Contract Report 2018-05
NOVEMBER 2018

BUILDING RESILIENCY TO CLIMATE CHANGE

A CALL TO ACTION

ILLINOIS
Illinois State Water Survey
PRAIRIE RESEARCH INSTITUTE

Cover photo (bottom left): Illinois Natural History Survey, Prairie Research Institute

ACKNOWLEDGMENTS

Funding for this project was provided by the Illinois Department of Natural Resources (IDNR) through a research grant. Sally McConkey (Illinois State Water Survey) and Nancy Holm (Illinois Sustainable Technology Center) provided project oversight. Mary Richardson and Jeanne Handy (Illinois State Water Survey) researched topics and compiled information. Jennifer Martin (Illinois Sustainable Technology Center) provided information on energy demand. Jeanne Handy designed the report.

The authors would like to gratefully acknowledge the contributions of many research professionals at the University of Illinois' Prairie Research Institute, as well as the valuable input and insights of Tom Heavisides (IDNR Natural Resources Contaminant Assessment Section Manager), Paul Osman (IDNR Statewide Floodplain Programs Chief), and Ron Davis (IDNR Mitigation Programs Manager).

CONTENTS

ABSTRACT

The changes in climate occurring today and those projected for the future will have a significant impact on weather extremes and average climate patterns, creating conditions that differ from the historical weather and climate data upon which our societies and systems are based. Disasters such as floods, severe rainstorms, tornadoes, winter storms, and summer drought will be different in the future, typically intensified by climate change. To adapt, it is incumbent upon state and local governments to understand the evolving trends, prepare for changes, and increase resiliency. Climate change impacts on extreme weather events should be included in updates to the Illinois Natural Hazard Mitigation Plan (NHMP) to better describe specific areas or vulnerable populations within the state.

This report highlights data from prominent researchers that describe the likely impacts of climate change on diverse and wide-ranging aspects of Illinois life as well as actions that other Midwestern states and communities are taking to address its negative effects. In Illinois, research and implemented strategies have yielded valuable information, but a coordinated, state-led effort is still necessary to prevent the increasing costs resulting from natural disasters and the cascading negative impacts on quality of life in the state. This report is a call to action for continuing disaster impact assessments and a starting point for Illinois government and its agencies to develop coordinated strategies to prepare for a changing climate and lead Illinois into a safe and prosperous future.

INTRODUCTION

Illinois is already experiencing negative climate-related impacts, and thus it is essential that a coordinated statewide effort be initiated to develop adaptation and mitigation actions to protect our state from loss of life, property damage, and economic stress. The changes in climate occurring today and those projected for the future will likely have a significant influence on weather extremes, such as floods, tornadoes, and summer droughts, as well as average climate conditions (USGCRP, 2017).

The 2017 United States Global Change Research Program (USGCRP) special report has compiled the most compelling evidence to date regarding climate change and its causes, noting that the period from 1901 to 2016 **"is now the warmest in the history of modern civilization."** The report further states, "The global climate continues to change rapidly compared to the pace of the natural variations in climate that have occurred throughout earth's history...observed trends are robust and have been confirmed by multiple independent research groups around the world (confidence level - very high)" (USGCRP, 2017).

Confidence Level
Very High
Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus (USGCRP, 2017)

The purpose of the current report is not to explore the causes of climate change but rather how our adaptation can reduce negative effects. Understanding the likely impacts of climate change provides a basis to formulate forward-looking adaptation strategies that increase resilience in communities and the state of Illinois. Every level of government has a role in adaptation and mitigation planning and execution. It is incumbent upon state government and its agencies and community leaders to address the impacts of climate change and carry out their responsibilities to ensure continued protection of public health, services, and infrastructure.

The intent of this report is to advance the discussion of strategies that address the negative impacts of climate change, promote investment in actions to increase resiliency in the face of an increasing risk of natural disasters, and prepare for opportunities that may arise to build resiliency. This report begins with a short review of the scientific research on climate variability and climate change. Focusing on Illinois, examples of possible impacts of these changes are discussed. The discussion then turns to adaptation planning in Illinois and other Midwestern states, including examples of strategies that address climate-related issues. The strategies presented are taken from a review of natural hazard mitigation and climate change adaptation plans developed by other states, agencies, and communities. This project is a preliminary examination of natural disaster risk in the context of a changing climate. The investigation was performed to complement the update to the 2018 Illinois Natural Hazard Mitigation Plan (NHMP), resulting in this stand-alone report.

This review is not an exhaustive study but is meant to be an introduction to the ideas and resources that are available for the state, its agencies, and communities. The report is a

starting point for state leaders to develop a coordinated effort toward actionable, cost-effective strategies to reduce the negative consequences of climate change. Such a plan is overdue in Illinois.

BACKGROUND

To facilitate a discussion of the most current scientific research on climate variability and future climate change in Illinois, the *Building Resiliency in the Face of Risk* workshop was hosted by the Illinois Department of Natural Resources (IDNR) and the Prairie Research Institute (PRI) on June 14, 2017 (PRI and IDNR, 2017). This event convened academic researchers, state agencies, nongovernmental organizations, businesses, and community leaders to discuss current observations and perceptions of Illinois' changing climate and its future impact on human health, ecosystems, insects and pests, groundwater, surface water, flooding hazards, and community resiliency in Illinois. The subsequent report (PRI and IDNR, 2017) provides excerpts from expert presentations given at the workshop and data on climate change impacts from various sources. The review provides insights on currently available studies but is not an exhaustive report on climate change effects.

Feedback and survey results of the 2017 workshop revealed that climate variability and its impacts are of great concern and that an effort is needed to keep the discussion of new research and information on climate change and resiliency active among PRI, state agencies, non-governmental organizations, and municipalities (PRI and IDNR, 2017). This report was funded by IDNR and undertaken by PRI to continue the dialog and information gathering. This report investigates climate change-related mitigation and adaptation strategies and actions proposed in various planning documents and provides examples applicable to Illinois.

DISCUSSION OF TERMINOLOGY

Climate Change Emissions Scenarios

According to the Intergovernmental Panel on Climate Change (IPCC), the term "climate change" refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2014b). Climate change may be due to natural internal processes or external forces, such as modulations of solar cycles and volcanic eruptions; however, the USGCRP (2017) report gives clear evidence that persistent anthropogenic changes in the composition of the atmosphere and in land use are the dominant forces driving climate change in recent decades. Anthropogenic changes come about with the extraction and burning of fossil fuels and the cutting down and burning of forests; these activities increase the amount of carbon dioxide (CO_2) and soot in the atmosphere.

The IPCC in their *Climate Change 2014 Report* (IPCC, 2014a) presented climate scenarios based on Representative Concentration Pathways (RCPs), which are emission scenarios representing

one stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0), and one scenario (RCP8.5) with very high greenhouse gas (GHG) emissions (IPCC, 2014a).

Figure 1 shows the observed and projected temperature change for Illinois for higher and lower emission scenarios.

Higher Emissions Scenario (RCP8.5): This scenario corresponds to a future in which CO_2 and methane emissions continue to rise because of fossil fuel use, albeit with significant declines in emission growth rates over the second half of the century, a significant reduction in aerosols, and modest improvements in energy intensity and technology (USGCRP, 2017).

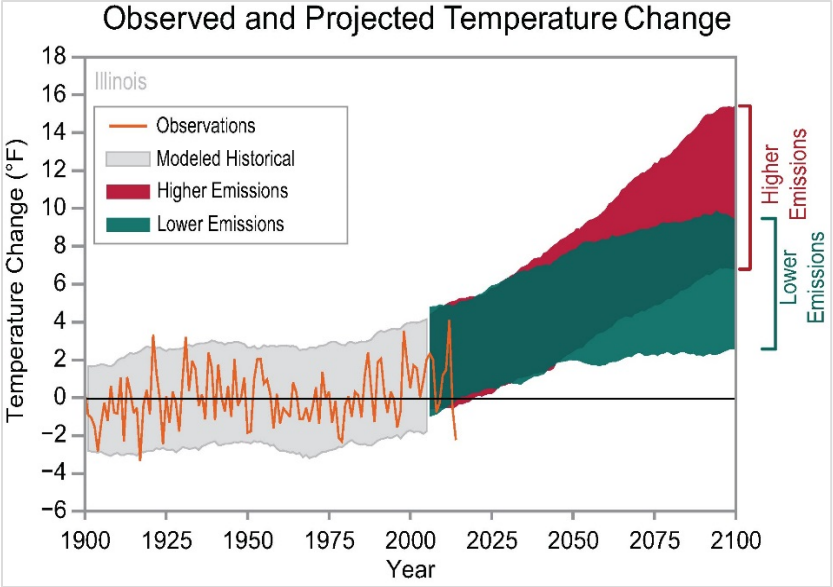


Figure 1. Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Illinois. Observed data are for 1900–2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Illinois (orange line) have risen about 1°F since the beginning of the 20th century. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of model simulations of the historical period (gray shading). Historically unprecedented warming is projected during the 21st century. Less warming is expected under a lower emissions future (the coldest years being about as warm as the hottest year in the historical record; green shading) and more warming under a higher emissions future (the hottest years being about 10°F warmer than the hottest year in the historical record; red shading). Source: CICS-NC and NOAA, NCEI (Frankson et al., 2017)

Lower Emissions Scenarios (RCP4.5 and RCP2.6): In these scenarios, atmospheric CO_2 levels remain below 550 and 450 ppm by 2100, respectively. Emissions of other substances are also lower; by 2100, CO_2-equivalent concentrations that include all emissions from human activities reach 580 ppm under RCP4.5 and 425 ppm under RCP2.6 (USGCRP, 2017).

Mitigation and Adaptation

The IPPC defines mitigation of climate change as human intervention to reduce the sources or increase the capture of GHGs. Examples of human intervention include the reduction of particulate matter emissions that can directly alter the radiation balance (e.g., soot) and measures that control emissions of carbon monoxide, nitrogen oxides, volatile organic compounds (VOCs) and other pollutants that can modify the concentration of ozone, which has an indirect effect on the climate (IPCC, 2014a).

In natural hazard planning vernacular, the term mitigation has a broader definition. The Federal Emergency Management Agency (FEMA) has the following to say about mitigation: "Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. For mitigation to be effective we need to take action now—before the next disaster—to reduce human and financial consequences later (analyzing risk, reducing risk, and insuring against risk). It is important to know that disasters can happen at any time and any place and if we are not prepared, consequences can be fatal" https://www.fema.gov/what-mitigation. In this report the term mitigation encompasses this broader definition and includes adaptation.

The National Climate Assessment Report states, "Adaptation refers to action to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Adaptation planning is occurring in the public and private sectors and at all levels of government, but few measures have been implemented" (USGCRP, 2014).

Resilience

The term resilience is used in many disciplines, and various working definitions have been proposed based on the subject and context. In the context of this report, the focus is on communities. In a 2013 report, *Definitions of Community Resilience: An Analysis*, published by the Community and Regional Resilience Institute (CARRI), 46 definitions are listed. Drawing from this research, CARRI developed the following definition adopted for use in this report: "Community Resilience is the capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change."

PART 1: ILLINOIS WEATHER AND CLIMATE – PAST, PRESENT, AND FUTURE

Long-term climate records of temperature and precipitation show that Illinois has become warmer and wetter over the past several decades.

The increase in temperature observed in the state has been predominantly driven by warmer overnight daily minimum temperatures during summer. However, Illinois has seen an increase in hot days as well. The warmer overnight temperatures are a result of the observed increase in humidity across the state. Increased humidity (wetter air) holds onto heat longer than drier air, so temperatures overall remain warmer. The increased humidity also contributes to an increase in recorded precipitation (PRI and IDNR, 2017).

The Illinois State Climatologist noted that to help place the observed warming climate regime into perspective, the winter season of 2016-2017 can be presented as a future climate analog. Winter 2016-2017 was one of the mildest and driest winters on record in Illinois, at 4-5°F warmer than normal. This warmth aligns with climate projections for mid-century, meaning that the 2016-2017 winter in Illinois (and much of the United States) should be expected to represent a typical winter during the year 2050 (PRI and IDNR, 2017; Angel, 2018).

KEY POINTS

THE STATE'S CHANGING CLIMATE

PROJECTIONS INDICATE THAT THE COMING DECADES WILL BRING CHANGES IN CLIMATE FAR MORE PRONOUNCED THAN THOSE ALREADY OBSERVED. THESE GENERAL STATEWIDE CHANGES INCLUDE BUT ARE NOT LIMITED TO:

- **HIGHER AVERAGE TEMPERATURES**
  AN INCREASE OF 3.8°F IS PROJECTED BY MID-CENTURY, AND 5.6°F BY THE CENTURY'S END UNDER A LOW EMISSIONS SCENARIO (USGCRP, 2014)
- **MORE DAYS OF EXTREME HEAT** (≥ 95°F) **IN SUMMER**
- **MORE SPRING PRECIPITATION**
- **MORE EXTREME RAIN EVENTS**
  PRECIPITATION WILL MORE LIKELY PRESENT AS HEAVY RAINFALL EVENTS (≥ 2 IN) WITH LONGER DRY PERIODS BETWEEN EVENTS. RAINFALL IS EXPECTED TO INCREASE THE MOST DURING FALL, WINTER, AND SPRING MONTHS.
- **MORE DRY DAYS IN SUMMER**
  MORE DRY DAYS COUPLED WITH HIGHER SUMMER TEMPERATURES AND INCREASED EVAPOTRANSPIRATION CAN BE ASSOCIATED WITH AN INCREASED POTENTIAL FOR SUMMER DROUGHT.

The National Oceanic and Atmospheric Administration, National Centers for Environmental Information (NOAA, NCEI) hosts State Climate Summaries that include historical climate variation and trends and future climate model projections. Figures 2 and 3 are excerpts from the state climate summary prepared for Illinois (Frankson et al., 2017).

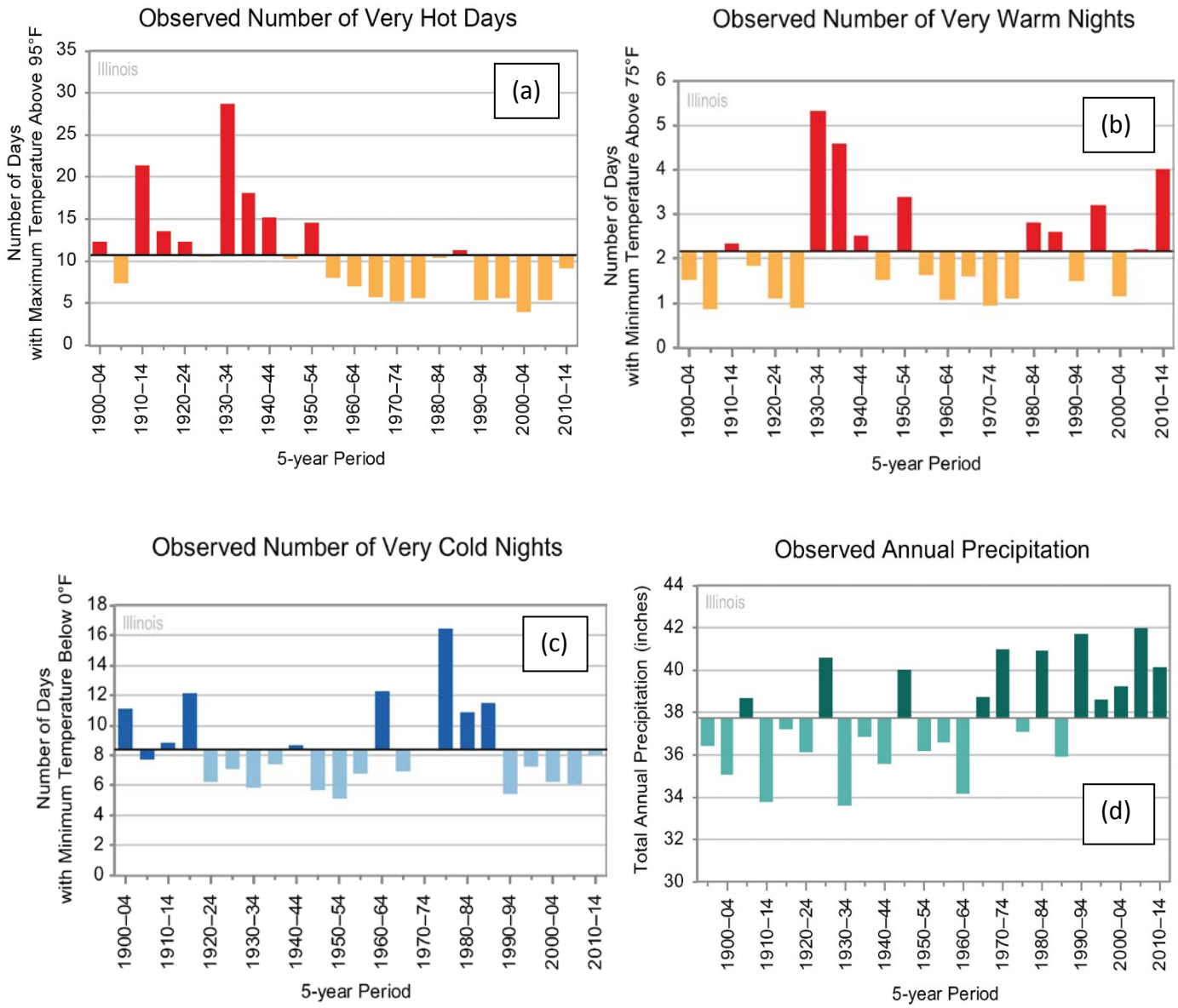


Figure 2. The observed (a) number of very hot days (maximum temperature above 95°F), (b) number of very warm nights (minimum temperature above 75°F), (c) number of very cold nights (minimum temperature below 0°F), and (d) total annual precipitation averaged over 5-year periods. The dark horizontal lines represent the long-term average. The values in Figures 3 a, b, and c are averages from 36 long-term reporting stations. The values in Figure 3d are from NCEI's version 2 climate division dataset. Since 1990, Illinois has experienced a below-average number of very hot days and no trend in very warm nights. However, the state has experienced a below-average number of very cold nights since 1990, indicative of winter warming. Annual precipitation varies widely but has been above average since 1990. Source: CICS-NC and NOAA, NCEI (Frankson et al., 2017)

According to the 2017 National Climate Assessment, annual precipitation in the Midwest has generally increased over the period 1948 to 2015. Precipitation totals for a 24-hour event with a 20-year return period (5% chance event) are 13% higher in the winter, 15% higher in the spring, 10% higher in the summer, and 27% higher in the fall (USGCRP, 2017). This has significant implications in Illinois as urban storm sewer systems are typically designed for a 5% or 10% chance event (duration of the event in hours varies by watershed). **Precipitation events once considered rare (average occurrence of once in every 500 years) are now occurring more often than historic records would lead us to expect** (UCS, 2018). Future precipitation will be more likely to occur as heavy rainfall events with longer dry periods between events.

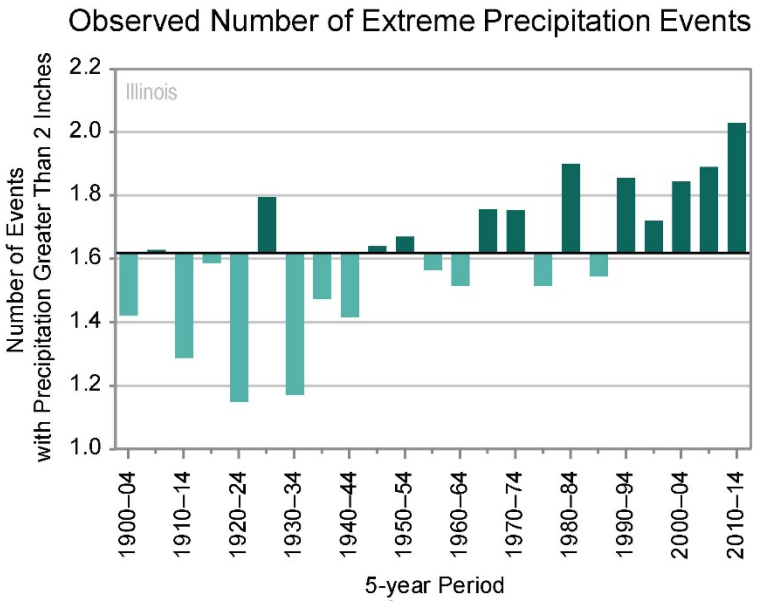


Figure 3. The observed number of days with extreme precipitation events (annual number of days with precipitation greater than 2 inches) for 1900–2014, averaged over 5-year periods. These values are averages from 43 available long-term reporting stations. A typical station experiences 1 to 2 such events each year. The number of extreme precipitation events has been above average since the 1990s. During the most recent 5-year period (2010–2014), Illinois experienced a record high number of events when stations averaged more than 2 events annually. The dark horizontal line is the long-term average (1900–2014) of 1.62 days per year. Source: CICS-NC and NOAA, NCEI (Frankson et al., 2017)

PART 2: EMERGING ISSUES FOR ILLINOIS RELATED TO CLIMATE CHANGE

Climate analyses project that future climate in Illinois will continue following the trend of warmer temperatures and wetter conditions. This will result in impacts to **agriculture**, **human health**, **flood risk, community stability, infrastructure**, **transportation**, **ecosystems**, and **energy demands.** The following sections present some of the potential impacts, but this is not an exhaustive examination.

Changing Agricultural Production Patterns and Yields

Agriculture dominates Midwest land use, with more than two-thirds designated as farmland. Corn and soybean yields have increased markedly by a factor of more than five over the past century largely due to technological innovation and the lengthening of the growing season (Pryor et al., 2014).

Both corn and soybeans are very vulnerable to abnormal weather events and climatic changes. Higher temperatures will result in an early spring and a longer growing season, which could enhance crop productivity. However, the projected heavier spring rainfall will increase the risk of spring flooding, causing damage to newly planted crops. Additionally, the strain placed on the crops by heat stress and possible longer dry spells/drought conditions in the summer will offset most productivity gains.

Figure 4 shows the results of a study by Mishra and Cherkauer (2010) on corn and soybean harvests in Illinois from 1980 to 2007. A high correlation between below-average yields and higher average maximum summer (June, July, and August) temperatures and drier meteorological conditions is easily discernable from the data.

KEY POINTS

Potential Climate-Related Impacts in Illinois Include but are not limited to:

Agricultural Yields

- Crop vulnerability to abnormal weather events and climatic changes
- Increase in endemic and foreign pests

Public Health Risks

- Increased frequency of extreme temperatures and increased humidity
- Degraded Air quality from increase in ground-level ozone and particulates
- Degraded drinking water quality from increase in heavy rainfall events and stormwater runoff
- Increased vector-borne disease

Flood Risk and Community stability

- Increased Riverine and Urban Flooding from more frequent heavy rainfall events and stormwater runoff
- negative impacts on transportation, agriculture, public health, and infrastructure
- Rising flood costs

Water Demand and Availability

- Increased demand during extended drought periods

Infrastructure and Transportation Impacts

- Negative impacts of heavy rainfall events and extreme temperatures on roads, bridges, buildings, highways, and rail systems

Ecosystem Disturbance

- Continued decline of native species and habitat health; increase in invasive species
- Shifting of plant hardiness zones

Lake Michigan Impacts

- Warmer waters and water level reduction affecting many sectors, from ecosystem and human health to transportation

Energy Demands

- projected increase in cooling demand by mid-century

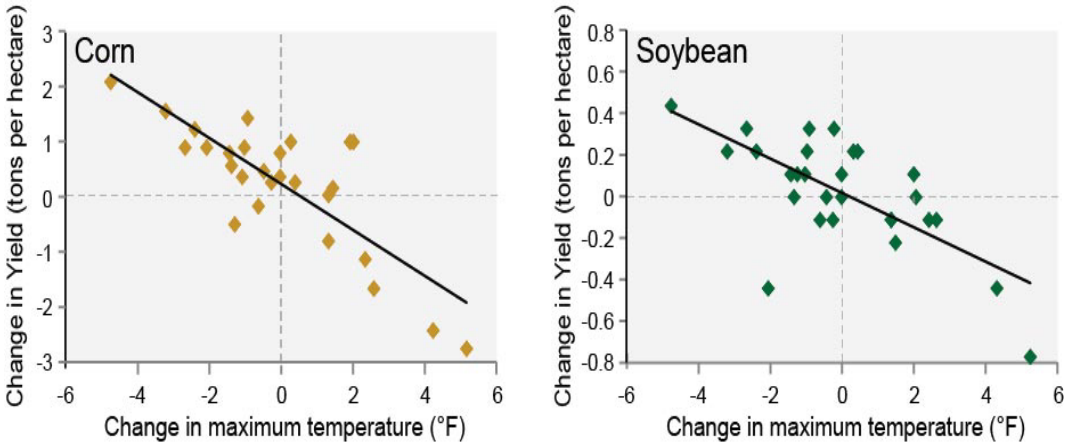


Figure 4. Decline of crop yields under higher temperatures (Mishra and Cherkauer, 2010)

Climate change also poses a threat to agriculture in Illinois via an increase in endemic pests and the introduction of new pests. Insects, weeds, and crop disease are all sensitive to temperature, precipitation, and CO_2 concentrations. Changes in these variables can facilitate new invasive species, introduce new species hierarchies resulting in new dominants, and stress the ecosystem, increasing pathways for foreign pests. Such changes in pest populations could, in turn, lead to increases in herbicide and pesticide use.

Temperature is the primary driving force behind insect development, growth, and behavior. It increases insect metabolism, results in earlier spring emergence, shortens lifecycle development, results in longer "in season" activity, and results in faster evolutionary changes. Monitoring of degree days (metric used to monitor pest development) shows that degree days are accumulating sooner in the year in Illinois, leading to earlier pest emergence. Clear year-to-year variability has been observed in insect populations, likely related to weather fluctuations. However, the exact linkages to climate change have not been identified (PRI and IDNR, 2017).

Increasing Public Health Risks

The Illinois State Climatologist notes that human health is intricately linked to weather and climate (PRI and IDNR, 2017). Research shows that temperature is the primary atmospheric variable likely to drive changes in health-related issues (USGCRP, 2014). Heat stress is projected to increase because of rising summer temperatures and humidity; the warmer atmosphere can hold more water than a cooler one. The frequency of major heat waves, when temperatures exceed 100°F, has increased in the Midwest over the past six decades, with extreme heat waves projected to occur twice a decade by mid-century (Pryor et al., 2014). U.S. statistics show that mortality increases 4% during heat waves compared with non-heat wave days (USGCRP, 2014). Heat wave-related mortalities are likely to be higher in urban areas where atmospheric pollution, heat island effects, and trapped gases intensify the effects of high temperatures. In Illinois, 88.5% of the population lives in cities (https://www.census.gov/). However, warmer winters will most likely decrease cold-related mortality (USGCRP, 2014).

Atmospheric moisture levels directly affect the human body. Precipitation contributes to increased health concerns through vector- and water-borne illness and the mixing and trapping of air pollutants. The increased public health risks due to reduced water quality with the onset of more frequent flooding is also of major concern (USGCRP, 2014).

Degraded air quality from anthropogenic emissions and longer pollen seasons is projected to intensify with higher temperatures and pollution and pollen exposures. More than 20 million people in the Midwest experience air quality that fails to meet national ambient air quality standards and can harm human health (Pryor et al., 2014). With the jet stream expected to move northward in a warming climate, the number of low pressure systems that help mix out air pollution across the Midwest is expected to decline. This will result in increased respiratory issues.

Degraded water quality can result from the expansion of urban areas, which reduces water infiltration into the soil and increases surface runoff. Many major Illinois cities are served by combined storm and sewage drainage systems. As surface area is increasingly converted to roads, parking lots, and other impervious surfaces and as extreme precipitation events intensify, urban stormwater runoff quantities will increase, potentially causing combined sewer overflows and further degrading surface water quality.

Climate Change Impact	Public Health Impacts
Extreme Rainfall and Floods	• Property damage, loss of home and livelihood, population displacement • Death from drowning • Injuries • Damage to drinking water and wastewater systems resulting in worsening quality of drinking water and disruption to agriculture • Water- and foodborne diseases from sewage overflow
Extreme Heat	• Heat-related illnesses such as heat cramps, heat rash, heat exhaustion, and heat stroke • Dehydration • Death • People with heart conditions are more likely to have heart attacks
Increased Temperatures and Rainfall	• Increased number and range of diseases spread by ticks and mosquitoes, such as West Nile virus and Lyme disease • Increased and worsening Respiratory diseases caused by ozone pollution • Increased and worsening allergies caused by pollen
Poor Air Quality/ Air Pollution	• Increased and worsening asthma, allergies, chronic obstructive pulmonary disease (COPD), and other breathing diseases

Source: CDC, n.d.

Water Quality Degradation and The Great Lakes: Degradation of water quality is expected to continue with climate change and increased urbanization, which reduces water infiltration into the soil and increases surface runoff. The Great Lakes, which provide drinking water to more than 40 million people and are home to more than 500 beaches, have been subject to recent sewage overflows, adding human fecal pathogens at outflow locations. One study estimated that increased storm events will lead to an increase of up to 120% in combined sewer overflows into Lake Michigan by 2100 under a very high emissions scenario, leading to additional human health issues and beach closures (Pryor et al., 2014).

Increasing Flood Hazards and Flood Risk

The state of Illinois has a long history of infrastructure and property losses due to flooding. All 102 Illinois counties have experienced flooding at various times at levels severe enough to warrant a Presidential Disaster Declaration. There have been 60 federal disaster declarations since 1957 and 40 of those were related to flooding. Between 2001 and 2013, Illinois had a flood-related disaster declaration nearly every year. Flooding is Illinois' most prominent natural disaster, causing major human and economic consequences and adversely affecting community stability (PRI and IDNR, 2017). The inundation of urban and agricultural land, adverse effects on the integrity and diversity of aquatic ecosystems, and the disruption of navigation along the region's roads, rivers, and reservoirs are additional impacts of flooding (Georgakakos et al., 2014). Despite better floodplain mapping, stringent regulations, and proactive flood mitigation programs, flood damages due to climate change continue to increase in Illinois.

Despite better floodplain mapping, strong regulations, and proactive flood mitigation programs, flood damages due to climate change continue to increase in Illinois. Photo source: FEMA

Both riverine and urban flood risks pose a problem to flood risk management because the changing climate conditions are expected to exacerbate flooding well into the future. A 2015 study by IDNR found that urban flooding has already increased in recent years, with over 90% of urban flooding damage claims from 2007 to 2014 being reported in locations outside the mapped floodplain on FEMA's Flood Insurance Rate Maps (FIRMs) (IDNR, 2015).

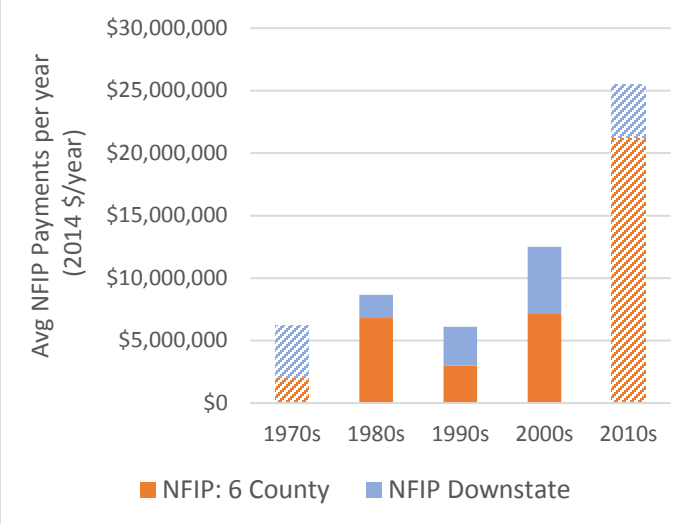


*Figure 5. NFIP claims and payouts have **trended up steeply** during the last 15 years primarily due to three large storm events. Hatching denotes decades (1976-1979 and 2010-2014) with partial data (IDNR, 2015).*

Figure 5 presents the increase in the National Flood Insurance Program (NFIP) claim payments in Illinois over the decades for the Chicago Metropolitan Area of Cook, DuPage, Lake, McHenry, Kane, and Will Counties and for downstate Illinois. Costs are adjusted to equivalent 2014 dollars. The average annual NFIP urban payouts ranged from $6.1 million to $8.7 million during the 1970s, 1980s, and 1990s.

During the 2000s, the average annual payout jumped to $12.5 million, and during the first five years (2010–2014) of the 2010s, the average annual payout increased to $25.5 million (IDNR, 2015).

Infrastructure and Transportation Impacts

The infrastructure for our cities, towns, and transportation systems has been designed based on historical weather and climate data. As the climate changes, current infrastructure designs will likely prove inadequate (WICCI, 2011). The same is true for the designs of critical infrastructure such as dams and protective levees, presenting public safety concerns.

According to Wuebbles et al. (2010), assessment of the effects of climate change on Chicago and the Great Lakes demonstrates that heavy rainfall events and extreme temperatures have the potential to adversely affect roads, bridges, buildings, highways, and rail systems. Changes in frost depth and air temperatures will require alterations in current building codes. Additional climate-related impacts cited include higher costs for road repairs and maintenance; landscaping; increased frequency of fire, police, and emergency response calls; use of non-local hospitals during extreme heat events; water treatment; and property insurance.

Water Supply Impacts

Addressing the future of water supply planning, the Illinois State Water Survey (ISWS) states, "Due to projected growth of the population and economy, Illinois could require 20 to 50% more water in coming decades. Ensuring adequate and reliable supplies of clean water for all users at reasonable cost requires us to think ahead into the near future. As a state, we need to know how much water will be available, how much water we will need, what the options are for providing additional supplies, how to reduce demand, and what the impacts and costs will be" (https://www.isws.illinois.edu/illinois-water-supply-planning).

Thermoelectric power generation accounts for a high percentage of water demand in the state (Meyer et al., in press). With projected increases in deployment of renewable energy technologies, water needs may be significantly reduced (see Rising Demand for Electricity section). On the other hand, as Illinois evaluates carbon capture, utilization, and storage applications for power plants, there may be increased water demands for this portion of the power generation sector (U.S. DOE, NETL, 2010). Additionally, much of the coal-fired power plants and nuclear plants in Illinois will reach a 50-year lifetime in the early 2020s; therefore, decisions will need to be made regarding deployment of new plants or replacement with renewable sources that require less water.

In 2012, groundwater supplied drinking water to 61% of Illinois' municipalities; Lake Michigan water supplied 14% of municipalities; inland surface water supplied 21% of municipalities; and the remaining 4% used a mix of sources. In terms of population served, groundwater was used by 28%, Lake Michigan water by 56%, and inland surface water by 13% (Hadley et al., 2017). The dual impact of increasing precipitation combined with longer dry periods has not yet been

investigated, but public water supplies dependent on surface water reserves in aging reservoirs may be the first to experience shortages caused by climate change. In northeastern Illinois, the demand on groundwater is already exceeding current supply demands as noted in Figure 6 (IDNR and PRI, 2017).

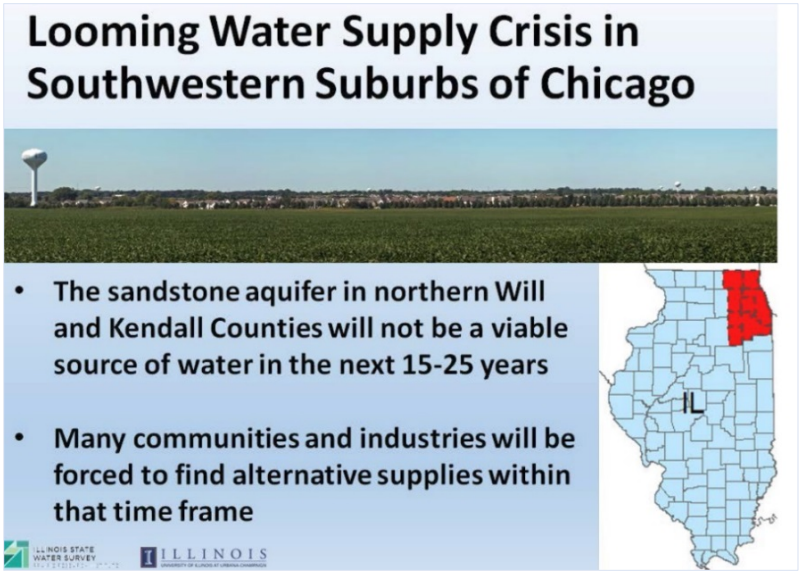


Figure 6. Of primary concern for Illinois scientists at the ISWS is the looming water supply crisis in the southwest Chicago suburbs (IDNR and PRI, 2017).

Observed Changes and Future Concerns for Illinois Ecosystems

Although many of the past changes in Illinois' natural ecosystems have been associated with land-use changes and habitat fragmentation, research by the Illinois Natural History Survey (INHS) suggests that a continuing decline in the populations of many native plants and wildlife species is likely attributable to climate change (PRI and IDNR, 2017). The projected warmer and drier summers are expected to increase the occurrence of plant and animal pathogens. Those species that are predicted to increase in population size and/or expanded range due to climate change primarily include non-native or otherwise undesirable species.

Climate change is also likely to cause a shift in the USDA plant hardiness zone designation by more than a whole unit (Figure 7), moving suitable habitats for some plant species northwards. The date of last frost is expected to move up by as many as 30 days by the end of the century (USGCRP, 2014).

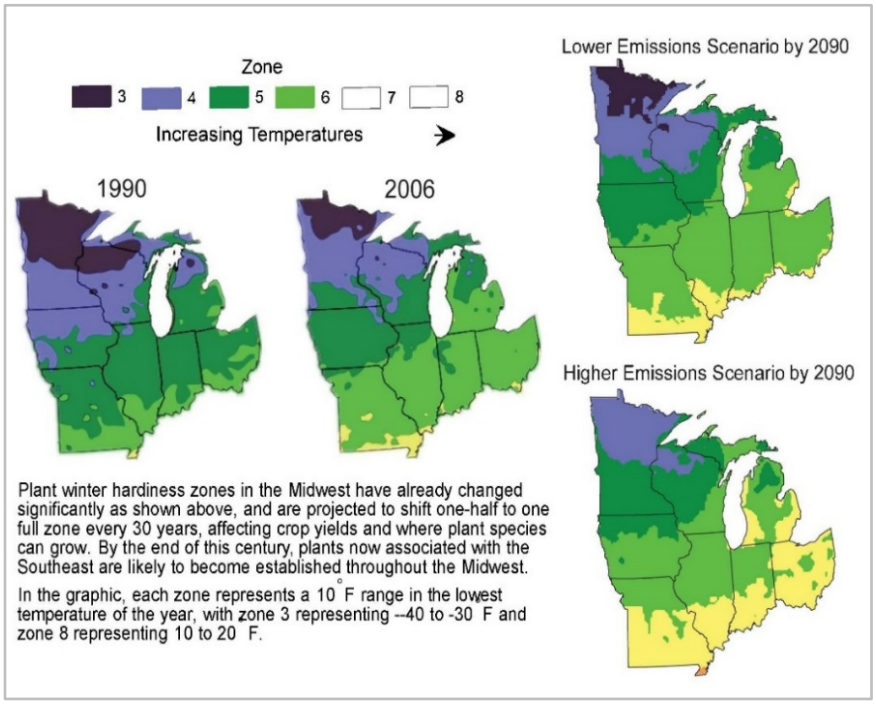


Figure 7. Projected shift of plant hardiness zones (USGCRP, 2009). Image source: Arbor Day Foundation, 2006

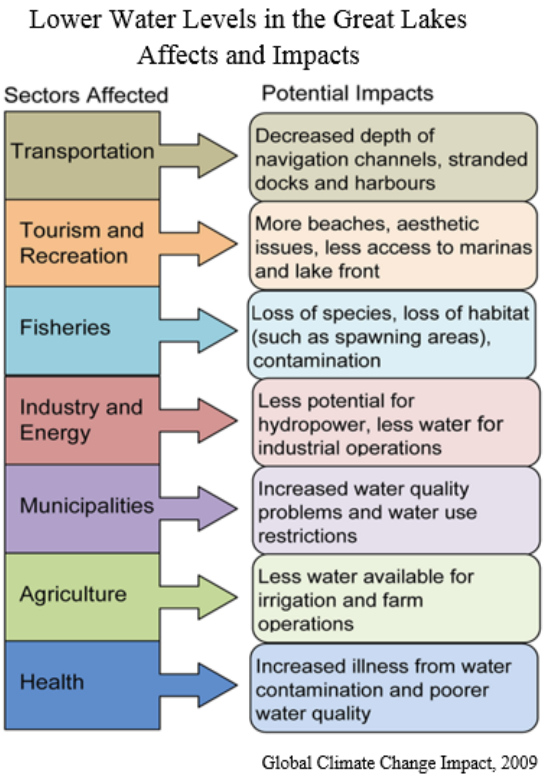
Warmer climates have increased invasive species in Illinois, such as garlic mustard, which is a non-native invader of forests. Photo source: INHS, 2017

Climate change may also diminish the carbon sink attribute of forests (more carbon captured than emitted) by contributing to an increase in disturbances caused by insect outbreaks, forest fires, and drought; and, in the case of forest fires, GHGs are added to the atmosphere (Pryor et al., 2014). Additionally, the structure and composition of Illinois forests are being affected by invasive plant species such as garlic mustard and bush honeysuckle that benefit, at the expense of native species, from a longer growing season resulting from a warming climate (INHS, 2017).

Climate change will affect aquatic ecosystems as well. With earlier spring seasons, lake water surfaces will warm earlier; with higher air temperatures, the water will reach higher temperatures in the summer and cool more slowly in fall. Warmer water will likely result in the production of phytoplankton earlier in the year; however, stratification of the water in the summer may reduce the size of the crop as well as reduce the amount of oxygen for bottom-dwelling bacteria, plants, and animals and could cause fish kills. Warmer water conditions will also favor warm-water species and change the species composition in lakes and rivers and increase harmful algae blooms.

Lake Michigan Impacts

The climate-driven changes of Lake Michigan's ecosystem may be considered most significant near shore in the areas most visible and important to Chicago for recreation and tourism; however, the growth of filamentous algae stimulated by warmer temperatures and higher nutrient concentrations is not only aesthetically displeasing but also may promote pathogens. As with other lakes and streams, the increase in water temperatures in Lake Michigan is likely to favor warm-water species of fish over cold-water types and allow an increase in invasive species (Wuebbles et al., 2010).



Reductions in the Great Lakes ice coverage has also been documented, leading to an increase in winter evaporation, which in turn results in lower lake levels (USGCRP, 2009). Under a higher emissions scenario (Figure 1), lake levels are projected to fall up to 2 feet by the end of this century. The decline in ice cover will lengthen the commercial navigation season,

but the changes in lake levels will mean a reduction in the future draft of the ships, which will influence the amount of cargo carried (Pryor et al., 2014). Additionally, Lake Michigan's winter ice cover provides a shielding effect that protects the shoreline and near-shore lake bottom from storm disturbances. A significant reduction in ice cover would result in increased shoreline erosion and decreased near-shore water quality (Wuebbles et al., 2010).

Rising Demand for Electricity and Changes in the Energy Landscape

The U.S. Energy Information Administration (EIA) has modeled projections that indicate electrical generation growth around 0.9% per year through 2050 (EIA, 2018). Renewables and natural gas will be the leading fuels in this projection (Figure 8). One factor contributing to the increase in electrical generation will be the rising demand due to weather pattern and climate changes.

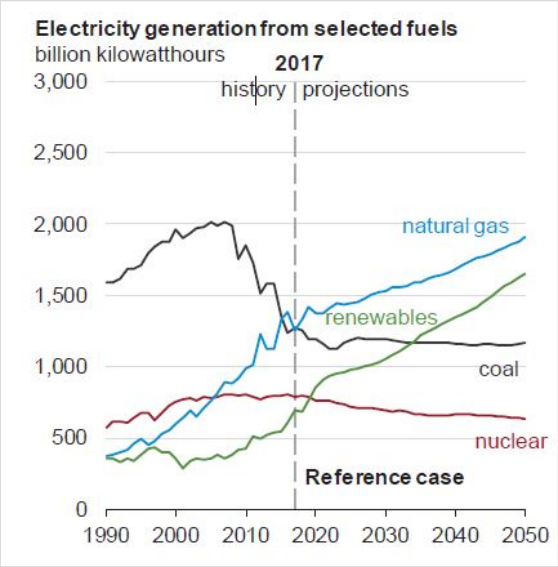


Figure 8. U.S. projected mix of electricity generation technologies (1990-2050). Source: EIA, 2018

A large range in seasonal air temperature causes an energy demand for both heating and cooling, with the highest demand for winter heating. The demand for heating in major Midwestern cities is typically five to seven times that for cooling. This is expected to shift because of longer summers, more frequent heat waves, and higher humidity, leading to an increase in the number of cooling degree days (Pryor et al., 2014). Cooling degree days are defined as the number of degrees that a day's average temperature is above 65°F, which generally leads to an increase in energy use for air conditioning (Figure 9).

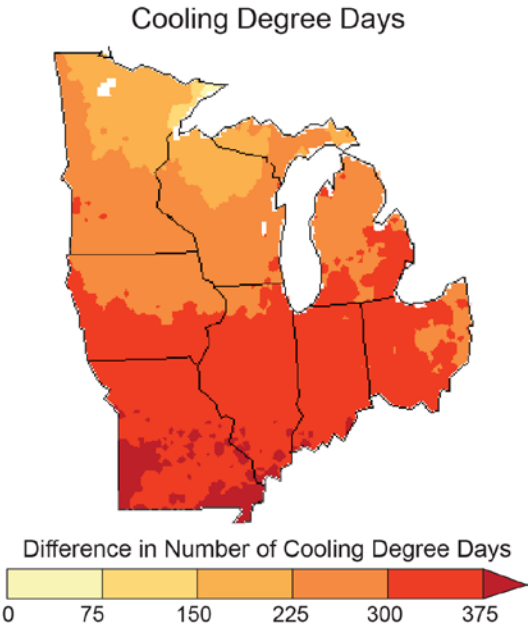


Figure 9. Projected mid-century (2041-2070) climate changes relative to the end of the last century (1971-2000) assuming continued emission increases. Source: NOAA NCDC/CICS-NC (Pryor et al., 2014)

Currently, the Midwest is a major exporter of electricity to other U.S. regions and has a highly energy-intensive economy (Hibbard et al., 2014). Energy use per dollar of gross domestic product is approximately 20% above the national average, and per capita GHG emissions are 22% higher than the national average due, in part, to the reliance on fossil fuels, particularly coal for electricity generation (Pryor et al., 2014).

Climate change presents the Midwest's (including Illinois') energy sector with many challenges, in part because of its current reliance on coal-based electricity and an aging, less reliable electric distribution grid that will require significant reinvestment even without additional adaptations to climate change (Pryor et al., 2014).

The U.S. EIA ranks Illinois as the "fifth largest energy-consuming state in the nation." Coal-fired power plants are the second largest electricity providers in the state and provide almost one-third of state generation (EIA, 2016). Illinois leads the nation in electricity generation from nuclear power, accounting for 12% of the nation's nuclear power generation (EIA, 2018). Because of past economic issues in the electricity market, two nuclear power stations that were scheduled to close now remain open for another decade after the passage of the Future Energy Jobs Bill (SB 2814). This Bill, Public Act 99-0906, became effective on June 1, 2017 (Illinois General Assembly, 2017).

The Future Energy Jobs Act (FEJA) helps Illinois decrease its dependence on fossil fuels and ensures a long-term plan with a 25% Renewable Portfolio Standard for the purchase of renewable energy resources by 2025. The plan also fixes Illinois' prior Renewable Portfolio Standards and requires electric utilities to increase energy efficiency programs and allow for new renewable energy development throughout the state. As defined by the FEJA legislation, "Renewable energy resources" include "wind, solar thermal energy, photovoltaic cells and panels, biodiesel, anaerobic digestion, crops and untreated and unadulterated organic waste biomass" (Illinois General Assembly, 2017).

Currently, Illinois has approximately 4,330 megawatts (MW) of wind generation installed, with an estimated projection of 1,300 MW of new wind development by 2030. As of April 2018, approximately 84 MW of electricity were generated by solar installations. Through FEJA, an additional 2,800 MW of new solar energy will be deployed across the state by 2030 (ELPC, 2018).

To continue accessing the benefits of clean air and water in Illinois and across the Midwest, we must identify the necessary changes within our energy landscape. Transitioning from fossil fuels such as coal to renewable resources has direct implications for public health and the quality of life in the Midwest, and renewable energy resources can be expanded to supply a considerable amount of our electricity needs in Illinois as nuclear and coal-fired power plant infrastructures age and become less efficient. Shifting from fossil fuels to renewable sources not only reduces GHG emissions and creates a healthier environment, but also generates long-term job growth in a clean economy. This switch to more renewable energy sources will take time. In the meantime, therefore, it is important to evaluate and test carbon capture technologies for coal-fired and natural gas power plants to reduce CO_2 emissions, which can impact climate and subsequently human health.

PART 3: FACILITATING CLIMATE-INFORMED PLANNING, POLICY, AND DECISIONS

Communities and government agencies can take the lead in preparing to withstand, respond, and adjust to changing climate. Immediate action will reduce future disruptions. Planning and investment need to reflect changing climate conditions, changing average conditions, and increases in the frequency and severity of extreme events (USGCRP, 2014).

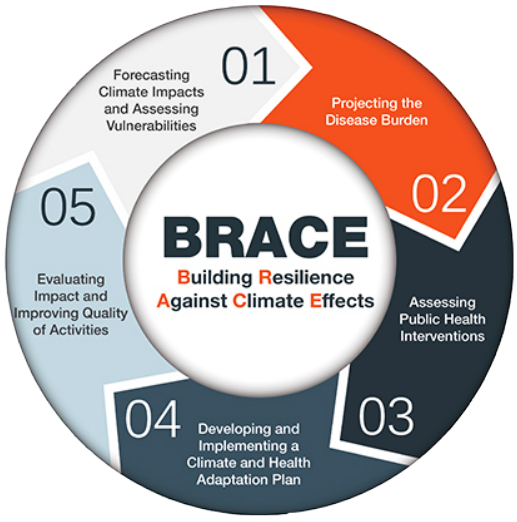
KEY POINTS

- Illinois climate change assessments and strategy development projects have yielded valuable information but do not represent a coordinated state-led effort.
- Midwest state-level task forces and assessments have produced reports on climate change impacts and adaptation strategies for Indiana, Minnesota, Wisconsin, and Iowa.
- Great Lakes Region task forces and assessments seek cross-jurisdictional coordination to enhance adaptation planning and implementation.

Illinois Climate Change Assessments and Strategies

Examples of collaborative approaches to climate change assessments and strategies for Illinois include efforts by the Illinois Climate Change Advisory Group, the Building Resilience Against Climate Effects project, the Institute of Government and Public Affairs Climate Change Policy Initiative, the Building Resiliency in the Face of Risk workshop, and the Chicago Climate Task Force, as described below. **Although these projects are important and should continue, they do not represent a coordinated state-led effort to address climate change.**

The **Illinois Climate Change Advisory Group** (ICCAG), which included stakeholders from the public and private sectors, produced a report providing a "detailed forecast of emissions and economic trends under 'business as usual' conditions through 2020." The global energy and environmental consulting firm, ICF International, was retained to model the emissions and economic impacts of different policy scenarios. The report proposed 24 strategies to reduce GHG emissions in Illinois (ICCAG, 2007). Illinois' total GHG emissions have increased from 192.9 million metric tons in 1990 to 219.2 million metric tons in 2016 (EIA, 2017).



Building Resilience Against Climate Effects (BRACE) is a project funded by the U.S. Centers for Disease Control and Prevention (CDC) to build the capacity of Illinois' public health system to minimize the public health impacts from climate change.

The CDC developed the BRACE framework to assist health departments in creating climate change adaptation plans. With CDC funding, the University of Illinois at Chicago School of Public Health (UIC) and the Illinois Department of Public Health (IDPH) are using the BRACE framework, which provides information and additional resources ranging from climate reports and action plans to a summer heat toolkit (BRACE – Illinois, https://braceillinois.uic.edu/).

Climate change research by the Institute of Government and Public Affairs (IGPA) **Climate Change Policy Initiative** at the University of Illinois at Urbana-Champaign seeks to identify how public policy can help protect Illinois' productivity, health, and future economic welfare. Since 2014, IGPA has produced numerous climate policy reports, which include "Preparing for Climate Change in Illinois" and "Wind Power: An Opportunity for Illinois." (https://igpa.uillinois.edu/reports/7)

The **Building Resiliency in the Face of Risk** workshop was hosted by the IDNR and PRI on June 14, 2017. This event brought together academic researchers, state agencies, nongovernmental organizations, businesses, and community leaders to discuss current observations and understanding of Illinois' changing climate and community resiliency in Illinois. The meeting featured scientists who presented research observations on increased health risks and energy demands due to rising temperatures, increased stress on crops from warmer temperatures and longer dry periods, risks to water supplies and water quality, increased flooding, and impacts to insects and wildlife across the state. Historic weather data were presented demonstrating that extreme events such as flash floods, heat waves, and droughts are on the rise across Illinois. The follow-up report documents excerpts from workshop presentations and presents data on climate change impacts (PRI and IDNR, 2017).

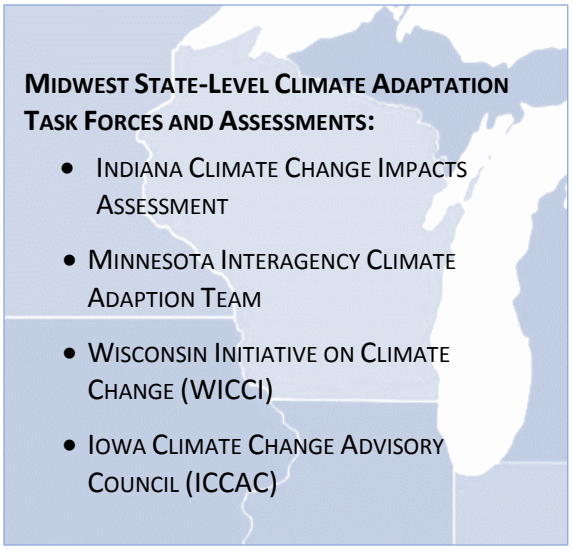
The **Chicago Climate Task Force** was created by the City of Chicago to assess the potential impacts of climate change on the city and, based on these impacts, develop an action plan. The Task Force included representatives from local communities, universities, business and labor, and city and state government. Leading scientists were consulted to describe various scenarios for Chicago's climate future and how these would impact life in the city. The studies estimate the potential impacts of climate change on human health, natural ecosystems, water resources, energy, and infrastructure in Chicago and the surrounding Great Lakes region. The analyses form the basis for the Chicago Climate Action Plan, which explores the implications of future climate scenarios and serves as a pattern for future regional assessments to directly inform adaptation and mitigation policy at the local to regional scale. The action plan outlines five strategies incorporating 35 actions. The strategies identified are: Energy-Efficient Buildings, Clean & Renewable Energy Sources, Improved Transportation Options, Reduced Waste & Industrial Pollution, and Adaptation (CCTF, 2008; Wuebbles et al., 2010).

Excerpt of Adaptation Strategies Developed for the City of Chicago (CCTF, 2008)

Manage heat	Update the heat response plan, focusing on vulnerable populations; complete further research into urban heat island effect and pursue ways to cool hot spots.
Pursue innovative cooling	Launch an effort to seek out innovative ideas for cooling the city and encourage property owners to make green landscape and energy efficiency improvements.
Protect air quality	Intensify efforts to reduce ozone-precursors through mitigation programs that reduce driving and emissions from power plants.
Manage stormwater	Collaborate with the Metropolitan Water Reclamation District on a Chicago watershed plan that factors in climate change and uses vacant land to manage stormwater.
Implement Green Urban Design	Implement key steps in Chicago's Green Urban Design plan to manage heat and flooding. These steps will enable Chicago to capture rain where it falls and reflect away some of the intensity of the sun on hot days.
Preserve our plants and trees	Publish a new plant-growing list that focuses on plants that can thrive in altered climate. Also draft a new landscape ordinance to accommodate plants that can tolerate the altered climate.
Engage the public	Share climate research findings with groups most affected—social service agencies, garden clubs, etc. Help individual households to take their own steps to reduce flooding and manage heat waves such as installing rain barrels and back-up power for sump pumps and planting shade trees.
Engage businesses	Work with businesses to analyze their vulnerability to climate change and take action.
Plan for the future	Use the Green Steering Committee of City Commissioners to oversee City implementation efforts and the Green Ribbon Committee of business and community leaders to assess how the Plan is being implemented, recommend revisions, report to the Mayor and all Chicagoans on our progress.

Midwestern State-Level Climate Change Assessments and Strategies

Reports on climate change impacts and strategies for adaptation have been produced for Indiana, Minnesota, Wisconsin, and Iowa.



Indiana Climate Change Impacts Assessment

In Indiana, the Purdue Climate Change Research Center has led an effort to coordinate scientists and decision-makers from across the state. They have and are continuing to work together to develop a series of reports that show how a changing climate will affect state and local interests. The series of reports include observed and expected climate change; impacts on health, forest ecosystems, urban green space, and agriculture; and adaptation strategies to reduce impacts (Purdue, 2018).

Green infrastructure (green space) is a management tool for storm water quality and quantity among other uses and benefits. The following is an example of an adaptation management strategy for urban green space from *Maintaining Indiana's Urban Green Spaces:*

"There are several proactive steps that can be taken to improve resilience of urban green infrastructure. Depending on the location and need, green spaces can be made more bio-diverse, enhancing their capacity to adapt to changing conditions; more redundant, providing insurance against loss of any one component; more modular, compartmentalizing areas to limit the spread of diseases or invasive pests and plants; and more connective, enabling migration of beneficial species" (Purdue, 2018).

Additional Indiana Climate Change Impacts Assessment reports are in progress, relating to aquatic ecosystems, tourism and recreation, water, energy, and infrastructure.

Minnesota Interagency Climate Adaptation Team (ICAT)

Minnesota ICAT reported in May 2017 (*Report of the Interagency Climate Adaptation Team*) on actions taken by 11 state agencies, including the Departments of Agriculture, Commerce, Health, Military Affairs, Natural Resources, Homeland Security and Emergency Management, and Transportation, as well as the Environmental Quality Board, Pollution Control Agency, Board of Water and Soil Resources, and Metropolitan Council, to adapt to climate changes and reduce climate change impacts. ICAT has identified adaptation indicators to monitor progress.

Examples of Minnesota state agency actions include the following:

The Minnesota Department of Commerce implements the **Weatherization Assistance Program** providing free home energy upgrades to income-eligible homeowners and renters to help save energy and ensure their homes are healthy and safe. Better insulation builds resilience to heat and cold while also lowering energy bills and greenhouse gas emissions.

The Minnesota Pollution Control Agency, in partnership with Conservation Corps Minnesota, supports **community resilience projects through Youth Outdoors and the Summer Youth Corps**. These projects focus on new green infrastructure in underserved urban neighborhoods and in cities throughout the state. The work helps to reduce storm water runoff, improve air quality, add pollinator habitat, and increase shaded areas.

The Minnesota Department of Transportation (MnDOT) conducted a **climate vulnerability assessment pilot project** as supported by the Federal Highway Administration to examine the effects of climate hazards on transportation systems. The project team scored and ranked 316 bridges, 521 large culverts, 920 pipes, and approximately 45 miles of road segments in MnDOT districts in southeast and northeast Minnesota.

The Minnesota Board of Water and Soil Resources worked with **four landowners and state, federal, and local agencies to restore wetlands**, an important approach for adapting to climate change by increasing the resiliency of watersheds. Hydrology restoration and planting diverse seed mixes decreases downstream flooding by retaining water from large storms while also increasing wildlife habitat.

The Metropolitan Council **maintains and rehabs its wastewater infrastructure** to ensure the system has the capacity to handle future demands and support communities' efforts to reduce excessive flows through inflow and infiltration reduction strategies. Efforts by communities, property owners, and the Council have helped to reduce volumes, even as precipitation, rainfall intensities, and populations have increased.

(ICAT, 2017)

Wisconsin Initiative on Climate Change Impacts

The Wisconsin Initiative on Climate Change Impacts (WICCI) released its first report in 2011, *Wisconsin's Changing Climate: Impacts and Adaptation*. WICCI uses working groups to conduct science-based assessments of potential climate change impacts on specific regions, ecosystems, communities, and industries in Wisconsin and to make recommendations on adaptation strategies. Each group is made up of scientists, experts, and practitioners.

The WICCI working groups have developed state adaptation strategies in the areas of Agriculture and the Soil Resource, Coastal Resources, Natural Habitats and Biodiversity, People and Their Environment, and Water Resources and continue to produce reports on climate change impacts and adaptation strategies (https://www.wicci.wisc.edu/publications.php). An example report is *Climate Wisconsin 2050: Wisconsin Communities* (August 2016) in which specific climate change impacts and adaptation strategies are identified. The following are examples of impacts on government facilities as well as adaptation strategies.

Government Facilities and Infrastructure

TEMPERATURE

CLIMATE IMPACTS

- High temperatures buckle pavement. Additional freeze-thaw cycles create potholes.
- Increased temperature puts more demand on HVAC systems.

ADAPTATION STRATEGIES

1. Increase monitoring of susceptible roadway pavements. Budget for increased roadway maintenance and repair.
2. Improve temperature control for public buildings (e.g., green roofs and windows with low-e glass). Service and replace HVAC systems for increased temperature.

PRECIPITATION

CLIMATE IMPACTS

- High water over roadways.
- Increased demand on stormwater drainage systems. Flooding and erosion around government facilities.

ADAPTATION STRATEGIES

1. Planning, signage, and alternative traffic routing for flooded roadways. Re-size culverts and drainage ways to accommodate larger flows.
2. Inspect and maintain stormwater systems. Build retention areas to collect increased rainwater runoff and store for later use.

State-Level Adaptation Strategies in Wisconsin (WICCI, 2011)

The 2011 report, *Wisconsin's Changing Climate: Impacts and Adaptation*, presented state adaptation strategies developed for the areas of Agriculture and the Soil Resource, Coastal Resources, Natural Habitats and Biodiversity, People and Their Environment, and Water Resources. These strategies were presented in four general categories: **taking action** to adapt to future climate**, building capacity** to make better decisions, **communicating** with stakeholders, and **filling gaps** in our understanding.

The following provides an example of recommended strategies within the area of People and Their Environment. The report notes there is a diversity of contributing factors leading to a wide range of possible strategies for adaptation.

Taking Action: Policy-makers should carefully weigh the impacts of their infrastructure investment decisions on human health and the state's capacity to adapt to a changed climate. For example, the health co-benefits of "green" transportation planning should be included in any cost-benefit analyses of adaptation to climate change.

- Air Quality: Expand the Wisconsin Department of Transportation Congestion Mitigation and Air Quality grants to reduce the number of vehicle miles traveled and improve vehicle and fuel technologies to reduce vehicle emissions.
- Human Health: Increase the urban tree canopy to reduce the urban heat island effect.
- Water Infrastructure: Upgrade urban storm drains and best management practices based on continuous hydrologic modeling and climate predictions. Manage runoff to minimize high-flow impacts rather than sediment removal during high storm flows. Distribute management strategies throughout urban watersheds to mitigate high flows. Anticipate groundwater impacts on stormwater infiltration management practices.

  Implement stormwater best management practices that will improve water quality while reducing sanitary sewer overflows. Increase capacity of municipal wastewater systems and minimize stormwater inflow and groundwater infiltration to prevent overflows. Require standby power for buildings with sump pumps to avoid system inflows caused by storm-related power outages.

  Identify locations that are vulnerable to climate impacts and apply more stringent design criteria. Flood-proof vulnerable buildings and infrastructure.

  Acquire land along waterways to prevent flooding, improve water quality and reduce sewer overflows.

  Use low-impact design to minimize runoff from newly developed areas. Construct green roofs to improve water quality, reduce sewer overflows and improve building cooling.

Building Capacity: Expand the activities of the Wisconsin environmental public health tracking program to include indicators of air pollution conditions linked to climate variability and change.

Establish a vector-borne disease surveillance program to collect data and other epidemiological reports. Build capacity for drinking water quality emergency assessment and response. The state should develop minimum design and performance standards for the control of the high-water impacts of development. In addition, it should:

- Provide local units of government with the technical and financial assistance needed to assess and mitigate their vulnerabilities to potential high-water conditions caused by present and future climate conditions.
- Identify at-risk stream crossings and develop maintenance and high-water contingency plans.
- Periodically update estimates of high-water profiles based on revised rainfall data.
- Assist local governments in development of regional continuous hydrologic simulation models for both surface water and groundwater.
- Use updated models to predict groundwater impacts on development.
- Incorporate climate change considerations into watershed management and restoration plans.
- Revise building standards to address runoff volume control.

The Wisconsin Department of Natural Resources should develop an approval process for prior converted wetlands that are being removed from agricultural use to encourage their restoration and prevent development in flood-prone areas.

Planners should coordinate with regulators to identify future land use changes and control land use around internally drained areas and over hydric soils and use updated models to predict groundwater impacts on development.

Communicating: Provide outreach and education on health impacts of air quality to county and city public health departments, school nurses, day care centers, summer camps, nursing homes and other facilities.

Educate communities about the hazards of building in areas prone to high water.

Coordinate with regulators to identify future land use changes and control land use around internally drained areas and over hydric soils.

Educate property owners about sanitary sewer inflow prevention.

Filling Gaps: Improve and maintain Wisconsin's climate monitoring network (weather, stream flow, groundwater) to provide continued high-quality data to support short- and long-term climate impact modeling.

Invest in research at the state and national levels to build capacity and provide knowledge in the areas of winter-spring hydrology, hydrologic modeling and decision-making under uncertainty for water resource management.

Study the impact of increased precipitation on the frequency of combined and sanitary sewer overflows and water quality.

Research opportunities for mass transit such as street cars, commuter rail, and high-speed rail to improve air quality and reduce ozone.

Iowa Climate Change Advisory Council

In 2011 the *Iowa Climate Change Adaptation and Resilience Report* was published. The investigation was a pilot project funded by the U.S. Environmental Protection Agency. The report lists nine findings on how to support communities that want to incorporate climate science into local planning efforts with the overarching recommendation for "federal agencies, the state of Iowa, and the local jurisdictions to work together to develop programs and incentives that encourage incorporating climate projections into the hazard mitigation risk assessment process and consider ways to encourage **innovative**, **integrated hazard mitigation and comprehensive planning.**"

Iowa Climate Change Adaptation and Resilience Report (USEPA and RIO, 2011)

- Local governments are at the forefront of adapting to climate change.
- Land use is a primary determinant of community and regional climate change adaptation capacity.
- Climate change data must be formatted and distributed in a way that is accessible and usable by state and local planners.
- Local and state planners need to increase skill sets to effectively use climate change data.
- Federal and state programs should create incentives that will improve the use of climate change data, including in the production of hazard mitigation plans.
- Communities need to integrate planning processes, specifically hazard mitigation and comprehensive land use planning.
- Federal and state programs and policies should give communities incentives to integrate planning processes, specifically hazard mitigation and comprehensive land use planning, and to incorporate no-regrets adaptation measures to produce symbiotic outcomes.
- Federal agencies should align and leverage funding and focus on pre-disaster planning for community resilience and sustainability.
- Investment decisions should take a regional perspective and be integrated across infrastructure types and sectors to realize co-benefits.

Examples of adaptation planning strategies to protect natural resources and agriculture include:

- Promote standards, regulations, and incentives for water conservation so that communities are better prepared to respond to lower water supplies. Water availability should be considered in development reviews, planning decisions, infrastructure investments, and development incentives.
- Use planning policies regarding infrastructure investments, extension of urban services and utilities, and preservation of natural or agricultural areas to create compact regional development patterns that avoid hazard-prone areas.

- Identify and protect wetland areas that slow the release of water into streams during times of extreme rain events.
- Establish strategies to promote redevelopment and compact new development that will minimize the conversion of farmland and woodland for urban use in order to reduce the amount of impervious surface coverage in watersheds.
- Develop state plans and programs to help farmers incorporate environmental protection practices, such as wetland protection, wetland restoration, buffer strips, and natural ground cover (grasses) that have been shown to lessen the "flashiness" of stream flow. Promote federal, state, and local funding for preservation of open space and farm and forest land (USEPA and RIO, 2011).

Great Lakes Region Climate Change Assessments and Strategies

The Great Lakes are a unique Midwestern resource that is not immune to the impacts of climate change. The report *The State of Climate Change Adaptation in the Great Lake Region* (Gregg et al., 2012) reviews projects, programs, adaptation methodology, and case studies, providing a rich resource of literature.

As part of the project's consideration of adaptation projects and initiatives, the research delves into capacity building and includes recommendations to coordinate planning and management. The report notes that the effects of climate change in the Great Lakes region will be felt at multiple scales and will require cross-jurisdictional coordination to enhance adaptation planning and implementation. The Great Lakes Restoration Initiative, which includes several federal departments and agencies, is an example of a robust regional coordination effort. This collaborative task force prioritizes and administers grants for restoration projects in the region.

Another federally funded effort is the Great Lakes Integrated Sciences and Assessments (GLISA), which is a collaboration of the University of Michigan, Michigan State University, Ohio State University, and Michigan Sea Grant. It is composed of leading climatologists, social scientists, and outreach specialists working to bridge the gap between producers and users of scientific information. The group focuses on adaptation to climate change in areas that include agriculture, watershed management, urban management, and natural resource-based tourism in Lake Huron and Lake Erie watersheds. Specific goals include developing an integrated network of stakeholders that will contribute to production of policy and usable science; conducting scientific research to address gaps in current knowledge; compiling, synthesizing, and comparing existing climate knowledge in the region and developing new approaches to enhance usability; and developing best practices for the use of climate projections in impact analyses and decision-making.

GLISA also maintains a website providing numerous resources, including climate change education materials, news and events, current research projects, decision-support tools, and funding opportunities (Gregg et al., 2012).

PART 4: NEXT STEPS FOR ILLINOIS' DECISION-MAKERS, SCIENTISTS, AND STAKEHOLDERS

Every level of government has a role in developing policies, strategies, and actions to adapt to and mitigate climate change impacts. Decision-makers, technical experts, and the public need to engage in mutual shared learning and shared production of relevant knowledge associated with climate change impacts (PRI and IDNR, 2017).

KEY POINTS

THE NEXT STEPS FOR ILLINOIS MUST INCLUDE:

- INFORMING AND SUPPORTING THE RESEARCH AND DEVELOPMENT OF STATE-LEVEL ADAPTATION STRATEGIES AND HAZARD MITIGATION ACTIONS, REGULATIONS, AND POLICIES BASED ON FUTURE CONDITIONS /CLIMATE CHANGE
- IDENTIFYING AND ENGAGING REPRESENTATIVES AND EXPERTS FROM MULTIPLE AGENCIES AND DISCIPLINES IN A COORDINATED EFFORT TO TACKLE STATEWIDE OBJECTIVES

At the state level, an investment in planning and research will build much needed capacity and provide knowledge in areas where uncertainty exists.

Climate change considerations should be included as an element of hazard in updates to the Illinois NHMP to better describe specific areas or vulnerable populations in the state, such as those at the highest risk from projected future conditions for extreme heat. A detailed, system-wide vulnerability assessment of Illinois' transportation infrastructure and assets could be performed that takes into account changing future conditions such as increased precipitation and more instances of extreme weather. This type of assessment could be linked directly to a risk assessment for state-owned facilities in the Illinois NHMP. Most importantly, state agencies should independently assess how to address the impacts of climate change on their operations and responsibilities.

Through the formation of a state-level climate change task force, a coordinated effort should be undertaken to tackle statewide objectives through adaptive strategies, policies, programs, and research with clear objectives, actions, and measures of progress.

Local governments also have a fundamental role in protecting their citizens, institutions, and infrastructure in the face of a changing climate and need not wait for state-led efforts. Communities need to integrate planning processes, specifically hazard mitigation and comprehensive land use planning (USEPA and RIO, 2011). For example, local governments should include higher floodplain management standards, incorporate updated design standards in stormwater ordinances, and adopt building codes that anticipate climate change.

Getting Started: Choosing Climate Change Adaptation and Mitigation Strategies

All climate change strategies should follow those goals used for any mitigations strategy: to identify and reduce or eliminate the impact that hazards have on life, property, social and economic activities, and natural resources from natural or man-made disasters. Using FEMA's five steps to a mitigation strategy as the basis, specific principles and strategies should be developed to help identify and mitigate *near-term* risk to people and properties under a wide

range of possible climate-related hazards. Reference can be made to FEMA's 2011-OPPA-01 FEMA *Climate Change Adaptation Policy Statement* and *2015 State Mitigation Plan Review Guide and* the U.S. EPA's 2014 *Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans*.

Appendix A provides examples of potential strategies compiled by the Natural Resources Defense Council (NRDC), which include mitigation actions, regulations, and policies. Also noted are the types of hazard risk (i.e., flood), mitigation techniques (i.e., education and awareness), and a suggested lead agency.

Further strategies are discussed in Appendix B, which includes suggestions for task force formation, key meetings, development of recommendations, and plan implementation.

CONCLUSIONS

Illinois scientists have sounded the alarm. There is little doubt that climate change will negatively affect the quality of life for the citizens of Illinois. Given the rate and scale of the climate-related changes observed today and those projected for the next century, a comprehensive approach is required to create adaptation strategies and plans. **Efforts to reduce climate change impacts, which cut across boundaries and societal considerations, will benefit from a collaborative approach that can additionally instill efficiency, economy, and innovation into the process**. Investment decisions should take a regional perspective and be integrated across infrastructure types and sectors to realize additional benefits. Communities, individual citizens, businesses, and policy leaders will likewise need to weigh potential impacts when deciding which adaptation strategies to implement and when and how to implement them. As we view hazard mitigation and adaptation planning through a climate lens, new decision-support tools for integrating scientific information will be crucial, creating opportunities for innovation.

This report is a call to action for the state, state agencies, and communities to understand the implications of climate change, formulate adaptive strategies, and adopt policies and programs with clear objectives, actions, and measurements of progress. A state-level task force can provide statewide objectives with leadership from the Governor's office and the legislature. Other key state agencies and groups include, but are not limited to, the Illinois Emergency Management Agency (IEMA), Interagency Hazard Mitigation Team (IHMT), Illinois Department of Transportation (IDOT), Illinois Department of Agriculture (IDOA), Illinois Department of Public Health (IDPH), Illinois Environmental Protection Agency (IEPA), Illinois Department of Natural Resources (IDNR), Illinois Department of Commerce and Economic Opportunity (IDCEO), and Illinois universities, with specific involvement of the Prairie Research Institute (PRI). Federal partners may include FEMA Region V, the National Oceanic and Atmospheric Administration (NOAA) National Weather Service, the U.S. Army Corps of Engineers (USACE), and state agencies' federal counterpart departments.

REFERENCES

Angel, J. R. 2018. *Climate Change and Hazard Mitigation*. Illinois Hazard Mitigation Plan 2018. In press. Springfield, IL.

Chicago Climate Task Force (CCTF). 2008. *Chicago Climate Action Plan*. Available at: http://www.chicagoclimateaction.org/pages/adaptation/11.php

Community and Regional Resilience Institute (CARRI). 2013. *Definitions of Community Resilience: An Analysis*. Available at: http://www.resilientus.org/wp-content/uploads/2013/08/definitions-of-community-resilience.pdf

Environmental Law and Policy Center (ELPC). 2018. *Renewables Plan Puts Illinois on Path to Clean Energy Leadership: Plan Approved in April 2018 Details New Renewables Procurements & Programs*. Available at: http://elpc.org/wp-content/uploads/2018/05/Updated-Illinois-RPS.pdf

Federal Emergency Management Agency (FEMA). 2011. *Climate Change Adaption Policy Statement 2011-OPPA-01*. Washington, D.C. Available at: https://www.fema.gov/media-library-data/20130726-1919-25045-3330/508_climate_change_policy_statement.pdf

Federal Emergency Management Agency (FEMA). 2015. *State Mitigation Plan Review Guide*. Washington, D.C. doi:FP 302-094-2.

Frankson, R., K. Kunkel, S. Champion, B. Stewart, D. Easterling, B. Hall, and J. R. Angel. 2017. *Illinois State Climate Summary*. *NOAA Technical Report NESDIS 149-IL.* 4 pp. Available at: https://statesummaries.ncics.org/il

Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, T. C. Richmond, K. Reckhow, K. White, and D. Yates. 2014. Climate change impacts in the United States: The third national climate assessment. Ed. J. M. Melillo, T.C. Richmond, and G. W. Yohe. Ch. 3 In *Water resources*. 69–112. doi:10.7930/J0G44N6T. Available at: https://nca2014.globalchange.gov/report/sectors/water

Gregg, R. M., K. M. Feifel, J. M. Kershner, and J. L. Hitt. 2012. *The state of climate change adaptation in the Great Lakes region*. EcoAdapt, Bainbridge Island, WA.

Hadley, D. R., J. A. Krueger, G. S. Roadcap, and C. R. Healy. 2017. *The Distribution of Water Use in Illinois*. Illinois State Water Survey Map Series 2017-01.

Hibbard, K., T. Wilson, K. Averyt, R. Harriss, R. Newmark, S. Rose, E. Shevliakova, and V. Tidwell. 2014. Climate change impacts in the United States: The third national climate assessment. Ed. J. M. Melillo, T. C. Richmond, and G. W. Yohe. Ch. 10 in *Energy, water, and land use*, 257–281. doi:10.7930/J0JW8BSF. Available at: http://nca2014.globalchange.gov/report/sectors/energy-water-and-land

Illinois Climate Change Advisory Group (ICCAG). 2007. *Report of the Illinois Climate Change Advisory Group.* Available at: http://www.epa.state.il.us/air/climatechange/documents/iccag-final-report.pdf

Illinois Department of Natural Resources (IDNR). 2015. *Report for the Urban Flooding Awareness Act*. Available at: https://www.dnr.illinois.gov/WaterResources/Documents/Final_UFAA_Report.pdf

Illinois General Assembly. 2017. *Public Act 99-0906, Future Energy Jobs Act*. Available at: www.ilga.gov/legislation/publicacts/99/PDF/099-0906.pdf

Illinois Natural History Survey, Prairie Research Institute (INHS, PRI). 2017. *Ecosystem Conservation and Management in an Era of Global Climate Change*. Available at: http://wwx.inhs.illinois.edu/files/2414/8676/2702/CTAP_GlobalClimateChangeBooklet_FINAL_05JAN2017.pdf

Interagency Climate Adaptation Team (ICAT). 2017. *Adapting to Climate Change in Minnesota. 2017 Report of the Interagency Climate Adaptation Team (ICAT).* Available at: https://www.pca.state.mn.us/sites/default/files/p-gen4-07c.pdf

International Panel on Climate Change (IPCC). 2014a. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 151 pp. Eds. R. K. Pachauri and L. A. Meyer. IPCC, Geneva, Switzerland.

International Panel on Climate Change (IPCC). 2014b. Annex II: Glossary. Eds. K. J. Mach, S. Planton, and C. von Stechow. In *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Eds. R. K. Pachauri and L. A. Meyer. IPCC, Geneva, Switzerland, 117–130.

Meyer, S., B. Dziegielewski, Z. Zhang, D. Abrams, and W. Kelly. 2018. *Water Demand in the Middle Illinois Water Supply Planning Region, 2010-2060*. Illinois State Water Survey Contract Report 2018-02, Champaign, IL.

Mishra, V. and K. A. Cherkauer. 2010. Retrospective droughts in the crop growing season: Implications to corn and soybean yields in the Midwestern United States. *Agricultural and Forest Meteorology* 150: 1030–1045. doi:10.1016/j.agrformet.2010.04.002.

National Oceanic and Atmospheric Administration, National Centers for Environmental Information (NOAA, NCEI). Available at: https://www.ncei.noaa.gov/

Prairie Research Institute, and Illinois Department of Natural Resources (PRI, IDNR). 2017. *Building Resiliency in the Face of Risk.* Available at: http://publish.illinois.edu/buildingresiliency/files/2017/06/Building-Resiliency-in-the-Face-of-Risk-Final-Report_6-30-17.pdf

Pryor, S. C., D. Scavia, C. Downer, M. Gaden, L. Iverson, R. Nordstrom, J. Patz, and G. P. Robertson. 2014. Ch. 18, Midwest. In *Climate Change Impacts in the United States: The Third National Climate Assessment.* Eds. J. M. Melillo, T. C. Richmond, and G. W. Yohe. U.S. Global Change Research Program 418–440. doi:10.7930/J0J1012N. Available at: http://nca2014.globalchange.gov/report/regions/midwest

Punchard Consulting. 2016, Sept. *Integrating Future Conditions into Hazard Mitigation Actions, Regulations and Policies for the State of Wisconsin*. Prepared for the Natural Resources Defense Council.

Purdue University. 2018. *Indiana Climate Change Impacts Assessment: Putting Global Change into Local Perspective.* Available at: https://ag.purdue.edu/indianaclimate/

Union of Concerned Scientists (UCS). 2018. *Climate Change, Extreme Precipitation, and Flooding: The Latest Science*. Available at: https://www.ucsusa.org/global-warming/globalwarming-impacts/floods#.W1tsStVKjmE

U.S. Department of Energy, National Energy Technology Laboratory (DOE/NETL). 2010. *Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements: 2010 Update.* Available at: https://www.netl.doe.gov/energy-analyses/pubs/2010_Water_Needs_Analysis.pdf

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (U.S. DHHS, CDC). *Climate and Health in Illinois*. Prepared for the Illinois Department of Public Health. Available at: http://www.dph.illinois.gov/sites/default/files/publications/publicationsoprclimatehealthreport.pdf

U.S. Energy Information Administration (EIA). 2016. Electricity, Form EIA860 Data, Schedule 3, Generator Data (Retired and Canceled Units Only).

U.S. Energy Information Administration (EIA). 2017. *State Carbon Dioxide Emissions Data*. Available at: https://www.eia.gov/environment/emissions/state/

U.S. Energy Information Administration (EIA). 2018. *Annual Energy Outlook 2018*. Available at: https://www.eia.gov/outlooks/aeo/

U.S. Environmental Protection Agency (USEPA) and Rebuild Iowa Office (RIO). 2011. *Iowa Climate Change Adaptation and Resilience Report.* Available at: https://www.epa.gov/smartgrowth/iowa-climate-change-adaptation-and-resilience-report

U.S. Global Change Research Program (USGCRP). 2009. *Global Climate Change Impacts in the United States*. Available at: https://nca2009.globalchange.gov/midwest/index.html

USGCRP. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Eds. J. M. Melillo, T. C. Richmond, and G. W. Yohe. doi:10.7930/J0Z31WJ2. Available at: https://nca2014.globalchange.gov/downloads

USGCRP. 2017. *Climate Science Special Report: Fourth National Climate Assessment, Volume I.* Eds. D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, 470 pp. U.S. Global Change Research Program, Washington, D.C. doi: 10.7930/J0J964J6. Available at: https://science2017.globalchange.gov/

Wisconsin Initiative on Climate Change Impacts (WICCI). 2011. *Wisconsin's Changing Climate: Impacts and Adaptations.* Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, WI. Available at: https://www.wicci.wisc.edu

Wuebbles, D., K. Hayhoe, and J. Parzen. 2010. Introduction: Assessing the effects of climate change on Chicago and the Great Lakes. *Journal of the Great Lakes Research* 36:1–6.

APPENDIX A: EXAMPLES OF FUTURE CONDITIONS/STATE HAZARD MITIGATION PLANNING TECHNIQUES

(Source: Natural Resources Defense Council)

MITIGATION ACTION, REGULATION OR POLICY	HAZARD RISK	MITIGATION TECHNIQUE / NOTES	SUGGESTED LEAD AGENCY
Incorporate resilience to changing future conditions as part of the minimum eligibility criteria for mitigation project investments.	Multiple	**Codes & Regulations**	**Emergency Management**
Update the state's flood maps to account for projected future changes in precipitation patterns through state and FEMA initiatives or other programs.	Flood	**Education & Awareness** Note: FEMA's Technical Mapping Advisory Council (TMAC), ASFPM, and others involved with ongoing research into the impacts of climate science and future conditions should be consulted regarding this incorporation into the mapping program.	**Natural Resources**
As part of hazard mitigation reviews for electric, natural gas, and water utility construction projects, consider both present and future vulnerability to flooding and other hazards.	Multiple	**Structure & Infrastructure Projects** Note: The determination of future vulnerability should extend at least to the projected useful life of the utility system or component.	**Commerce Commission**
Implement green infrastructure as part of roadway and other transportation-related projects to protect infrastructure from flooding.	Flood	**Structure & Infrastructure Projects** Note: Funding may be available through a variety of federal grant programs that provide support for green infrastructure projects, including FEMA's Hazard Mitigation Assistance programs.	**Transportation**
Research and identify technical resources that can assist state and local governments in understanding the most up-to-date projections of future conditions; update the inventory of resources on a continual basis as new resources become available.	Multiple	**Education & Awareness**	**Emergency Management**
Update the inventory of state-owned and operated buildings, structures, and facilities to identify which may be vulnerable to increased risk of hazards in the future due to projected changes to hazard areas and/or changes in hazard frequency or severity.	Multiple	**Education & Awareness**	**Emergency Management**

MITIGATION ACTION, REGULATION OR POLICY	HAZARD RISK	MITIGATION TECHNIQUE / NOTES	SUGGESTED LEAD AGENCY
Add consideration of future conditions when awarding grants by listing "acquisition and removal of structures that are projected to face an increased risk of flooding in the future" in the list of program priorities.	Flood	**Codes & Regulations**	**Natural Resources**
Recommend the development of a sentinel monitoring program that provides early warning data on discernable signals of changing future conditions and associated impacts in order to support more timely and robust decision-making.	Multiple	**Education & Awareness** Note: The program could be linked to existing data collection measures (e.g., stream gages, NWS weather stations) and NOAA's new National Water Model, which will be over 700 times more spatially dense and 20 times more frequent than the current NWS hydrologic forecast system.	**Natural Resources**
Conduct a thorough review of the existing criteria for prioritizing proposed hazard mitigation projects as listed in the State Hazard Mitigation Plan and incorporate long-term resilience to future projected conditions as an additional/specific evaluation factor.	Multiple	**Codes & Regulations**	**Emergency Management**
Assess the emergency preparedness and hazard mitigation opportunities related to the life and safety threats posed by increasing incidents of extreme heat, particularly for those specific areas and/or vulnerable populations who will be disproportionately affected.	Extreme Heat	**Education & Awareness** Note: This could include public outreach/awareness campaigns linked to heat emergency response plans and potential long-term hazard mitigation projects that could potentially be funded through hazard mitigation grant programs (e.g., emergency generators for targeted cooling centers, green infrastructure projects that increase tree canopy, permeable/cool pavements), which can reduce the urban heat island effect in developed/developing areas.	**Public Health**
Develop a standard operating procedure to ensure the vulnerability of critical infrastructure to projected future conditions is factored into the state's post-disaster recovery and reconstruction decisions through FEMA's Public Assistance (PA) program, particularly as it relates to maximizing hazard mitigation opportunities through PA Section 406 Mitigation.	Multiple	**Structure & Infrastructure Projects** Note: PA Section 406 Mitigation is an often an underutilized source of funding following presidential disaster declarations.	**Emergency Management**

MITIGATION ACTION, REGULATION OR POLICY	HAZARD RISK	MITIGATION TECHNIQUE / NOTES	SUGGESTED LEAD AGENCY
Prepare a Climate Adaptation Plan or "Long-term Resilience Strategy" for Illinois that identifies the policies, programs. and activities needed to reduce the negative impacts of long-term future conditions and extreme weather on the state's physical, social, economic, and environmental resources.	Multiple	**Codes & Regulations**	**Natural Resources**
Conduct a detailed, system-wide vulnerability assessment of Illinois' transportation infrastructure and assets that takes into account changing future conditions, including, but not limited to, increased precipitation/changing hydrology and more extreme weather.	Multiple	**Structure & Infrastructure Projects** Note: Such an assessment could be linked directly to a risk assessment for state-owned facilities in the State Hazard Mitigation Plan but provide more specific and granular information necessary for the identification and prioritization of hazard mitigation measures.	**Transportation**
Encourage water sector utilities to conduct future condition vulnerability assessments and prepare resilience plans through the promotion of tools and resources available through EPA's Climate Ready Water Utilities (CRWU) initiative.	Multiple	**Structure & Infrastructure Projects**	**Commerce Commission**
Lead or support pilot studies to examine the changing hydrology for the state's rivers due to altered precipitation patterns and watershed development. Disseminate the findings of these and other scientific studies on future hydrology for improved floodplain management planning, community development, and infrastructure protection standards.	Flood	**Education & Awareness**	**Natural Resources**
Prepare a compendium of examples and/or best practices on how resilience to uncertain future conditions has been addressed in the scoping and design of capital projects. In particular, provide examples of previous hazard mitigation projects that provided long-term, permanent, and/or higher levels of protection than required for existing conditions.	Multiple	**Structure & Infrastructure Projects** Note: Cite projects that have eliminated any residual risk to natural hazards (e.g., floodplain acquisitions), elevation projects that have provided flood protection beyond the 100-year flood event, and other long-term investments in the reduction of risk to uncertain future events.	**Emergency Management**

MITIGATION ACTION, REGULATION OR POLICY	HAZARD RISK	MITIGATION TECHNIQUE / NOTES	SUGGESTED LEAD AGENCY
Coordinate with IDNR on more detailed assessments of how changing future conditions (particularly increases in prolonged drought) will impact the state's agricultural sector, and on the development of policy and program responses to minimize the long-term adverse effects of these impacts.	Drought	**Education & Awareness**	**Agriculture**
Routinely update and coordinate with Illinois' BRACE program's efforts to develop strategies that address health risks related to potential severe weather and climate-driven events, particularly as it relates to collaborative opportunities to develop public policy and provide technical assistance or funding for risk-reduction measures.	Multiple	**Education & Awareness**	**Public Health**
IEMA and IDPH coordinate to promote the incorporation of hazard mitigation strategies to address the greatest public health vulnerabilities to extreme weather and changing future conditions in local hazard mitigation plans. This should include enhanced collaboration between local emergency management agencies, departments of health, the integration of public health and social vulnerability analyses in local risk assessments, and the development and prioritization of actionable policies and projects.	Multiple	**Education & Awareness** Note: Provides the opportunity for local communities to leverage a wealth of evidence-based data on how changing future conditions are projected to impact public health, especially for those populations considered most vulnerable, in addition to resources that can support the development of projects and best practices to reduce associated risks.	**Public Health**
Integrate data and narrative content on future condition projections for each applicable hazard included in the State Hazard Mitigation Plan. This could be included as a stand-alone subsection or integrated into existing subsections as appropriate.	Multiple	**State Hazard Mitigation Plan** Note: Due to the fact that the changing future conditions are not specific natural hazards per se, but rather an amplifier of existing hazards that are already largely understood, the most effective method to address the projected effects/impacts of future conditions on natural hazard risks in the State Hazard Mitigation Plan is to incorporate new content into each hazard-specific section.	**Emergency Management**

MITIGATION ACTION, REGULATION OR POLICY	HAZARD RISK	MITIGATION TECHNIQUE / NOTES	SUGGESTED LEAD AGENCY
Develop a new "Climate" section as part of the State Hazard Mitigation Plan that describes the state's climate variability and projected future conditions as an emerging risk factor.	Multiple	**State Hazard Mitigation Plan** Note: The narrative should highlight those natural changes already being observed across the state and make clear that Illinois' climate is always changing and that plans should not be based solely on historical data.	**Emergency Management**
Update the State Hazard Mitigation Plan to better describe which specific areas or vulnerable populations within the state are at highest risk of increased morbidity and mortality as a result of projected future conditions for extreme heat.	Extreme Heat	**State Hazard Mitigation Plan** Note: Heat Vulnerability Index maps can help identify high-risk locations and populations to receive prioritized focus for emergency preparedness, response, and hazard mitigation efforts.	**Emergency Management**
Update the State Hazard Mitigation Plan to reflect the projected increase in the likelihood of summer drought in Illinois. Update to reflect the eligibility of Aquifer Storage and Recovery projects for FEMA Hazard Mitigation Assistance programs.	Drought	**State Hazard Mitigation Plan** Note: FEMA announced the eligibility of Aquifer Storage and Recovery projects to support community interest in increasing available water supply. FEMA has developed a tool to support cost-effectiveness evaluations for Aquifer Storage and Recovery projects.	**Emergency Management**
Update the State Hazard Mitigation Plan to identify the programs, policies, regulations, plans, or practices that address resilience to changing future conditions and extreme weather. This plan should include identifying the enabling state legislation and legal authorities applicable to regulation and planning for long-term resilience activities.	Multiple	**State Hazard Mitigation Plan** Note: An inventory of the state's relevant long-term resilience planning activities will help identify gaps and opportunities for synergies with hazard mitigation activities and policy-making.	**Emergency Management**

APPENDIX B: INTERAGENCY TASK FORCE

The 2016 report, *Integrating Future Conditions into Hazard Mitigation Actions, Regulations and Policies of the State of Wisconsin* (Punchard Consulting, 2016), recommends the formation of an Interagency Task Force with leadership from the state agencies responsible for natural resources and emergency management and state science institutes. Included in the report are suggestions for key meetings, development of recommendations, and plan implementation, as described below.

Key Meetings

The Task Force meetings should recognize and incorporate the best available data, information, and knowledge in a shared process that results in education, compromise, and, finally, resolutions on specific terms or standards for policy enactment.

It is recommended that:

- an outside expert in participatory planning and decision-making techniques be used to help design and facilitate the meeting series;
- the facilitator should be supported at a minimum by a climate scientist and a hazard mitigation specialist who can speak authoritatively and share their expertise and knowledge on these topics as most relevant to Illinois; and
- additional experts may be required as the Task Force begins to draft the specific terms and standards required for policy implementation.

Meeting	Purpose	Outcome
Introduction and Briefing	Present background information, climate data, future conditions, natural hazard plans, existing climate adaptation plans, policies, programs, and activities	Improve the understanding and clarification of future conditions; Identify gaps in the data and conflicts or weaknesses in the background information; Prioritize natural hazards to be addressed and an early discussion of available policy options, constraints, etc.
Interactive Workshop(s)	Develop a consensus on future condition scenarios that are deemed to be unacceptable and for which the new hazard mitigation actions, regulations, and policies are to be based	Develop scenarios for the most critical climate stressors and hazard concerns and be as specific as possible.
Interactive Workshop(s)	Review and discuss *alternative* hazard mitigation actions, regulations, and policies to minimize the impacts and consequences for those adopted future condition scenarios deemed unacceptable by the Task Force	Develop alternative hazard mitigation actions, regulations. and policies to address hazard concerns

Meeting	Purpose	Outcome
Strategic Planning Session	Review, discuss, prioritize, and identify the overall benefits, costs, and existing constraints or barriers to the adoption and/or implementation of specific actions, regulations, or policies	Identify statewide strategies to be implemented; Identify the stakeholders who are responsible for strategy implementation
Implementation Planning	Develop the procedures and/or standards required to carry out the actions, regulations, or policies identified by the Task Force	Set up monitoring, evaluating, and reporting protocols for implementation progress to help promote adaptive management practices
Final Report	Review and discuss the draft report on Task Force recommendations	Present final report

Draft Report on Task Force Recommendations

A draft summary report should be prepared on the key findings and conclusions of the Task Force's planning and decision-making process, including a prioritized listing of the recommended hazard mitigation actions, regulations, and policies that incorporate future conditions. A meeting with the Task Force members should occur to review and provide additional input into the final report, particularly as it relates to the specific terms or standards and implementation plans for the actions, regulations, and policies being recommended.

Finalize Report on Task Force Recommendations

A finalized report should be prepared in close coordination with the Office of the Governor and Cabinet leadership as required, which should then be published and distributed. The report should provide a summary of next steps that are aligned with the implementation plans for recommended hazard mitigation actions, regulations, and policies. The report should be viewed as a living document that will be updated as needed to account for new knowledge, data, and scientific evidence about the impacts of climate change on the State of Illinois.

Implementation Phase

State agencies should proceed with their implementation plans for each assigned hazard mitigation action, regulation, or policy, as outlined by the Task Force and as authorized through the Office of the Governor and Cabinet leadership, as required.

As part of any implementation plan, state agencies should build in flexibility that allows for unanticipated changes and the leveraging of new data, information, and knowledge. The application of routine monitoring, evaluation, and reporting procedures should help facilitate adaptive management planning, as recommended above (Punchard Consulting, 2016).