GLISA
A NOAA CAP/RISA TEAM

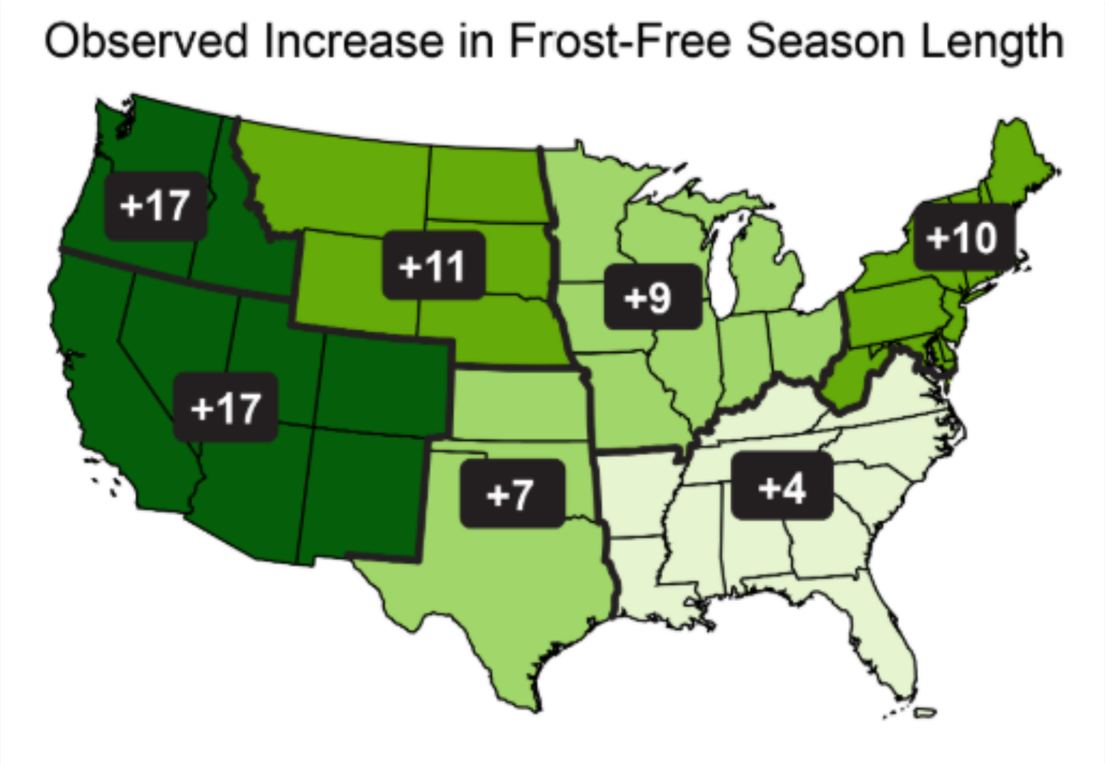
CLIMATE CHANGE IMPACTS ON MICHIGAN AGRICULTURE

SUMMARY

- A longer growing season will positively impact some crop yields through mid-century.
- By the end of the century, more frequent and intense severe weather, more flooding and drought risks, as well as more pests and pathogens will likely reduce crop yields.
- Water availability and quality will likely pose challenges for agriculture.
- Earlier warm spells, coupled with variability in spring freezes, may result in more freeze damage early in the growing season.
- Projected changes in precipitation coupled with rising extreme temperatures before mid-century, will reduce agricultural productivity to levels of the 1980s without major technological advances. [1]

Climate change will have both positive and negative impacts on agricultural yields in the Great Lakes region. A longer growing season and more atmospheric carbon dioxide may alter crop yields through the middle of the 21st century. Beyond that, however, crop yields may decrease as more extreme weather, stress from pests and weeds, and other factors outweigh the benefits of a more fertile atmosphere and soil. [2] [3] [4] [5] [6]

Changes in the timing and amount of precipitation may affect the amount and quality of water available for agricultural use. Increased precipitation in the spring and fall may decrease the number of workable field days during critical periods of planting and harvesting. And stronger and more frequent heavy precipitation events will increase erosion risks and reduce water quality by increasing runoff. [7]



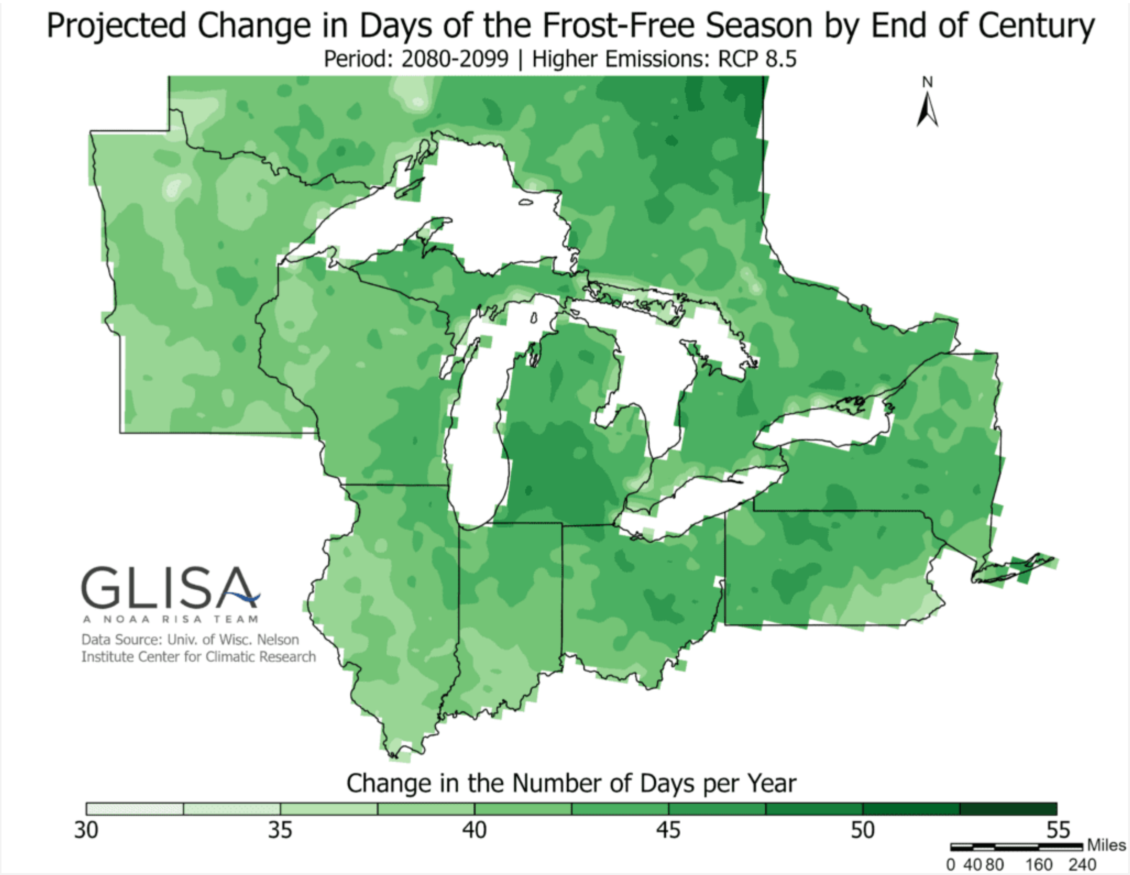
Observed change in the frost-free season length in the United States. The Midwestern and Northeastern U.S. experienced an increase in the frost-free season of 9 and 10 days, respectively from 1958-2012. Image provided by the U.S. Global Change Research Program (USGCRP) Third National Climate Assessment (NCA3, 2014)

REGIONAL VARIATION OF CLIMATE CHANGE IMPACTS

The potential benefits and risks also vary throughout the region. Northern Wisconsin agriculture, for example, is likely to benefit from climate change further into the future, due to its more northern location. [8] By contrast, there has already been an observed decrease in crop yields in southern regions due to an increased number of summer days exceeding 86ºF (30ºC). [9]

POTENTIAL IMPACTS VARY BY CROP TYPE

Land involved in agricultural production represents a significant portion of land use and forms a major part of the economy in the Great Lakes region. Corn, soybeans, and wheat dominate the southern and western portions of the region while fruit, nuts, and specialty crops have been a signature of north and east parts of the Great Lakes region for more than 150 years. [10] The potential vulnerabilities to a changing climate vary dramatically from row crops to perennial fruit crops. While new adaptation efforts can be applied on an annual basis to support most row crops, orchards and other fruit crops require several years to reach optimal yield, during which time major changes to growing practices are usually unfeasible.



The projected change in the number of days of the frost-free (growing) season by the end of the century. Data provided by the University of Wisconsin-Madison Nelson Institute Center for Climatic Research (UW-RegCM4).

CORN AND SOYBEANS

The two main commodity crops in the Midwest are corn and soybeans, which are grown on 75% of the arable land. [11] For soybeans, yields have a two in three chance of increasing early in the near-future due to increased carbon dioxide stimulation. Yields will likely decline towards the end of the century due to increased heat stress from the increased number of days with temperatures above 95 and 100°F. For corn, small long-term average temperature increases will shorten the duration of reproductive development, leading to yield declines, even when offset by increases in CO2 stimulation that will likely occur in a warmer climate. [12] [13] Impacts due to these factors will likely be most severe in more southerly located field cropping regions such as Missouri or southern Illinois.

FRUIT CROPS

Commercial fruit trees in the region will face both positive and negative impacts. These include the benefits of a longer growing season, but also increased pests and a higher sensitivity to cold temperatures that occur after bud break. [14] [15] [16] More intense heat waves, excessive rain interspersed with drought, and higher humidity will likely lead to degraded market quality as well as yield by mid-century. [17] In general, agricultural management will need to account for other climate change impacts, such as lower water tables. [18] Many negative impacts of climate change on agriculture could potentially be avoided by using adaptive farming techniques, such as drought-resistant varieties of crops and more efficient irrigation systems. [19] Diversifying planting dates, pollination periods, chemical use, and crop selection are all examples of methods that can be used to reduce the vulnerability of overall production to climate extremes or changes in pests and pathogens. [20] [21]

WARMER TEMPERATURES AND INCREASED FREEZE VULNERABILITY

The Great Lakes growing season has lengthened by 16 days from 1951-2017, primarily due to an earlier occurrence of the last spring frost in recent decades. [22] [23] Warm-season temperatures are projected to increase more in the Midwest than any other region of the United States. [24] The frost-free season is projected to increase 10 days by early century, 20 days by mid-century, and up to a month by late century compared to the period 1976–2005 (based on a high emissions scenario). [25] Paradoxically, the frequency of spring freezes that occur after the initial phases of crop development have increased during the same time frame. This is likely due to warm-spells that are occurring earlier in the year that in the past, spurring earlier crop development. This has resulted in an increased risk of production losses with time. [26] In 2012 and 2007 in the Northeast and in 2002 in Michigan, similar events severely impacted apple, grape, cherry, and other fruit crops. [27] [28]

Changes in midwinter freeze-thaw patterns in more temperate portions of the region have also impacted fruit crops. For example, midwinter-freeze damage cost New York Finger Lakes wine grape growers millions of dollars in losses in the winters of 2003 and 2004. [29] This damage was attributed to de-hardening of the vines during an unusually warm December, which increased susceptibility to cold damage prior to a subsequent hard freeze. Future crop yields will likely be affected more frequently by anomalous weather events like late winter cold air outbreaks coinciding with long-term changes in seasonality. Cold air outbreaks are defined here as at least two consecutive days during which the daily average surface air temperature is below 95% of the simulated average wintertime surface air temperature. [30]

A picture of a fruit crop affected by a sudden freezing event.

EFFECTS OF INCREASED PRECIPITATION AND HUMIDITY

Climate models project spring precipitation and humidity to increase through mid-century, leading to a number of adverse effects in the region such as soil erosion, more favorable conditions for pests and pathogens, and degraded quality of stored grain. [31] [32] Increased precipitation and soil moisture in conjunction with warmer temperatures also lead to increased loss of soil carbon and degraded surface water quality, due to loss of soil particles and nutrients. [33] [34] The prevalence of fungus and bacterial plant disease outbreaks, such as bacterial spots in pumpkin and squash, can increase under such wet and humid conditions. [35] [36] [37]

EFFECTS OF INCREASING CARBON DIOXIDE ON PESTS AND WEEDS

Increasing CO2 concentrations and temperatures will pose increased challenges to pest control in agricultural settings. For example, Roundup, the most widely-used herbicide in the United States, loses its efficacy on weeds grown at the CO2 levels likely to occur in the coming decades. [38] Warming winters led to increased survival and reproduction of existing insect pests as well as enabling northward range expansion of new pests and crop pathogens into the Great Lakes region. [39] Rising humidity also leads to longer dew periods and high moisture conditions that favor many agricultural pests and pathogens for both growing plants and stored grain.

EXTERNAL RESOURCES

U.S. Drought Monitor: The U.S. Drought Monitor is a weekly map of drought conditions that is produced jointly by the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture, and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln.

The Pileus Project: The overarching purpose of the Pileus Project is to provide useful climate information to assist decision makers. One of two current focus industries in the Great Lakes region is agriculture.

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