AN ASSESSMENT OF THE IMPACTS OF CLIMATE CHANGE IN ILLINOIS

AN ASSESSMENT OF THE IMPACTS OF
CLIMATE CHANGE IN ILLINOIS

The development of this report was co-led by:
Donald Wuebbles [1], James Angel [2], Karen Petersen [3], Maria Lemke [3]

Contributing authors (listed alphabetically):

Daniel Abrams [2]
Jessicca Allen [4]
Andrew Ballinger [5]
Jonathan Coppess [1]
Sergiusz Czesny [2]
Qihong Dai [1]
Sam Dorevitch [6]
James Ellis [1]
Trent Ford [2]
Benjamin Gramig [1]
Elena Grossman [6]
Aaron Hager [1]
Chelsea Harbach [7]
Louis Iverson [8]
Atul Jain [1]
Walt Kelly [2]
Madhu Khanna [1]
Praveen Kumar [1]
Kenneth Kunkel [4,9]
Andrew Leakey [1]
Tzu-Shun Lin [1]
Momcilo Markus [2]
Jeff Matthews [1]
Sally McConkey [2]
Gregory McIsaac (retired) [1]
Jim Miller [1]
William Miller [10]
Aaron Packman [10]
Jennifer Quebedeaux [1]
Charles Roswell [2]
Shubhayu Saha [11,12]
Swarnali Sanyal [1]
Nicholas Seiter [1]
Ashish Sharma [2]
Teresa Steckler [7]
Chris Stone [2]
Cory Suski [1]
John Taft [2]
Elizabeth Wahle [7]
Mike Ward [1]
Zhenxing Zhang [2]

Author Affiliations: (1) University of Illinois at Urbana-Champaign (UIUC); (2) Prairie Research Institute, UIUC; (3) The Nature Conservancy; (4) NOAA CICS-NC; (5) The University of Edinburgh; (6) University of Illinois at Chicago School of Public Health; (7) UIUC Extension; (8) U.S. Forest Service; (9) North Carolina State University; (10) Northwestern University; (11) CDC; and (12) Emory University.

Suggested Citation: Wuebbles, D., J. Angel, K. Petersen, and A.M. Lemke, (Eds.), 2021: An Assessment of the Impacts of Climate Change in Illinois. The Nature Conservancy, Illinois, https://doi.org/10.13012/B2IDB-1260194_V1.

Executive Summary

President Abraham Lincoln, 2nd State of the Union Address, 1862

"The dogmas of the quiet past are inadequate to the stormy present. The occasion is piled high with difficulty, and we must rise with the occasion. As our case is new, so we must think anew, and act anew."

Why Illinois? Why now?

Although used in a different context at the time, the quote above from President Lincoln appropriately expresses the challenges from a changing climate that Illinois faces at this time. Climate, the long-term averages and statistics of weather, is changing rapidly in the state of Illinois, as well as throughout the world. For example, in Illinois, the frequency and intensity of extreme heat and heavy precipitation events are increasing, and winters are generally milder. Climate change is a major environmental challenge that is likely to affect many aspects of life in Illinois, ranging from human and environmental health to the economy. Illinois is already experiencing societal impacts from the changing climate and, as climate change progresses and temperatures continue to rise, these impacts are expected to increase over time.

This assessment takes an in-depth look at how the climate is changing now in Illinois, and how it is projected to change in the future, to provide greater clarity on how climate change could affect urban and rural communities in the state. Beyond providing a general overview of anticipated climate changes, the report explores predicted effects on hydrology, agriculture, human health, and native ecosystems. These topics were selected because they touch on many aspects of people's lives and well-being in the state of Illinois.

Scientific evidence indicates it is extremely likely that human activities—which have led to drastic increases in emissions of greenhouse (heat-trapping) gases, especially from the use of fossil fuels and extensive land use changes—are the dominant cause of global changes in climate, dating back to at least the mid-1900s. For the last century, there are no convincing alternative explanations for the observed warming that are supported by observational evidence. Natural variability or natural cycles cannot account for the observed changes in climate, nor are they the result of changes in radiation from the Sun.

The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse gases emitted globally and, to a limited degree, on remaining uncertainties in the sensitivity of Earth's climate to those emissions. Most of the analyses in this assessment are based on two scenarios for greenhouse gas concentration trajectories: a lower scenario (RCP4.5) and a higher scenario (RCP8.5). The RCP8.5 scenario corresponds to a future where carbon and methane emissions continue to rise throughout the century, while the RCP4.5 scenario assumes a rapid movement away from fossil fuels over the coming decades.

Increasing temperature

Over the past 120 years, the average daily temperature in Illinois has increased, especially the average overnight temperature. The average daily temperature has increased by 1–2°F in most areas of Illinois. Overnight minimum temperatures have increased more than daytime maximum temperatures. In some areas of the state, the increase in overnight minimum temperatures has exceeded 3°F, while the daytime maximum temperature increase has ranged between 0–1.5°F in most areas. This difference in trends between day and night is most prominent in summer, resulting in an increase in the number of warm summer nights. The number of freezing winter nights has decreased. By the end of the 21st century, unprecedented warming of 4–9°F under the lower scenario and 8–14°F under the higher scenario is likely in Illinois. This is likely to be accompanied by large increases in extreme high temperatures, a longer growing season, and less severe extreme cold.

Changing precipitation patterns

Illinois has gotten wetter overall in the last century. Over the last 120 years, mean precipitation has increased by 5 to 20%, varying across the state, and the number of 2-inch rain days in Illinois has increased by 40%, reflecting major regional changes in the hydrologic cycle. Over the same time period, extreme droughts have become less common.

Drought risk in Illinois is not only related to precipitation; changes in temperature also play an important role. Increased temperatures have led to more evaporation from soils, which can cause significant crop and ecosystem stress during dry conditions. Annual evapotranspiration has increased, especially in the summer months. Projections of increasing temperatures suggest evapotranspiration will continue to increase in Illinois, as will the risk for short-term droughts.

Illinois is expected to see an overall increase in precipitation in the coming decades as the climate warms, with larger increases in the north compared to the south. The projected changes in total precipitation vary widely by season. For the end of the 21st century and the higher scenario, substantial increases in precipitation are projected for winter (+10% to +20%) and spring (+5% to +25%), with small changes in the fall and decreases of around 5% projected for summer. Similar, but smaller trends are projected for the lower scenario. Total seasonal snowfall is likely to decline through the 21st century, as a result of fewer snow days and more rainy days. The distribution of precipitation in Illinois is also projected to become more extreme, with increases in both heavy rains and the length of dry spells.

Intensity of weather extremes

Climate change is causing more extreme weather events across the United States. Heat waves have become more common since the 1960s, while extreme cold temperatures have generally decreased. Intense summer storms occur more often as temperatures rise.

Extreme warm days will increase in Illinois. By the end of the century, the annual hottest 5-day maximum temperature in northern Illinois is projected to increase from 92°F to a range of 96–104°F under the lower scenario and 100–110°F under the higher scenario. In central Illinois, the annual hottest 5-day maximum temperature will increase from 94°F to a range of 98–106°F under the lower scenario and 102–112°F under the higher scenario. In southern Illinois, the annual hottest 5-day maximum temperature is projected to increase from 96°F to 100–107°F under the lower scenario and to 102–114°F under the higher scenario. Projections show increases in single-day extreme temperatures as well, with projected increases in the annual number of days with a daily maximum temperature of 95°F or higher.

Meanwhile, the number of extremely cold days (with temperature less than 32°F) will decrease significantly. For the mid-21st century, the increases in temperature for the coldest days are about 4–8°F for the lower scenario and 4–10°F for the higher scenario. For the late-21st century, the increases are 6–10°F for the lower scenario and 10–16°F for the higher scenario. The freeze-free season is also projected to increase, by about 10–15 days for mid-century with the lower scenario and around 15–20 days with the higher scenario. For the late-21st century, the increases are around 15–20 days for the lower scenario and 30–45 days for the higher scenario, with somewhat greater increases in northern Illinois.

A warmer atmosphere holds more moisture, increasing the frequency and intensity of heavy rain and snow events. The projected changes in the number of days with precipitation of 2 inches or greater for Illinois show an increase everywhere. The increase in precipitation will vary substantially with time period and scenario. Mid-21st century projections show 0–60% increase under the lower scenario and 30–90% increase under the higher scenario. Late-21st century projections show 0–60% increase and 60–150% increase in the lower and higher scenarios, respectively.

Impacts on hydrology and water resources

One of the greatest natural resources in Illinois is fresh water, both in the form of abundant precipitation and in the major rivers systems of the Mississippi, Ohio, and Illinois, as well as Lake Michigan. Although unseen, important groundwater aquifers run throughout the state, providing millions of people in Illinois with reliable water supplies. However, a changing climate poses challenges to the hydrology of the state. Most of the rivers in Illinois have already experienced increased flooding. Driven primarily by precipitation trends and land development, flooding in most Illinois rivers and streams is expected to continue to increase. An increase in intense rainfall is also expected to exacerbate flooding in urban drainage systems, which are already stressed due to aging and undersized stormwater systems, as well as land development that has altered natural drainage patterns and increased impervious surfaces.

Climate change in the form of increased precipitation and rainfall intensity tend to increase nutrient loads in rivers. However, other factors (e.g., wetland restoration) can also influence riverine nutrient loads. Combined sewer outflows (CSOs) affect water quality in urban streams and rivers and Lake Michigan in the Chicago region. Both CSOs and increased overland flooding cause environmental damage and public health hazards, such as increased exposure to infectious diseases and contaminated drinking water.

As surface water supply is often limited by low streamflow, unless it is augmented by in-channel or off-channel storages, climate change may increase risks of inadequate surface water supply in drought conditions. Projected increases in precipitation would increase recharge to shallow aquifers. This could result in higher water tables during springtime conditions, increasing basement flooding and necessitating more tile drainage in row crop areas. Conversely, more intense summer droughts could result in lower water tables during peak pumping conditions in the summer, potentially impacting the sustainability of the groundwater resource used in water supply.

Impacts on Agriculture

In Illinois, agriculture forms a central pillar of the economy and a dominant part of the landscape. Illinois' fertile soils, level to gently sloping land, and favorable climate make it uniquely situated to be a major agricultural producer, especially of corn and soybeans. Yet, the favorable climate that Illinois farmers depend on is already and will continue to be impacted by climate change. Illinois is expected to face a much different climate than any experienced in the state's history, and agriculture is likely to face significant hurdles adapting to this new climate. Future agricultural production in Illinois is strongly dependent on investments made today in agricultural research and development, efforts to reduce greenhouse gas emissions, and practices to help farmers cope with climate risks.

Heat and water stress are likely to reduce corn yields by mid-century in Illinois, although the severity of loss depends on available technology and new management practices. Some yield losses could be overcome if sustained improvements in seed technology and management adaptations, such as planting date adjustments and input optimization, are able to mitigate the impact of extreme heat and drought. Increased atmospheric CO_2 is likely to benefit soybean yields in the near-term, but, as heat and water stress intensify later this century, soybean yields are expected to decline. Increased CO_2 is not expected to impact corn yields, even in the near-term.

Crops and livestock in Illinois are negatively impacted by weeds, pests, and diseases, which are expected to increase because of warmer winters, increased spring precipitation, and higher summer temperatures. Warming temperatures will also shift plant hardiness zones northward, making certain varieties of fruits, vegetables, and nuts unable to thrive in Illinois. Adopting new crop varieties, adjusting management practices, and investing in new machinery may help growers adapt.

Impacts on human health

Communities across Illinois are expected to experience adverse health impacts as a result of climate change. Rising temperatures will increase the risk of heat-related illness, such as heat exhaustion and heat stress, and exacerbate respiratory illnesses. Increasing precipitation and flooding will amplify the risk of water-borne infectious diseases, mold exposure, and flood-related injuries. The risk of vector-borne diseases will also increase as the range for disease-carrying ticks and mosquitoes expands due to more favorable climate conditions and as the length of the biting season extends. Levels of mold, pollen, and ozone pollution, which are triggers of asthma and allergies, are expected to increase and the pollen season will lengthen, resulting in more severe respiratory allergies and more frequent asthma attacks. Mental health is also likely to suffer, owing to increased stress associated with direct climate impacts, such as extreme weather events, as well as stress associated with climate change as an existential threat.

Communities that are already the most vulnerable are likely to suffer the worst health impacts from climate change. Those that currently have high rates of chronic disease, poor housing, barriers to health care access, unhealthy community design, and polluted air are expected to experience more severe health impacts from climate change than the population of Illinois overall. Thus, the issue of public health and climate change is also an issue of equity. Climate change is also expected to increase some health care costs and associated economic losses.

Impacts on ecosystems

Climate change is expected to have wide-ranging impacts on the forests, prairies, wetlands, and freshwaters of Illinois. Owing to the large number of factors involved, projecting the climate impacts on Illinois' ecosystems is difficult. In general, climate change will interact with and amplify the impacts of other stresses already affecting the state's ecosystems. A significant portion of native habitat in Illinois is fragmented and degraded due to widespread land conversion, which will reduce the ability of native flora and fauna to adapt to rapid climate changes.

Although climate change could enhance conditions for some native species, it will likely make conditions less suitable for others. For example, some tree species (e.g., sweetgum, winged elm, and post oak) are expected to adapt well to a changing climate, while others are expected to fare poorly (e.g., pignut hickory, black willow, American basswood, pin oak, chinkapin oak, and eastern white pine). Warmer water temperatures will alter the growth, survival, and reproduction of aquatic species, as well as predator-prey relationships, while increased precipitation and flooding may reduce important habitat availability for some species. A further expansion of non-native invasive species and pathogenic pests, which can have negative repercussions across ecosystems, is also likely.

Efforts to conserve, restore, and expand Illinois' natural areas will be critical for ensuring the survival of native flora and fauna. Conserving natural ecosystems, which are inherently more resilient to climate change than more highly managed systems (e.g., tree plantations), and restoring connections among these areas can help to safeguard native plants and wildlife and enhance their ability to adapt to changing conditions. These efforts can also help to sequester carbon, which is important for combatting climate change. Because much of the state's land is in private ownership, managing natural lands effectively will require cooperation among private landowners, environmental organizations, and natural resource agencies.

Knowledge and research priorities

This assessment provides localized climate projections that can be used by lawmakers, government agencies, nonprofits, businesses, individual landowners, and farmers to develop adaptation and mitigation plans to decrease the magnitude of a wide range of adverse impacts from climate change. However, additional knowledge and research is required to decrease uncertainty and improve predictive capabilities. High-priority recommendations for research include:

Improved climate modeling The development of very-high-spatial-resolution climate models would provide more robust simulations of heatwaves, severe thunderstorms, and extreme precipitation. The development of integrated models of the atmosphere, land, and the Great Lakes would further enhance the utility of weather forecasts and long–term climate projections.

Water resources Sustainable management of water supplies from surface and sub-surface sources for drinking and irrigation must be guided by assessments of the availability and replenishment capacities of these sources in a changing climate. Given the high cost and long construction times for large-scale built infrastructure, it is important to develop strategies that integrate conventional stormwater infrastructure with distributed green infrastructure to mitigate local and regional flooding risks, while also maximizing co-benefits to people and nature.

Agriculture Research is needed to understand complex plant responses associated with combined stresses (e.g., elevated CO_2 and summer drought) under different management practices on crop yields and to support the development of plant traits and adaptive management practices that improve crop performance in future growing conditions. Further research would be useful to better understand the mitigation potential of farming and management practices. Social science research on the vulnerability of rural communities and effective strategies to enhance the adaptive capacity and resilience of rural communities is also needed.

Human health Social science research is critical to improve our understanding of the vulnerability of rural and urban communities, develop strategies to enhance adaptive capacity and resilience, and overcome barriers to the adoption of improved health communication strategies. The relationship between climate change and mental health is a burgeoning field of research that needs continued support. Expanded and more comprehensive cost-benefit analyses of climate and health adaptation strategies would provide decision makers with data-driven tools to make informed decisions and take action.

Ecosystems The collection of baseline data through ongoing trend assessments and further research on the ways that plant and animal species cope with altered precipitation patterns and increasing temperatures is needed to inform natural resource management decisions. In particular, studies to identify the factors that contribute to successful ecological restoration of different ecosystem types will be critical to help mitigate the adverse effects of climate change on biodiversity.

For more information about this report, contact Karen Petersen at karen.petersen@tnc.org.

The Nature Conservancy
400 N. Michigan Avenue, Suite 1100
Chicago, IL 60611
nature.org/illinois