LOCALIZED CLIMATE INFORMATION
FOR MENOMINEE COUNTY, MICHIGAN

GLISA
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Historical and projected future climate trends for Menominee County in Michigan are summarized in this report. Menominee County is located in Michigan's West Upper (WUM) climate division.

Regional and Local Climate Summary

The climate division in which Menominee County is contained has seen increases in annual air temperature. While at the same time annual precipitation has decreased. These increases have not been consistent throughout the year. Temperature increases have been largely observed in winter and spring. Summer and fall temperature increases have been substantially smaller.

Table 1: Summary of observed climate change statistics for the West Upper climate division. Changes are for the 1951-1980 to 1981-2010 time period.

	Annual	Winter	Spring	Summer	Fall
Temperature	1.5°F	2.6°F	1.5°F	1.1°F	0.8°F
Precipitation	-2.9%	0.1%	-7.8%	-9.7%	8.1%

Annually, precipitation has decreased in the climate division that includes Menominee County. This decrease has not been evenly distributed throughout the year. Seasonally, precipitation has increased during the fall. Summer and spring have seen decreases in precipitation. While winter precipitation amounts have remained constant, in terms of the amount falling as rain or liquid-water contained in snow.

Lake Michigan water temperatures have risen during the summertime and lake ice levels have declined during the winter, though there is significant interannual variation.[1,2] Increased water temperatures and ice cover declines have the potential to alter the near-shore climate through increased evaporation and potential for increased lake effect snowfall. Though lake event snowfall is less common on the windward side of Lake Michigan.

Future climate information for WUM and Menominee County comes primarily from global and regional climate models (GCMs and RCMs). In the Midwest, the GCMs project a wider range of temperature and precipitation outcomes than the RCMs, so some of the values reported here are beyond what is shown in the RCM-based maps later in this report. No model perfectly simulates the physics that govern global, regional, and local climate, so several models are consulted[3] to describe potential climate changes in the Midwest and Menominee County..

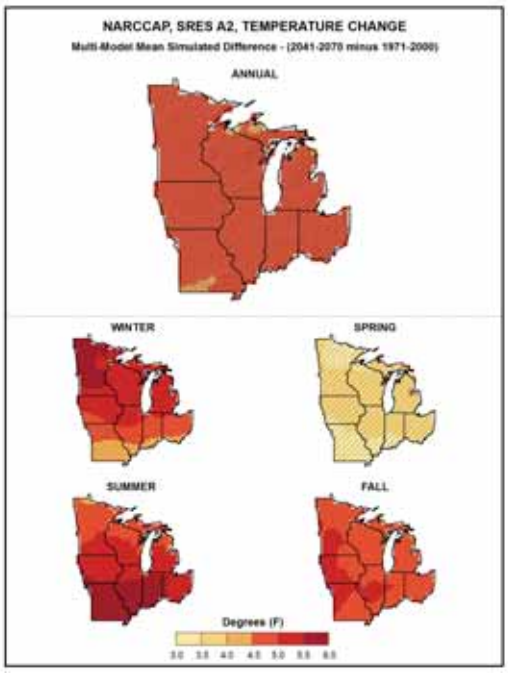
Table 2: Summary of projected climate changes for the Midwest with localized descriptions for Menominee County.[3]

		Short Term (2021-2050)	Long Term (2041-2070)
Annual	**Temperature**	Midwest ranges from 1.5-4.5°F warming with an average around 3°F.	Midwest ranges from 3-5°F warming with an average around 4.5°F. Warming is consistent across most of the Midwest.
	Precipitation	Midwest ranges from -4% to +7% change.	Midwest ranges from -7% to +12% change. WUM has some of the greatest projected annual increases.
Winter	**Temperature**	Midwest ranges from 2-5°F warming with an average around 3.5°F.	Midwest ranges from 3.5-7°F warming with the greatest warming in the north. WUM averages warming toward the upper bound of that range.
	Precipitation	Midwest ranges from -3% to +15% change.	Midwest ranges from -3% to +17% change. Projected changes for WUM are an increase in winter precipitation from 10-17%

Spring	Temperature	Midwest ranges from 1-5°F warming with an average around 3°F.	Midwest ranges from 2-7°F warming. Spring has the smallest increases of any season. Projections of warming in WUM show similar range to most of the larger Midwest.
	Precipitation	Midwest ranges from +2% to +10% change.	Midwest ranges from -5% to 15% changes in precipitation. WUM averages slight increases.
Summer	Temperature	Midwest ranges from 1.5-5.5°F warming with an average around 3.5°F.	Midwest ranges from 2.5-9°F warming. The degree of warming for WUM is in the middle of that range.
	Precipitation	Midwest ranges from -13% to +11% change.	Midwest ranges from -23% to 19% changes in precipitation. WUM shows on average a slight increase (~5%).
Fall	Temperature	Midwest ranges from 1.5-4.5°F warming with an average around 3°F.	Midwest ranges from 3-6.5°F warming. Temperatures in WUM average close to the rest of the region. Though areas near Lake Michigan may experience less warming.
	Precipitation	Midwest ranges from -4% to +7% change.	Midwest ranges from -8% to 12% changes in precipitation. WUM has average increases near the upper bound of that range.
Extremes	Temperature		Days below freezing are projected to decrease across WUM by about three weeks per year. Greater decreases are projected along Michigan's Lake Superior coast. Days above 95°F are projected to increase on average by 5-10 days per year in WUM..
	Precipitation		There is great uncertainty in extreme precipitation projections, but days with greater than 1" precipitation events are projected to increase the most (30% to 50%)in WUM when compared to the larger Midwest region. The largest increases are expected closest to the coastline. Most projections agree that the longest dry period for a year will decrease by a few days in WUM.

On an annual and seasonal basis all models indicate warming temperatures, but models start to diverge from one another in mid- (2041-2070) to late-century (2070-2099) projections. On average, annual temperatures across the Midwest are projected to increase by about 4.5°F by the mid-century. In the near term, temperature increases are projected to be less.

Regional differences start to emerge when seasonal temperature changes are considered. In winter, the greatest warming is projected for the northern Midwest. Winter temperatures in WUM averaged across all regional models project an increase of about 5.0°F, the most widespread increase of any season. Spring temperatures show the least amount of warming across the Midwest, but there is potential for slightly larger increases along the Lake Michigan coast. Projected summer temperature increases across the Midwest range from 2.5°F to 9°F with the greatest increases in the south. Summer temperatures in WUM are shown to increase by 4.5°F to 5.5°F on average. Projected fall temperatures across the Midwest show increases of 3°F to 6.5°F. Fall increases in WUM average 4.5°F to 5°F.

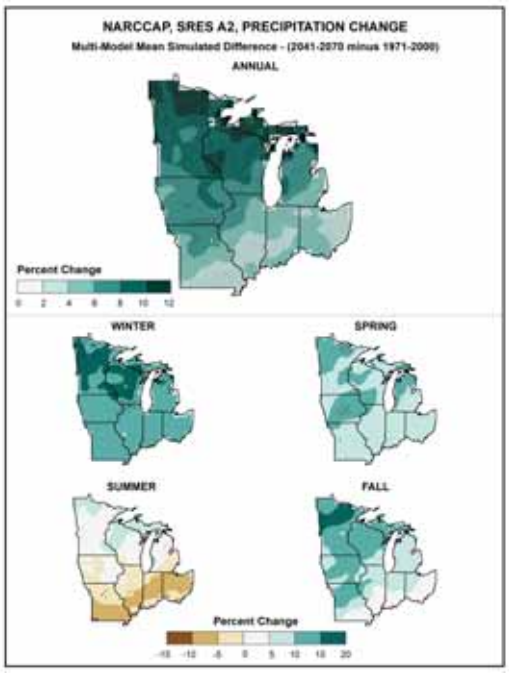


Projected annual and seasonal temperature changes for mid-century in the NARCCAP climate models. Image source: NOAA Midwest Technical Report[4]

Average temperatures are warming, but fewer cold days are expected than more hot days. Days below freezing are projected to decrease by about three weeks per year in WUM by mid-century. Michigan's coastlines may experience even fewer cold days per year. Days with maximum temperatures above 95°F will remain the same along the coast and increase by a few days per year in Michigan's Upper Peninsula (~5-10 days/yr). Larger increases are projected farther south in the Midwest. Consecutive days with maximum temperatures over 95°F will remain the same or increase by a few days per year across WUM.

By mid-century the freeze-free season is projected to increase in WUM by three to four weeks with smaller increases along the Lake Michigan coast.

Precipitation trends across the Midwest also vary depending on the season. A major difference from the temperature projections discussed above is that the models are in less agreement about future precipitation amounts. Over most of the Midwest less than half of the models agree on the direction (+/-) of precipitation changes. Model averages indicate increasing precipitation for WUM during all seasons, though there is especially high uncertainty for summer projections. During summer the global climate models range from 20% reductions in precipitation to 20% increases in precipitation for the Midwest, and the regional models range from +/-10% changes. Fall projections have similar disagreements but to a lesser degree. Fall precipitation is projected to increase by 10% to 15% on average in Menominee County. Spring precipitation across Menominee County average slight increases of 5% to 10%.



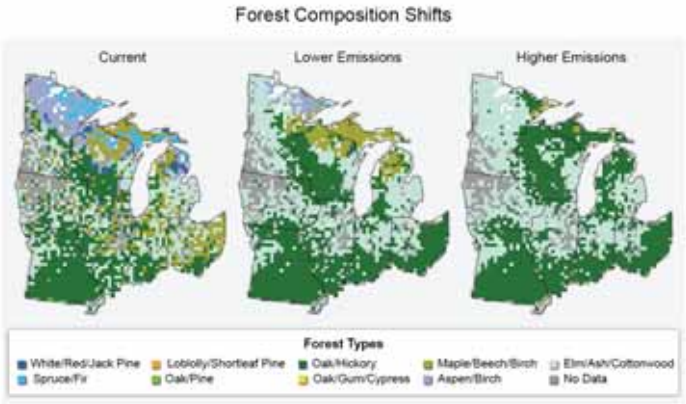
Projected annual and seasonal precipitation changes for mid-century in the NARCCAP climate models. Image source: NOAA Midwest Technical Report Figure 41[4]

Projecting extreme precipitation events is challenging, because the models do not simulate the intensity of individual events well. The majority of models agree that the number of days with greater than one inch of precipitation will increase in the future. WUM, including Menominee County, has a projected increase of 30-50% more days with more than one inch of precipitation, which is greater than locations farther south in the Midwest. In addition, most models agree that WUM is projected to experience fewer dry days (2-4 days) during the longest dry period in a given year.

Climate Impacts

Observed and projected climate changes result in varying impacts on people and the environment. The Western Upper Peninsula and Menominee County contains a mix of land types including: agricultural lands, forests, and coastal areas; thus climate impacts are summarized for these different areas of concern. Summary information on climate impacts to WUM and Menominee County are derived from the National Climate Assessment: Midwest Technical Reports for specific sectors[5,6,7].

Forest Impacts



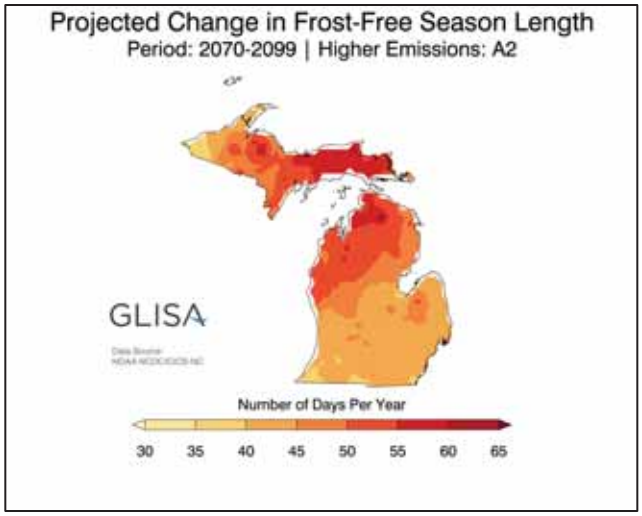
As climate changes, species can often adapt by changing their ranges. Maps show current and projected future distribution of habitats for forest types in the Midwest under two emissions scenarios, a lower scenario that assumes reductions in heat-trapping gas emissions (B1), and a very high scenario that assumes continued increases in emissions (A1F1).[8]

Forests are a significant commercial, recreational, and cultural resource for the region. Most forests in WUM are classified as Laurentian Mixed Forests. The best available research indicates that forests in the region may experience the following impacts associated with the expected changes in climate.

- Climate change will amplify many existing stressors to forest ecosystems, such as invasive

species, insect pests and pathogens, and disturbance regimes.
- Climate change will result in shifts in the types of trees, wildlife species, and the types of land cover present in the region (ex. change from forest to non-forest land type).
- Forests will likely become less diverse. With tree species shifting from spruce, pine, fir, and maple to a more southerly composition of oak and hickory.
- Many tree species will have insufficient migration rates to keep pace with climate change.
- Many iconic forms of recreation within forests will change in extent and timing, due to climate change. For example, snow-machining, skiing, and hunting access could all be affected.
- Expected changes will likely alter many traditional and modern cultural connections to forests. For example, increased temperatures and shifts in tree species could affect maple sugaring over time.

Agricultural Impacts



- *Projected annual change in the length of the frost-free (growing season) for the state of Michigan by the end of the 21st century (2070-2099) using a high emission scenario. Data Source: NOAA NCDC/CICS-NC*

Already observed impacts:
- More intense rain events at the beginning of crop cycles have required re-planting efforts and increased field maintenance costs.
- Increased floods and droughts have negatively impacted yields and increased costs.
- Warmer spring soil temperatures have increased yields.
- Increased over-wintering of pests due to warmer temperatures has decreased yields.
- Longer frost-free periods have increased yields.
- Increased number of winter freeze-thaw cycles has improved soil water infiltration.

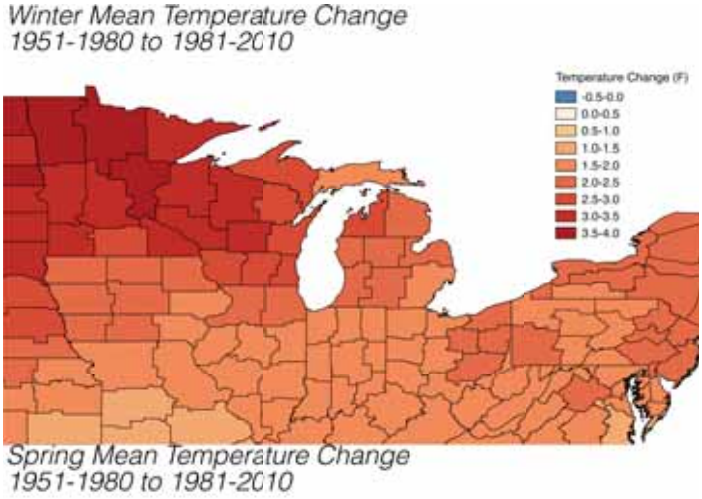
Future impacts:
- Plant hardiness zones are projected to shift to longer growing seasons.
- Increased atmospheric carbon dioxide will not significantly affect crop yields.
- Warming temperatures will allow new insects and diseases to move into the region.
- Soil erosion is projected to increase as the wettest precipitation events intensify.
- Exposure of livestock species to the combination of temperature and humidity factors will increase stress levels.

Coastal/Fisheries Impacts

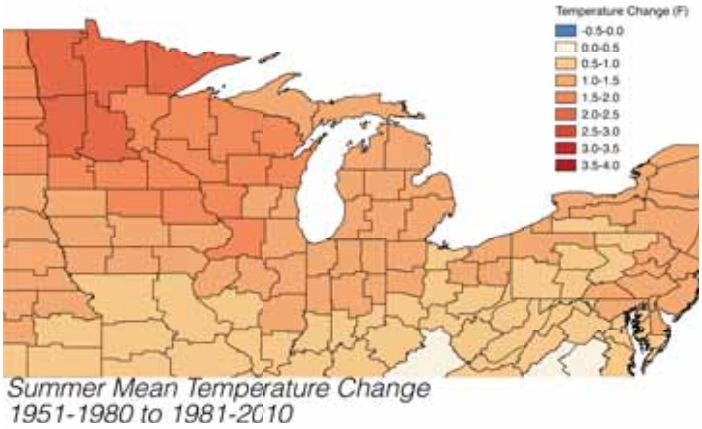
- Great Lakes water levels will generally remain within the natural historical range of water levels. Average levels may be slightly below the long-term mean.
- Heavy winter and spring precipitation events will increase nutrient and sediment loading into the Great Lakes.
- Reduced ice cover in large lakes will increase surface water temperatures and evaporation.
- Increase surface water temperatures will cause gradual shifts in fish species distributions in the lakes. Will likely see more warm-water species and less cold-water species (i.e. whitefish).

Local Climate Differences

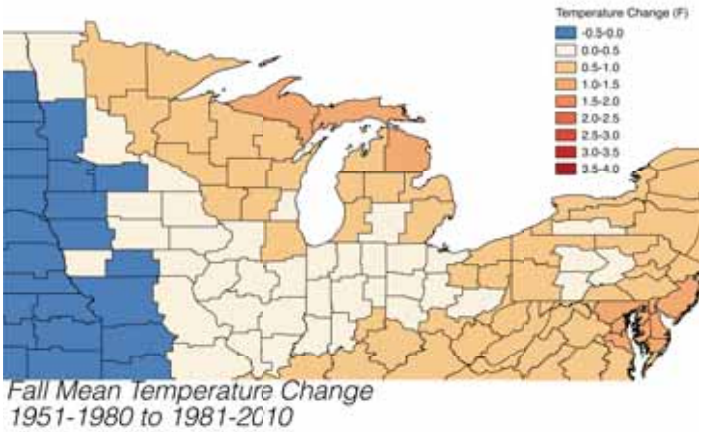
The maps and discussion that follow highlight how recent climate changes in the Menominee County and WUM differ from regional climate changes[9].



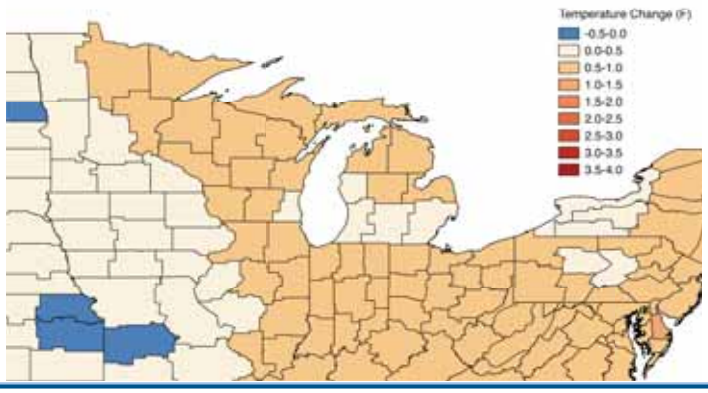
Winter temperatures have risen the most out of the four seasons. Winters in WUM have warmed by 2.6 ℉. Though wintertime temperatures have warmed in this region, seasonal snowfall amounts have not seen a clear positive or negative trend. This is interesting, as northern areas of the Midwest have seen increases in annual snowfall while more southerly portions of the Midwest have observed decreases.[10]



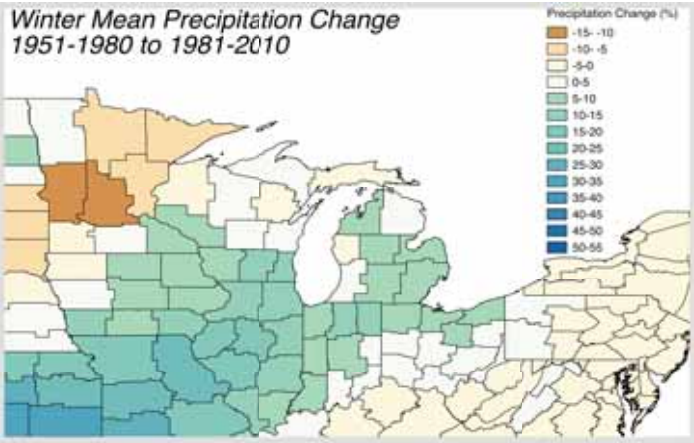
Spring temperatures have warmed 1.5 ℉. This is similar to the warming observed in other climate divisions located in Upper and Lower Michigan



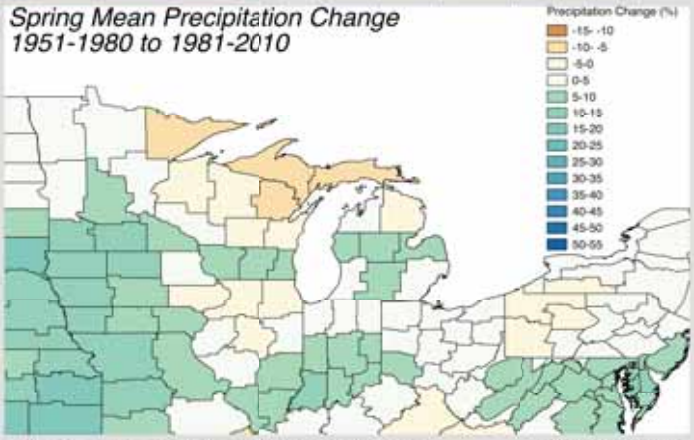
Summer temperatures have not increased as substantially as winter or spring (1.1 ℉) in the West Upper climate division over the period from 1981-2010 when compared to 1951-1980. This is fairly consistent with other locations across the northern Midwest. This observed warming is greater than regions to the southern and western portions of the Midwest, where average summer temperatures have been relatively flat or slightly declining.



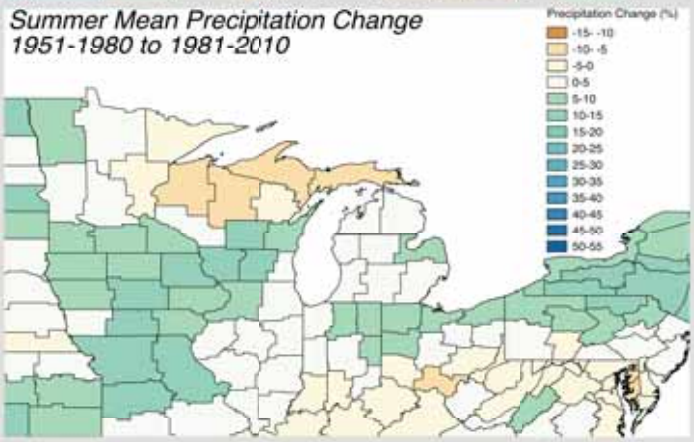
Fall temperatures have increased slightly less in magnitude than summer (0.8 ℉). Changes have been similar across most of the Midwest in the fall.



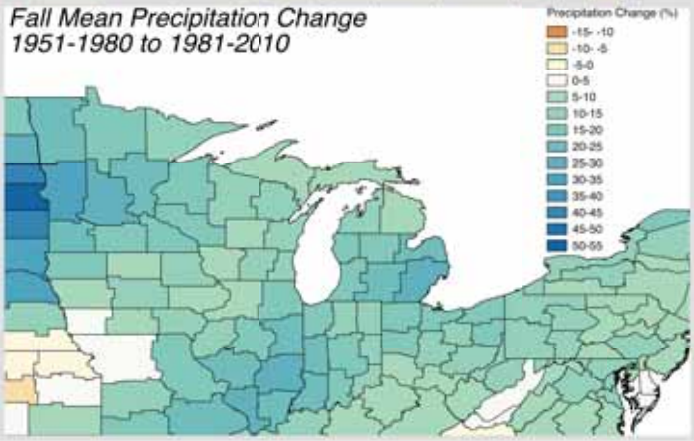
Winter precipitation has remained relatively flat across the West Upper climate division, with a small increase of 0.1% between the normal periods. This is similar to trends observed in North Eastern Wisconsin and the Eastern Upper Peninsula of Michigan.



Spring precipitation in WUM has decreased (7.8%). This decrease is slightly larger when compared to most of the Midwest, where precipitation changes have been mixed. These changes are likely within the range of natural variability.



Summer precipitation has decreased over the area (9.7%) for the period from 1981-2010. This is similar to other climate divisions east and west of WUM.



Fall precipitation has generally increased across the Midwest; there are not strong differences between WUM and the rest of the region. WUM precipitation has increased by 8.1% in the fall.

References

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[3] The models consulted include those from the Coupled Model Intercomparison Project (CMIP) version 3 and the North American Regional Climate Change Assessment Program (NARCCAP) regional climate models. The "high" emissions scenario (SRES A2) projections were used.
[4] "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment Part 3. Climate of the Midwest U.S." (2013). Available at: http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-3-Climate_of_the_Midwest_U.S.pdf
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[7] Hatfield, J., 2012: Agriculture in the Midwest. In: *U.S. National Climate Assessment Midwest Technical Input Report*. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center, http://glisa.msu.edu/docs/NCA/MTIT_Agriculture.pdf.
[8] Prasad, A. M., L. R. Iverson, S. Matthews, and M. Peters, cited 2007: A Climate Change Atlas for 134 Forest Tree Species of the Eastern United States [Database]. U.S Department of Agriculture, Forest Service, Northern Research Station. [Available online at http://www.nrs.fs.fed.us/atlas/ tree].
[9] The maps are based on the nClimDiv Dataset (http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php), which is a Federal data product for climate division data.
[10] Andresen, Jeff, Steve Hilberg, and Ken Kunkel. "National Climate Assessment Midwest Historical Climate." (2013).