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Climate Change Impacts on Illinois Agriculture

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Methods and Supplementary Materials

Please visit https://www.climatehubs.usda.gov/hubs/midwest/assessing-impacts-climate-change-midwest-agriculture for the methods and supplementary materials associated with this report.

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Climate Change Impacts On Illinois Agriculture

Agriculture is a critically important aspect of economic and social life across much of Illinois, with the market value of products sold totaling over $17 billion in 2017. Key crops include corn, soybeans, hay, wheat, pumpkins, sweet corn, beans, oats, and horseradish. Animal agriculture is focused primarily on hogs, beef, and dairy cattle. In 2017, Illinois was 2nd in the nation for grain and oilseed production and ranked 4th in the nation for hogs.[1]

Agricultural productivity is particularly vulnerable to weather and climate variability. In 2015, central Illinois received nearly double the usual rainfall from May-July, which had serious consequences for the pumpkin harvest, leading to shortages for consumers nationwide.[2] In recent decades, Illinois' climate has been changing in various ways (Table 1), a trend which is projected to continue and intensify.[3] These changes are resulting in significant impacts on the state's agricultural sector.

Observed Changes to Illinois' Climate

Temperature

- Average annual temperatures have increased by 1.7°F between 1979 and 2021. The number of days with nighttime minimum temperature at or above 70°F has been generally above average over the last decade and steadily increasing over the last 5 decades.[4]
- Winters and springs have warmed the most compared to their long-term averages, resulting in nearly two additional weeks of the growing season.[3]

Precipitation

- Average annual precipitation has risen significantly (+5.7"), with the greatest increases observed during the spring and summer months.[3]
- Extreme precipitation events (greater than 2 inches) have become more frequent.[3]

"In recent decades, Illinois' climate has been changing in various ways, a trend which is projected to continue and intensify."

Table 1. Observed changes in Illinois' climate based on data from 1979 – 2021.

	Annual (Jan – Dec)		Summer (Jun – Aug)		Fall (Sep – Nov)		Winter (Dec – Feb)		Spring (Mar – May)	
	Average	**Change**	**Average**	**Change**	**Average**	**Change**	**Average**	**Change**	**Average**	**Change**
Temperature	52.6 °F	+1.7 °F	74.1 °F	+0.7 °F	54.2 °F	+1.6 °F	29.1 °F	+1.7 °F	52.6 °F	+1.5 °F
Precipitation	40.5"	+5.7"	12.2"	+2.2"	9.8"	-0.1"	6.9"	+1.3"	11.7"	+2.4"
Vapor Pressure Deficit	6.4 mb	+0.5 mb	10.5 mb	+1.1 mb	6.5 mb	0.0 mb	2.0 mb	0.0 mb	6.6 mb	+0.1 mb
Extreme precipitation (days with 2")	1.0 days	+1.5 days								
Growing Season Length (frost-free days)	184 days	+10.4 days								

Impacts on Agriculture

- Opportunities to plant alternative varieties of crops in response to a longer growing season, increased temperatures, and other changes.
- Greater frequency of heat stress on livestock.
- Increased risk of agricultural drought.
- Erratic spring freeze/thaw cycles that may damage fruit crops.
- Wetter soils, resulting in delayed planting, erosion, and nutrient loss.
- Increased impacts from insect pests, weeds, and plant and animal pathogens.
- Higher production costs and lower yields for some crops.[5,6]

Climate Outlook

Models of future climate indicate that temperatures are projected to warm, precipitation is expected to become more variable and extreme, and the growing season is anticipated to continue to lengthen. The climate projections in this section are based on the average of 17 different climate models.[7] Two possible futures are presented: a moderate emissions scenario in which greenhouse gas emissions peak around mid-century and then slowly decline, and a higher emissions scenario in which emissions continue to rise throughout the 21st century.[8] Careful planning and adaptive action can lower the risks of climate change impacts for producers. There are many ways to adapt to climate change based on the situation and needs of a particular farm, and some examples are presented below.

Image: Soybeans planted into no-tilled corn residue. Source: Farmers.gov

Temperature

Illinois can expect to see fewer extremely cold nights, more very warm nights, and more extremely hot days (Table 2). By mid-century (2040-2059) under a higher emissions scenario, **the annual average temperature in Illinois is projected to increase by 5.4°F compared to the 1979-2005 baseline**.[7] By late-century (2080-2099), annual temperature increases may exceed 10°F. These scenarios are compared to average observed thresholds during the 1979 – 2005 period.

Table 2. Mean temperature threshold changes and model ranges for Illinois compared to the 1979 – 2005 period.

	Temp Lows ≤ 32°F	Temp lows ≥ 80°F	Temp highs ≥ 86°F	Temp highs ≥ 95°F
Mid-century, moderate emissions	-32.5 days *(-48.9 to -16.8)*	+2.8 days *(+0.2 to +11.5)*	+78.2 days *(+64.5 to +93.7)*	+18.9 days *(+6.0 to +41.6)*
Mid-century, higher emissions	-36.7 days *(-54.8 to -17.7)*	+5.3 days *(+0.5 to +20.2)*	+84.3 days *(+69.1 to +95.7)*	+26.4 days *(+10.1 to +51.7)*
Late century, moderate emissions	-41.9 days *(-57.7 to -21.6)*	+6.6 days *(+0.2 to +22.0)*	+85.8 days *(+69.3 to +102.4)*	+28.3 days *(+6.9 to +57.3)*
Late century, higher emissions	-64.8 days *(-81.9 to -39.6)*	+28.5 days *(+5.69 to +59.9)*	+108.6 days *(+87.6 to +125.8)*	+65.0 days *(+29.7 to +99.6)*

What Does This Mean to Agriculture?

- Increased heat stress severely impacts farmers, farm workers, and animals. Among livestock, high heat can decrease meat and milk quality and quantity, and egg production.[5,9,10,11]
- The frequency of short-term and rapid onset drought during the summer is potentially higher due to warmer temperatures and increased precipitation variability.[23] Decreased soil moisture affects plant physiology, potentially leading to an increased risk of reduced yields or crop losses, but uncertainty remains.[5,11]
- Increased soil temperatures affect the appropriate timing of fertilizer application. With soils remaining above 50°F later into the fall season, fields are prone to nitrogen loss and subsequent water quality impacts following nitrogen applications.[12]
- Elevated overnight temperatures affect corn development and vegetable crops, negatively impacting yields.[11]
- By 2055, yields of rainfed corn in central Illinois are projected to decline by 23-34% according to some estimates.[13]

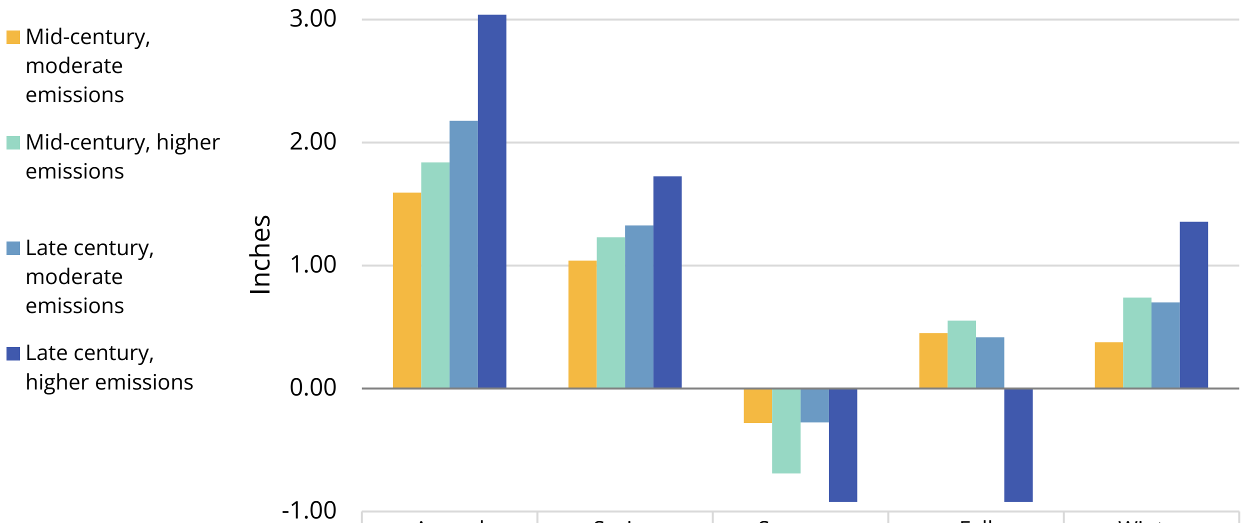
Adaptation Options

- Choose crop species or varieties that are more suited to future conditions (tolerant of heat and water stress).
- Integrate alternative crop species via conservation crop rotations to maintain or improve soil health.[14]
- Utilize cover crops or reduce tillage to bolster soil health and increase water-holding capacity.
- Choose longer maturity corn cultivars to take advantage of longer growing season (potentially increasing yields), or plant shorter maturity corn varieties earlier in the season to avoid reproductive stages happening during worst risk of drought in later summer (likely to give average, but more consistent yields).[14]
- Explore options related to agroforestry practices, such as windbreaks and alley cropping, which provide shade and can buffer crops and livestock from increasing heat.[15]

Image: Checking soil aggregate for organic matter and stability. Source: USDA.gov

Precipitation

Annual precipitation is expected to increase, with the largest seasonal increases likely during winter and spring. Decreases in total precipitation and greater variability are projected during the summer. These changes are stronger under the higher emissions scenario and for the late 21st century (2080-2099) (Figure 1).



	Annual	Spring	Summer	Fall	Winter
Mid-century, moderate emissions	1.59	1.04	-0.28	0.45	0.38
Mid-century, higher emissions	1.84	1.23	-0.69	0.55	0.74
Late century, moderate emissions	2.18	1.33	-0.28	0.42	0.70
Late century, higher emissions	3.04	1.73	-0.92	-0.92	1.36

Figure 1. Projected precipitation changes for Illinois, annually and seasonally, in inches.

What Does This Mean to Agriculture?

- Winter and spring increases in precipitation will lead to further loss of field workdays, impaired root growth and function, and prolonged field wetness.[11]
- Wetter pastures and paddocks increase susceptibility to animal foot diseases and may impact livestock nutrition maintenance schedules and gestational weight.[16,17]

Adaptation Options

- Consider planting earlier in the season, which may be possible due to small increases in field workability days in late March to early April, coupled with an earlier last frost date.[14]
- Use filter strips or riparian buffers in areas prone to flooding.[18]
- Increase soil health by improving soil structure and organic matter content to be better able to infiltrate precipitation, increase water-holding capacity, and maintain plant-available water during periods of dryness. Management to improve soil health can reduce risk of climate-related impacts as well as improve productivity.[11] Options include conservation crop rotations, cover crops, and reduce tillage.

Precipitation Intensity

Illinois is already experiencing increases in extreme precipitation events (with precipitation greater than 2 inches); these events are likely to be even more frequent in the future.[3]

What Does this Mean to Agriculture?

- The increased frequency of extreme precipitation results in increased soil erosion and nutrient loss from fields, contributing to nonpoint source pollution.

Adaptation Options

- Adjust dates of planting, tillage, and harvest.[5]
- Manage and improve soil health and increase water infiltration by minimizing tillage, managing crop residue, planting cover crops, selecting soil-stabilizing crops, and managing the intensity of grazing.[5]
- Minimize soil erosion by installing grassed waterways and prairie strips, or by practicing contour farming.
- Incorporate trees through alley cropping systems or other agroforestry practices to reduce the rate of soil erosion in crop fields. Living roots in well-managed perennial systems help hold soils in place when heavy rains occur.[19,15]

Growing Season Length

Growing season trends across Illinois since 1950 are variable across the state (Figure 2). While many counties have seen an increase of a few days per decade, counties in the central portion of Illinois have seen decreasing trends over the last six decades. By mid-century however, under a higher emissions scenario, the growing season is expected to increase by an average of 33 days. This is a result of later first frosts in the fall and an earlier onset of frost-free conditions in spring.

What Does this Mean to Agriculture?

- Pests, diseases, and weeds may expand their ranges. Additionally, the number of pest generations per season may increase, resulting in a greater impact on crops or livestock. An increased need for chemical treatments to address these impacts may lead to greater pesticide and herbicide resistance.
- Longer growing season length may provide additional time for harvest and other end-of-season processes. Also, cover crops may experience increased post-harvest growth.
- Warmer winters increase risk of spring freeze injury by accelerating development of buds.
- Warmer winter temperatures may mean that chill hours for fruit crops are not met.[11]

Adaptation Options

- Plant earlier in the spring or consider options for double cropping.[18]
- Address pest, weed, and disease issues by diversifying crop rotations, enhancing use of Integrated Pest Management (IPM) techniques, and planting species and varieties that are resistant to pests and disease. [18]
- Consider planting fruit species and varieties which require fewer chilling hours, while keeping in mind the potential risk of trees and shrubs breaking dormancy during late-winter warm spells.
- Incorporate a diversity of species, such as in agroforestry systems, to spread biological and financial risk and create habitat diversity to promote beneficial insects and pollinators.[15]

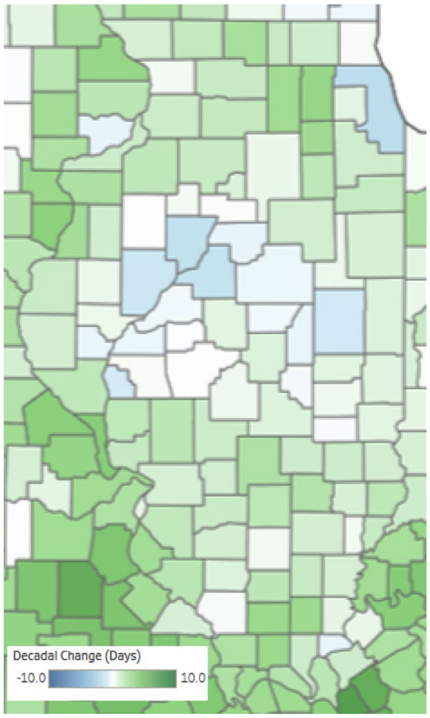


Figure 2. Decadal growing season length trends by county in Illinois, 1950-2021 based on gridded ACIS dataset. Figure courtesy of the Midwestern Regional Climate Center and the Midwest Climate Hub.

Relative Humidity

Despite increased water vapor in the atmosphere and precipitation, uncertainty remains in whether current trends of relative humidity will continue. This uncertainty is due to relative humidity's dependence on air temperature and a lack of model consistency of historical trends in temperature. Models indicate that relative humidity is projected to decline annually and across all seasons, with the greatest decreases projected to occur during summer. However, if minimum (nighttime) temperature trends continue to outpace maximum (daytime), vapor pressure deficits will not increase, and relative humidity will stay higher.

What Does this Mean to Agriculture?

- If relative humidity decreases:
    - Plants will be more prone to wilting and stunted growth.
    - Certain animal respiratory viruses may have a longer survival duration.[20]
    - Tree mortality may increase, especially for younger trees.[19]
- If relative humidity increases:
    - Wetness duration may increase leading to enhanced disease potential for crops.[21]
    - Plants will have limited ability to evaporate water (part of the transpiration process) or draw nutrients from the soil.[22]

Adaptation Options

- Plant varieties adapted to drier or wetter climates (or those that may withstand high variability) if available (including crops, pasture grasses, and tree fruit).[18]
- Use of mulch, cover crops, no-till, or reduced tillage to retain soil moisture and reduce soil temperatures. [18]
- Where appropriate, the establishment of trees to reduce evaporative water loss from the soil surface. Additionally, soils within agroforestry systems are better able to infiltrate and store water, which will be critically important in climates with warmer, drier summers.[15]

Image: Cover crops can reduce pest pressure, retain soil moisture, reduce soil temperatures, and mitigate nutrient loss. Source USDA.gov

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