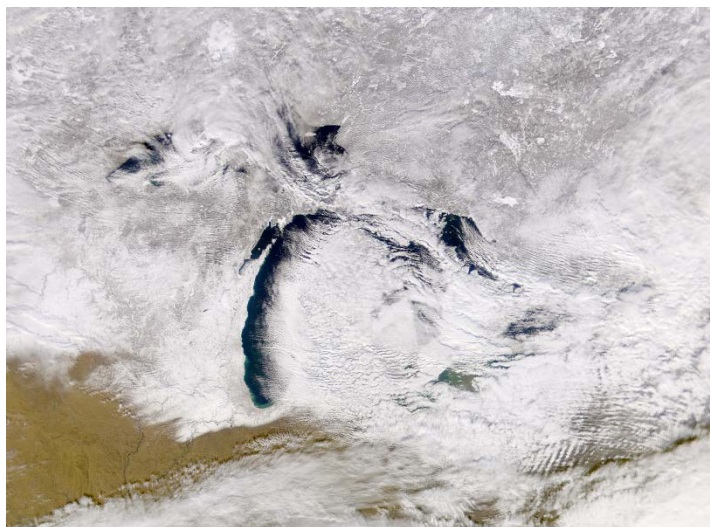
Effects on Forests

How does the climate affect forests? There are many direct and indirect ways. An example of a direct effect might be changes in phenology, for example when trees leaf-out in the spring or when flower buds open. An indirect effect might be the damage done by an insect whose range expands due to warmer winters.

Many forest processes are regulated by photoperiod and less driven by climate change. Other processes are influenced by temperature and other weather variables. The timing of leaf expansion is a common example. Dr. Andy Burton (Michigan Technological University) has observed that sugar maple growing season length has increased by 11.5 days over the past 20 years across a range of sites in Michigan.⁴

Forests are ecological systems that may be slow to respond to climate change. Much of the change is not predicted to occur until the middle of this century. In particular, mature trees are long-lived organisms and may not be good indicators of climate change. However, tree regeneration patterns may be early indicators, especially along ecotones of change (e.g. forest-prairie, hardwood-boreal). Regeneration of red maple and black ash is occurring in certain boreal forests, which is not typical.⁵ Studies are underway examining changes across ecotones in Michigan, Wisconsin, and Minnesota.

More mobile taxa, such as birds and mammals, have experienced expansions in ranges.⁶ These wildlife species serve important roles in the distribution and success of forest regeneration. Moose populations have declined across most of their southern range. Warmer temperatures are an important driver of that dynamic.⁷



Michigan's climate is influenced by the Great Lakes. Forests in Michigan are adapted to areas of lake-effect snowfall and characteristic winter weather. Image courtesy the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE.



Projections

Michigan’s climate is expected to grow warmer and more variable, with increasing drought stress in late summer.⁸ Winters are expected to warm faster than other seasons. Rainfall shows an increase in spring, but a possible decrease in summer. However, precipitation projections vary considerably among models and across regions. Warmer summer temperatures and less rainfall can lead to more severe droughts. Increased CO₂ levels tend to boost forest productivity but this effect may be limited by water availability and other environmental conditions. Growing seasons are expected to continue to lengthen. Table 1 highlights some of the projected climate-related impacts for Michigan forests.⁹

Models

Models based from a variety of sources are used to help predict future forest changes. Models are also useful to determine how different variables interact and which variables may be more important when answering a particular question. Model development and interpretation is complicated. A single tree species or forest type may “behave” differently according to different models or climate inputs.

Effects on more complex climate-driven factors are less certain (wildfire, invasive species), but we have greater confidence in situations where multiple model projections agree and are reinforced by manager expertise.

Table 1. Projected Impacts to Forest Drivers and Stressors

Projected Change (Confidence statements in parentheses)	Explanation
Temperatures will increase (robust evidence, high agreement)	<i>All global climate models project that temperatures will increase with continued increases in atmospheric greenhouse gas concentrations.</i>
Winter processes will change (robust evidence, high agreement)	<i>All evidence agrees that temperatures will increase more in winter than in other seasons across the Upper Midwest, leading to changes in snowfall, soil frost, and other winter processes.</i>
Growing seasons will get longer (robust evidence, high agreement)	<i>There is a strong agreement that projected temperature increases will lead to longer growing seasons in Michigan.</i>
Amount & timing of precipitation will change (medium evidence, high agreement)	<i>All global climate models agree that there will be changes in the precipitation patterns.</i>
Intense precipitation events will continue to become more frequent (medium evidence, high agreement)	<i>There is general agreement that the number of heavy precipitation events will continue to increase in the assessment area. If they do increase, impacts from flooding and soil erosion may also become more damaging.</i>
Droughts will increase in duration and area (limited evidence, low agreement)	<i>A study using multiple climate models indicates that drought may increase in extent and area, and an episodic precipitation regime could mean longer dry periods between events.</i>
Soil moisture patterns will change (medium evidence, high agreement) with drier soil conditions later in the growing season (medium evidence, medium agreement).	<i>Studies show that climate change will have impacts on soil moisture, but there is disagreement among climate and impact models on how soil moisture will change during the growing season.</i>
Climate conditions will increase fire risks by the end of the century (medium evidence, medium agreement)	<i>National and global studies agree that wildfire risk will increase in the region, but few studies have specifically looked at wildfire potential in the Midwest.</i>
Many invasive species, insect pests, and pathogens will increase or become more damaging (limited evidence, high agreement)	<i>Evidence indicates that an increase in temperature and greater moisture stress will lead to increases in these threats, but research to date has examined few species.</i>
Boreal species will face increasing stress from climate change (medium evidence, high agreement)	<i>Impact models agree that boreal or northern species will experience reduced suitable habitat and biomass across Michigan, and that they may be less able to take advantage of longer growing seasons and warmer temperatures than temperate forest communities.</i>
Southern species will be favored by climate change (medium evidence, high agreement).	<i>Impact models agree that suitable habitat and biomass will increase for many temperate species across Michigan, and that longer growing seasons and warmer temperatures will lead to productivity increases for temperate forest types.</i>
Forest communities will change across the landscape (limited evidence, high agreement).	<i>Although few models have specifically examined how communities may change, model results from individual species and ecological principles suggest that recognized forest communities may change in composition as well as occupied range.</i>
Forest productivity will increase across the assessment area (medium evidence, medium agreement).	<i>Some model projections and other evidence support modest productivity increases for forests across the assessment area, although there is uncertainty about the effects of CO₂ fertilization. It is expected that productivity will be reduced in localized areas.</i>

1: National Climatic Data Center, www.ncdc.noaa.gov/cag/

2- 4: Handler et al. 2014. Michigan Forest Ecosystem Vulnerability Assessment and Synthesis. GTR-NRS-129. www.nrs.fs.fed.us/pubs/45688

5: Fischelli, Nicholas et al. 2013. Temperate Tree Expansion into Adjacent Boreal Forest Patches Facilitated by Warmer Temperatures. *Ecography* 36: 001-010.

6: Handler et al. 2014.

7: Lenarz et al. 2009. Temperature Mediated Moose Survival in Northeastern Minnesota. *Journal of Wildlife Management*, 73(4): 503-510.

8-9: Handler et al. 2014.

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This bulletin is part of a series about climate change and forests. More detailed information about forest adaptation and climate change can be found in Handler (2014) and Swanston & Janowiak (2012). Three additional Michigan State University bulletins provide climate background “Climate Basics” – E3151, “Greenhouse Gas Basics” – E3148, and “Frequently Asked Questions About Climate Change” – E3150.