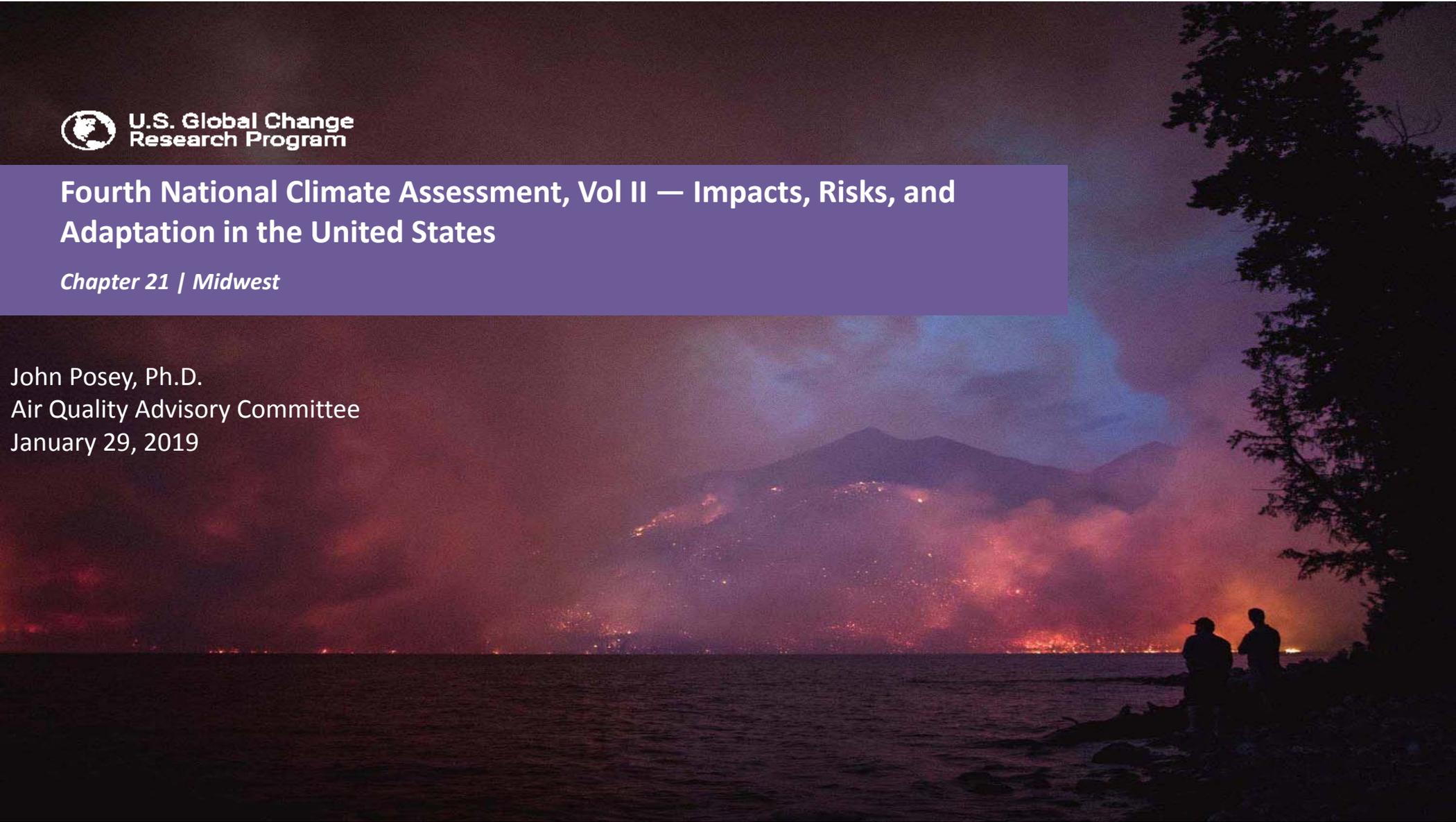




Fourth National Climate Assessment, Vol II — Impacts, Risks, and Adaptation in the United States

Chapter 21 | Midwest

John Posey, Ph.D.
Air Quality Advisory Committee
January 29, 2019



National Climate Assessment

- Mandated by federal law: Global Change Research Act of 1990
- Overseen by US Global Change Research Program
 - Working group of 14 federal agencies
- Two Volumes:
 - V. 1: Climate Science Special Report released November, 2017
 - V. 2: Impacts, Risks and Adaptation released November 2018
 - 29 chapters
 - ~300 authors
 - Peer review coordinated by National Academies of Science

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Regions

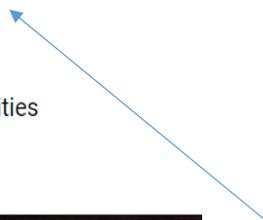
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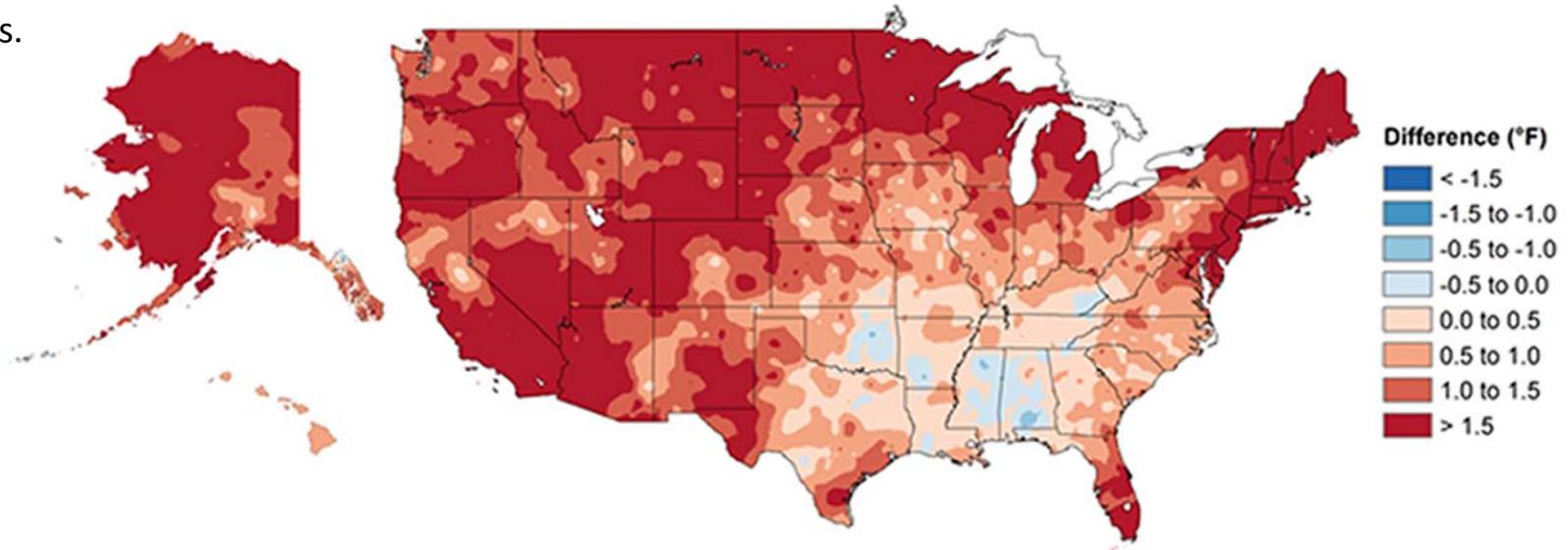


Sectors

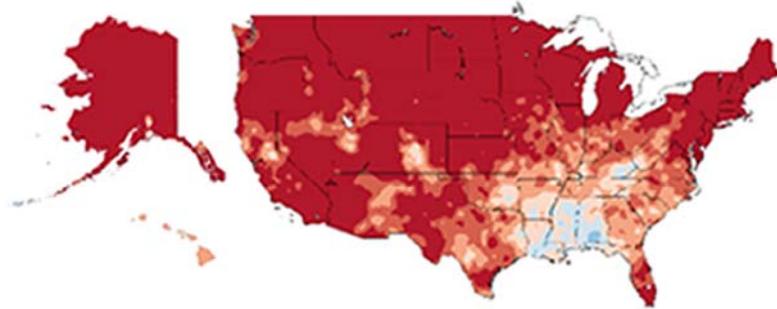
Regions

Observed changes in mean temperature, 1901-1960 vs. 1986-2016.

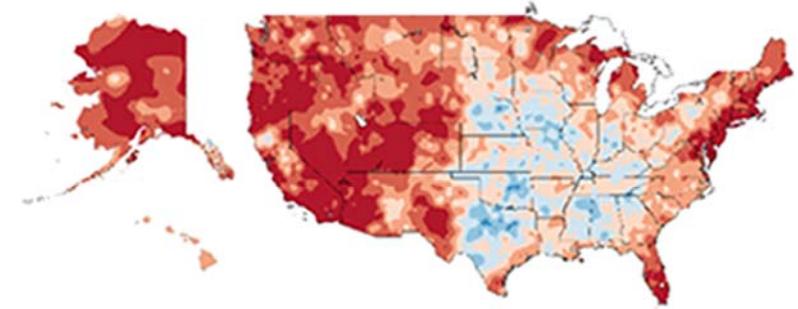
Annual Temperature



Winter Temperature



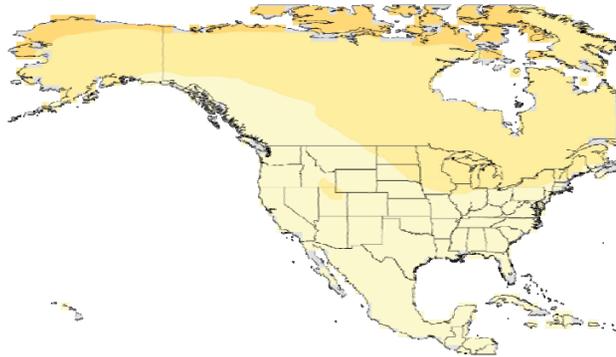
Summer Temperature



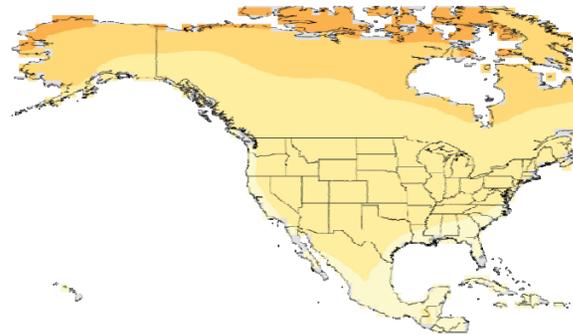
Projected Changes in Annual Average Temperature

Mid 21st Century

Lower Scenario (RCP4.5)

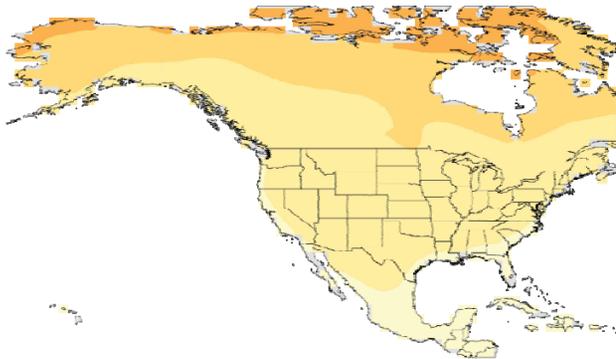


Higher Scenario (RCP8.5)

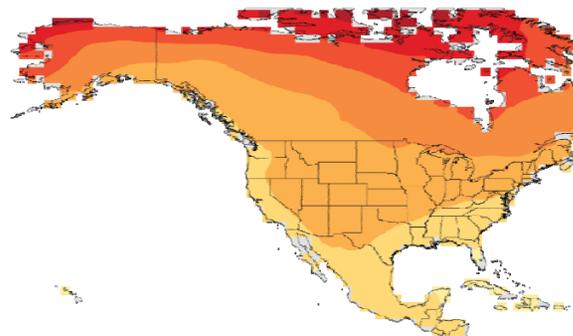


Late 21st Century

Lower Scenario (RCP4.5)



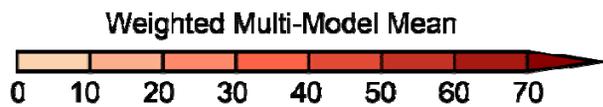
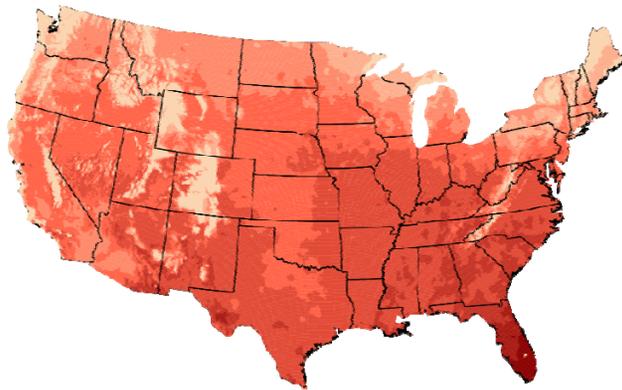
Higher Scenario (RCP8.5)



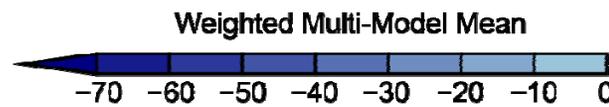
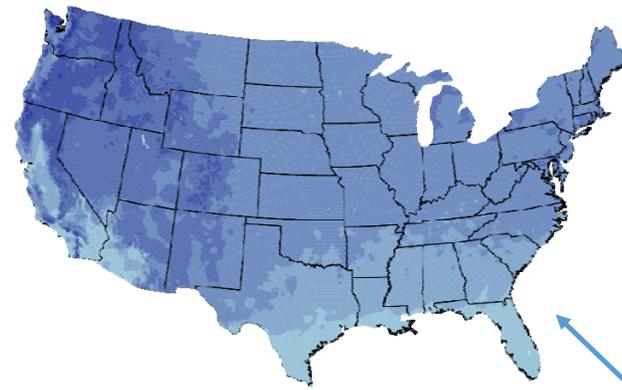
Change in Temperature (°F)



Projected Change in Number of Days Above 90°F
Mid 21st Century, Higher Scenario (RCP8.5)



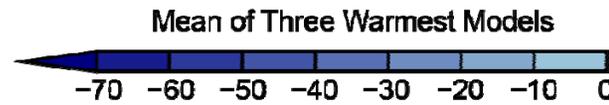
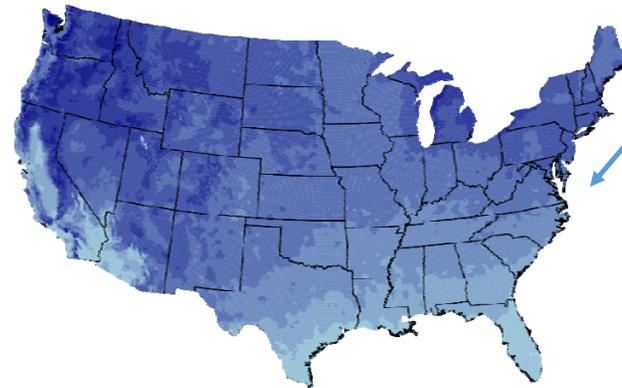
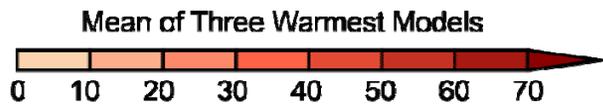
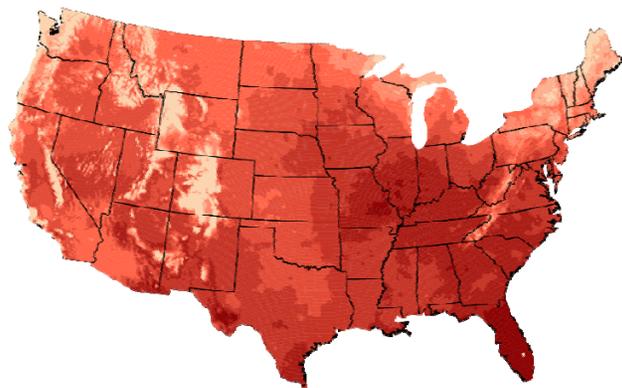
Projected Change in Number of Days Below 32°F
Mid 21st Century, Higher Scenario (RCP8.5)



CMIP
Ensemble
Mean

1901-1960:
44.4/year

1987-2016:
46.1/year

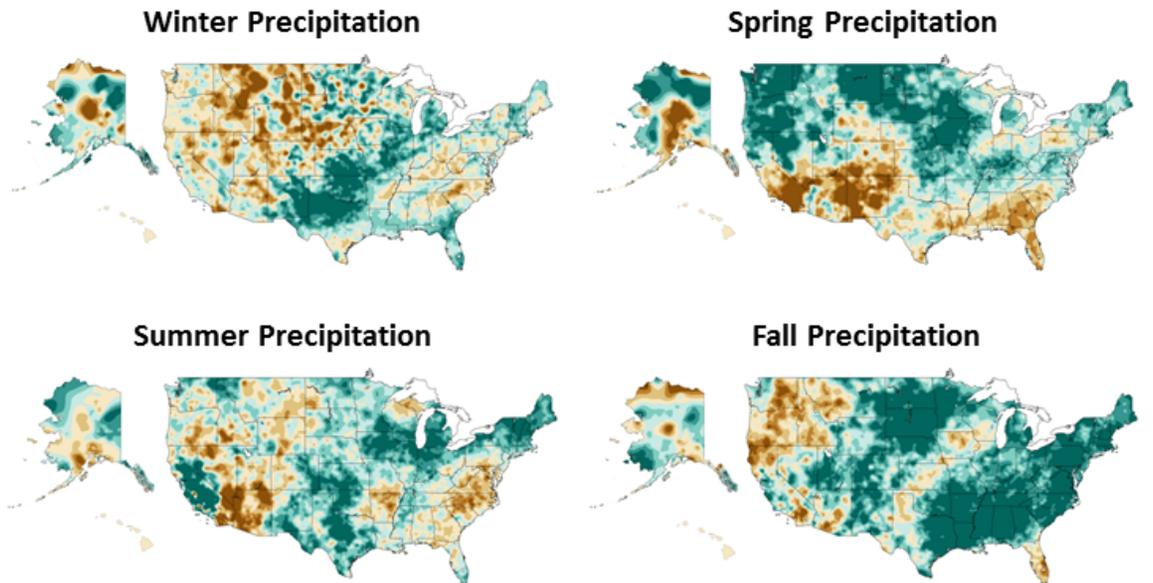
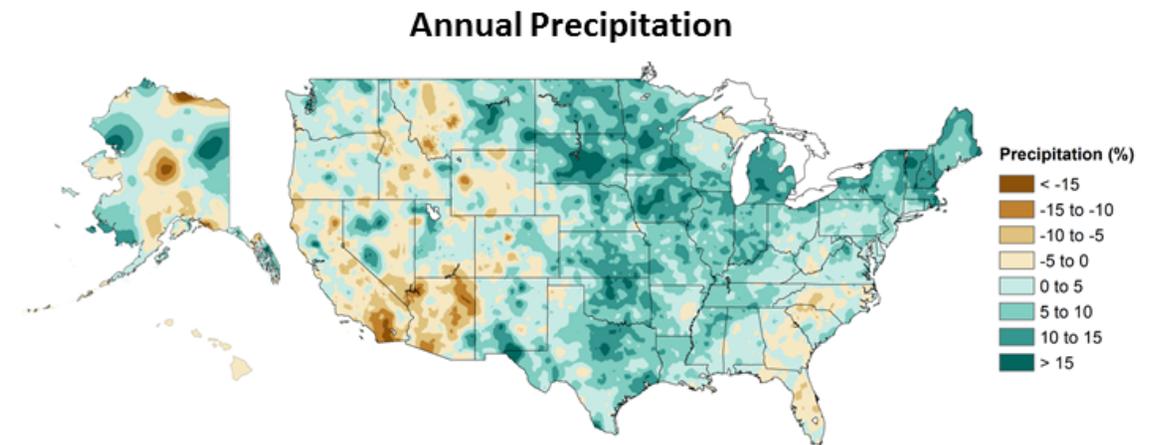


Warmest 3

Observed changes in precipitation,
1901-1960 to 1986-2016

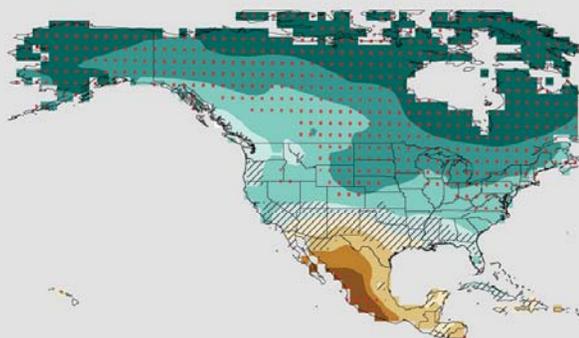
Hannibal, May 1, over flood stage:

- 1879-1968: 11
- 1969-2018: 25

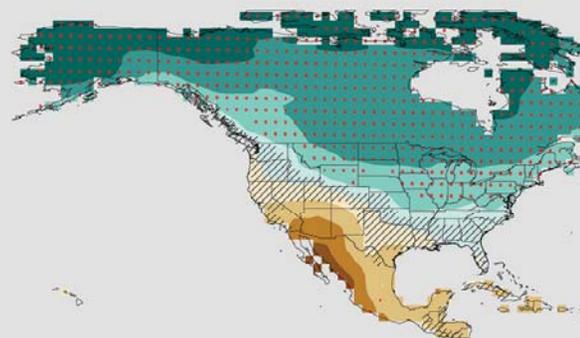


Projected Change (%) in Seasonal Precipitation RCP 8.5 Scenario

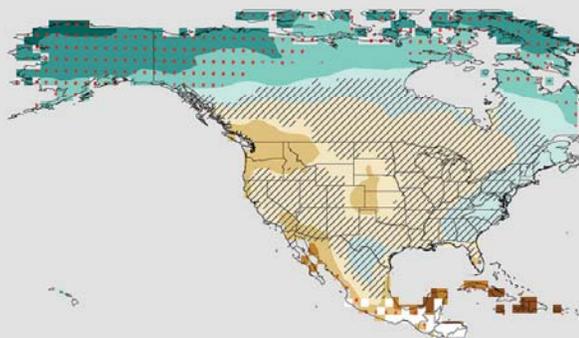
Winter



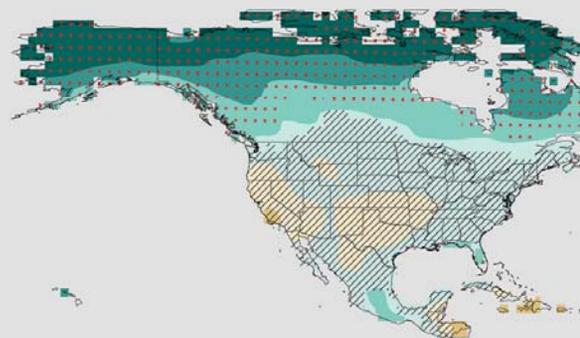
Spring



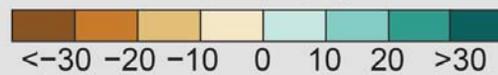
Summer



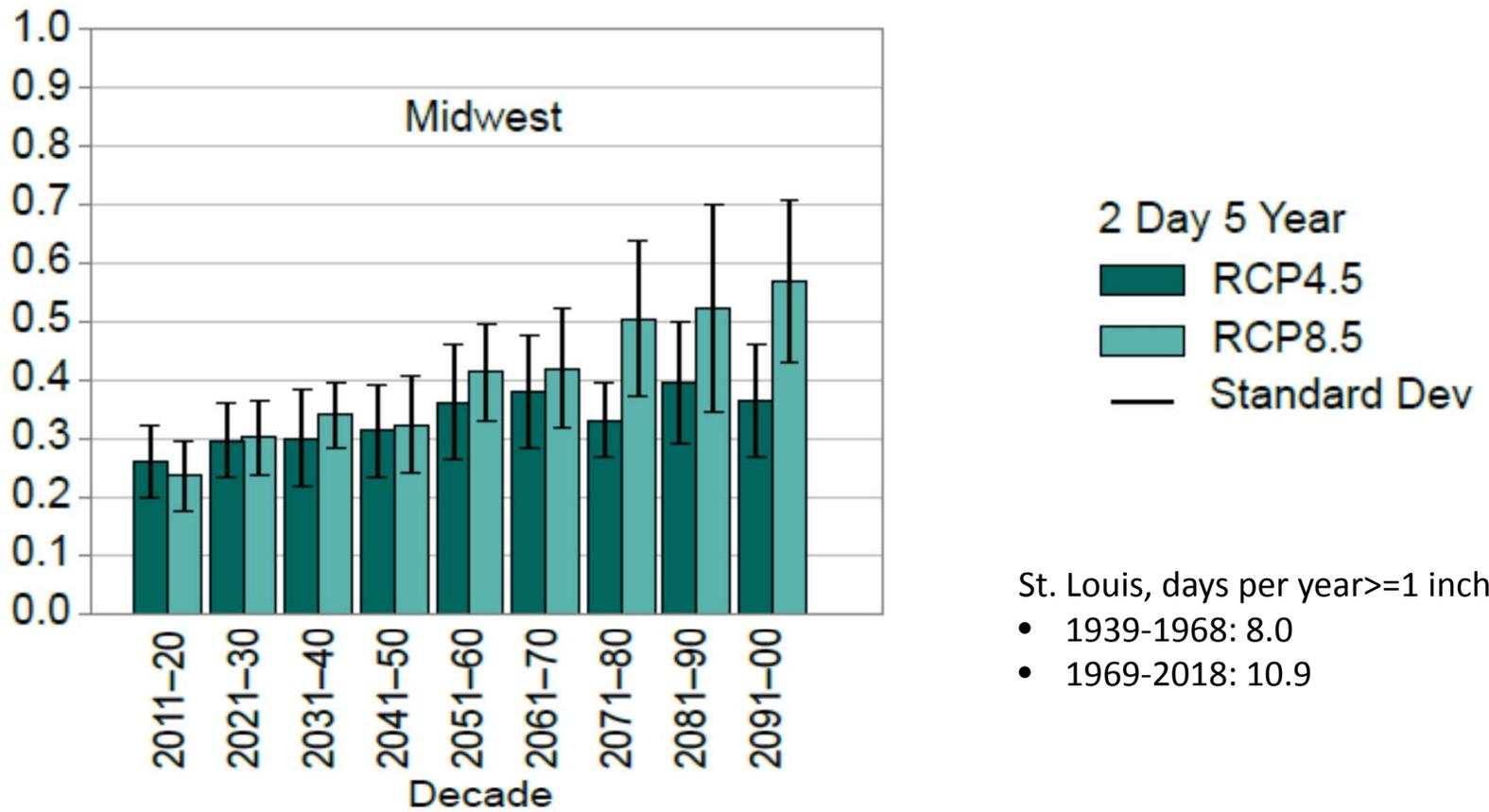
Fall



Change (%)



Change in return period for 2-day 5-year event



St. Louis, days per year ≥ 1 inch precip:

- 1939-1968: 8.0
- 1969-2018: 10.9

21 Key Message #1



Agriculture

The Midwest is a major producer of a wide range of food and animal feed for national consumption and international trade. Increases in warm-season absolute humidity and precipitation have eroded soils, created favorable conditions for pests and pathogens, and degraded the quality of stored grain. **Projected changes in precipitation, coupled with rising extreme temperatures before mid-century, will reduce Midwest agricultural productivity to levels of the 1980s without major technological advances.**

Fig. 21.3: Drying Effect of Warmer Air on Plants and Soils

As air temperature increases in a warming climate, vapor pressure deficit (VPD) is projected to increase. VPD is the difference between how much moisture is in the air and the amount of moisture in the air at saturation (at 100% relative humidity). Increased VPD has a drying effect on plants and soils, as moisture transpires (from plants) and evaporates (from soil) into the air. (a) Cooler air can maintain less water as vapor, putting less demand for moisture on plants, while warmer air can maintain more water as vapor, putting more demand for moisture on plants. (b, c) The maps show the percent change in the moisture deficit of the air based on the projected maximum 5-day VPD by the late 21st century (2070–2099) compared to 1976–2005 for (b) lower and (c) higher scenarios (RCP4.5 and RCP8.5). *Sources: U.S. Forest Service, NOAA NCEI, and CICS-NC.*

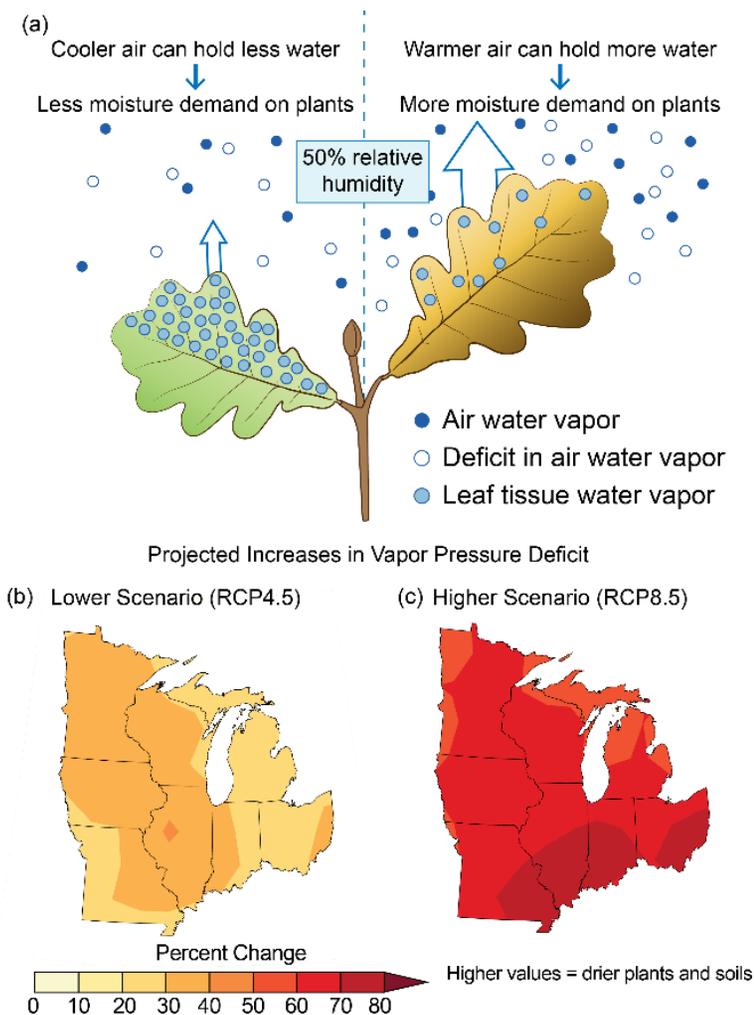




Fig. 21.2: Conservation Practices Reduce Impact of Heavy Rains

Integrating strips of native prairie vegetation into row crops has been shown to reduce sediment and nutrient loss from fields, as well as improve biodiversity and the delivery of ecosystem services.³³ Iowa State University's STRIPS program is actively conducting research into this agricultural conservation practice.³⁴ The inset shows a close-up example of a prairie vegetation strip. *Photo credits: (main photo) Lynn Betts, (inset) Farnaz Kordbacheh.*

21 Key Message #2



Forestry

Midwest forests provide numerous economic and ecological benefits, yet **threats from a changing climate are interacting with existing stressors such as invasive species and pests to increase tree mortality and reduce forest productivity. Without adaptive actions, these interactions will result in the loss of economically and culturally important tree species** such as paper birch and black ash and are expected to lead to the conversion of some forests to other forest types or even to non-forested ecosystems by the end of the century. Land managers are beginning to manage risk in forests by increasing diversity and selecting for tree species adapted to a range of projected conditions.



Fig. 21.4: Forest Diversity Can Increase Resilience to Climate Change

The photo shows Menominee Tribal Enterprises staff creating opportunity from adversity by replanting a forest opening caused by oak wilt disease with a diverse array of tree and understory plant species that are expected to fare better under future climate conditions. *Photo credit: Kristen Schmitt.*

21 Key Message #3



Biodiversity and Ecosystems

The ecosystems of the Midwest support a diverse array of native species and provide people with essential services such as water purification, flood control, resource provision, crop pollination, and recreational opportunities. **Species and ecosystems**, including the important freshwater resources of the Great Lakes, **are typically most at risk when climate stressors, like temperature increases, interact with land-use change, habitat loss, pollution, nutrient inputs, and nonnative invasive species.** Restoration of natural systems, increases in the use of green infrastructure, and targeted conservation efforts, especially of wetland systems, can help protect people and nature from climate change impacts.

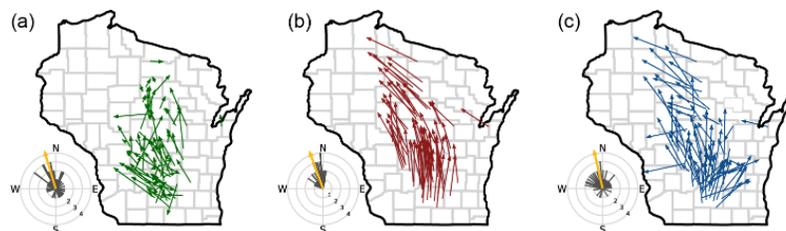


Fig. 21.5: Climate Change Outpaces Plants' Ability to Shift Habitat Range

While midwestern species, such as understory plants in Wisconsin, are showing changes in range, they may not be shifting quickly enough to keep up with changes in climate. The panels here represent 78 plant species, showing (a) observed changes in the center of plant species abundances (centroids) from the 1950s to 2000s, (b) the direction and magnitude of changes in climate factors associated with those species, and (c) the lag, or difference, between where the species centroid is now located and where the change in climate factors suggests it should be located in order to keep pace with a changing climate. *Source: adapted from Ash et al. 2017.*¹⁴¹ ©John Wiley & Sons, Ltd.

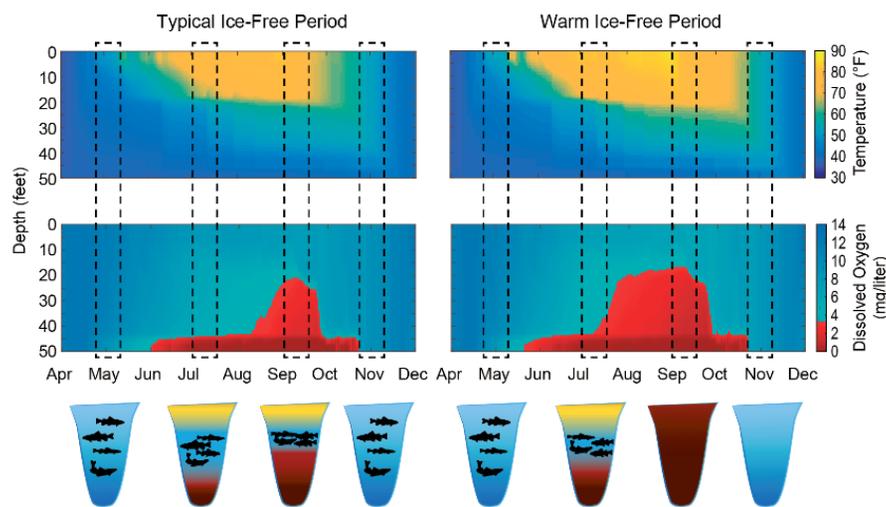


Fig. 21.6: Coldwater Fish at Risk

The graphic shows the oxythermal (oxygen and temperature) habitat of coldwater fish in midwestern inland lakes, illustrated by water depth under (left) a typical ice-free period and (right) a warm ice-free period (right). The top plots show water temperatures during the ice-free period, and the bottom plots show the dissolved oxygen concentrations. The schematics at the bottom illustrate the area of the lake that is ideal habitat for coldwater fish (in blue) and areas that represent water outside of the temperature or dissolved oxygen limit (in yellow and red, respectively). The left plots show how available habitat “squeezes” during a typical year, while the right plots illustrate a complete loss of suitable habitat during very warm years. *Source: Madeline Magee, University of Wisconsin.*

Fig. 21.7: Wetland Restoration Projects Can Help Reduce Impacts

The Blausey Tract restoration project on the U.S. Fish and Wildlife Service's Ottawa National Wildlife Refuge (Ohio) restored 100 acres of former Lake Erie coastal wetlands that were previously in row crop production. In addition to providing habitat for wildlife and fish, these wetlands help reduce climate change impacts by storing water from high-water events and by filtering nutrients and sediments out of water pumped from an adjacent farm ditch. This work was carried out by two conservation groups, The Nature Conservancy and Ducks Unlimited, in partnership with the U.S. Fish and Wildlife Service, and was funded by The Great Lakes Restoration Initiative. [186.187](#) (top) Shown here is the Blausey Tract restoration site in early spring of 2011, prior to the restoration activities. (bottom) In the spring of 2013, just two years after the start of restoration, the site already was providing important habitat for wildlife and fish. *Photo credits: (top) ©The Nature Conservancy, (bottom) Bill Stanley, ©The Nature Conservancy.*



21 Key Message #4



Human Health

Climate change is expected to worsen existing health conditions and introduce new health threats by increasing the frequency and intensity of **poor air quality days, extreme high temperature events, and heavy rainfalls; extending pollen seasons; and modifying the distribution of disease-carrying pests and insects**. By mid-century, the region is projected to experience substantial, yet avoidable, loss of life, worsened health conditions, and economic impacts estimated in the billions of dollars as a result of these changes. Improved basic health services and increased public health measures—including surveillance and monitoring—can prevent or reduce these impacts.

Fig. 21.9: Projected Changes in Ozone-Related Premature Deaths

Maps show county-level estimates for the change in average annual ozone-related premature deaths over the summer months in 2050 (2045–2055) and 2090 (2085–2095) compared to 2000 (1995–2005) under the lower and higher scenarios (RCP4.5 and RCP8.5) in the Midwest. The results represent the average of five global climate models. *Source: adapted from EPA 2017.*²⁸

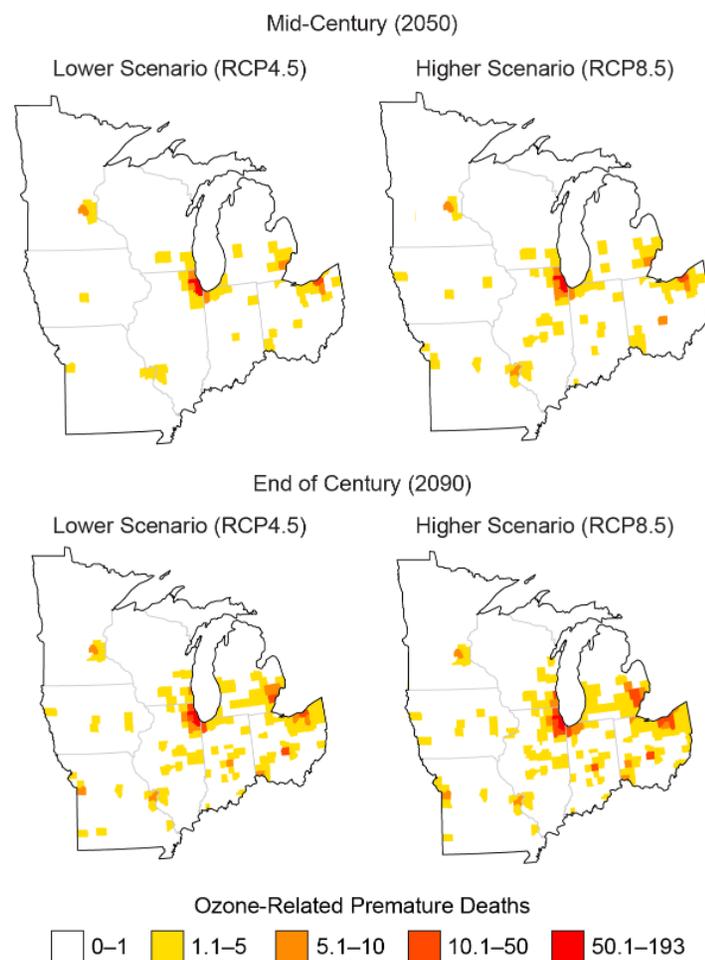
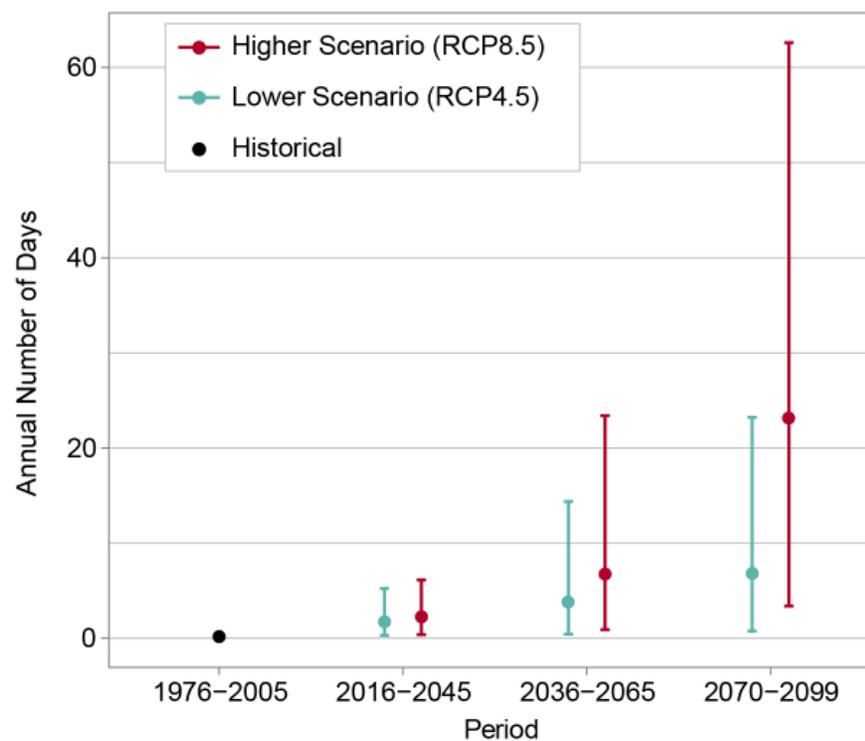


Fig. 21.10: Days Above 100°F for Chicago

This graph shows the annual number of days above 100°F in Chicago for the historical period of 1976–2005 (black dot) and projected throughout the 21st century under lower (RCP4.5, teal) and higher (RCP8.5, red) scenarios. Increases at the higher end of these ranges would pose major heat-related health problems for people in Chicago. As shown by the black dot, the average number of days per year above 100°F for 1976–2005 was essentially zero. By the end of the century (2070–2099), the projected number of these very hot days ranges from 1 to 23 per year under the lower scenario and 3 to 63 per year under the higher scenario. For the three future periods, the teal and red dots represent the model-weighted average for each scenario, while the vertical lines represent the range of values (5th to 95th percentile). Both scenarios show an increasing number of days over 100°F with time but increasing at a faster rate under the higher scenario. *Sources: NOAA NCEI and CICS-NC.*



21 Key Message #5



Transportation and Infrastructure

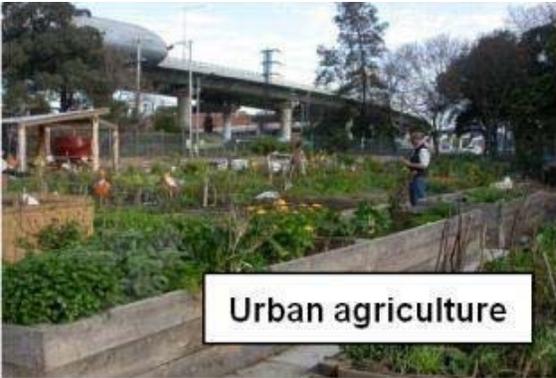
Storm water management systems, transportation networks, and other critical infrastructure are already experiencing impacts from changing precipitation patterns and elevated flood risks. Green infrastructure is reducing some of the negative impacts by using plants and open space to absorb storm water. The annual cost of adapting urban storm water systems to more frequent and severe storms is projected to exceed \$500 million for the Midwest by the end of the century.

Fig. 21.11: Meramec River Flooding

This composite image shows portions of Interstate 44 near St. Louis that were closed by Meramec River flooding in both 2015 and 2017. The flooding shown here occurred in May 2017. *Image credit: Surdex Corporation.*



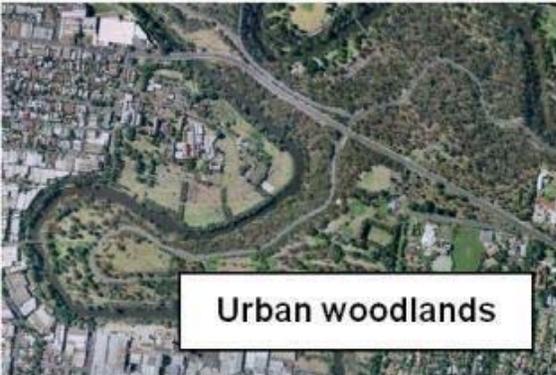
Urban green infrastructure



Urban agriculture



Green walls



Urban woodlands



Suburban street trees



City street trees



Green roofs



Sensitive urban design



Parks, gardens & golf courses

Source: Capital Region
Climate Readiness
Collaborative

21 Key Message #6



Community Vulnerability and Adaptation

At-risk communities in the Midwest are becoming more vulnerable to climate change impacts such as flooding, drought, and increases in urban heat islands. Tribal nations are especially vulnerable because of their reliance on threatened natural resources for their cultural, subsistence, and economic needs. Integrating climate adaptation into planning processes offers an opportunity to better manage climate risks now. Developing knowledge for decision-making in cooperation with vulnerable communities and tribal nations will help to build adaptive capacity and increase resilience.

13

Chapter 13: Air Quality



KM1: More than 100 million people in the United States live in communities where air pollution exceeds health-based air quality standards. Unless counteracting efforts to improve air quality are implemented, climate change will worsen existing air pollution levels. This worsened air pollution would increase the incidence of adverse **respiratory and cardiovascular health effects**, including premature death. Increased air pollution would also have other environmental consequences, including reduced visibility and damage to agricultural crops and forests.

KM2: **Wildfire** smoke degrades air quality, increasing the health risks to tens of millions of people in the United States. More frequent and severe wildfires due to climate change would further diminish air quality, increase incidences of respiratory illness from exposure to wildfire smoke, impair visibility, and disrupt outdoor recreational activities.

KM3: The frequency and severity of **allergic illnesses, including asthma and hay fever**, are likely to increase as a result of a changing climate. Earlier spring arrival, warmer temperatures, changes in precipitation, and higher carbon dioxide concentrations can increase exposure to airborne pollen allergens.

KM4: Many emission sources of greenhouse gases also emit air pollutants that harm human health. Controlling these common emission sources would both mitigate climate change and have immediate benefits for air quality and human health. Because methane is both a greenhouse gas and an ozone precursor, reductions of methane emissions have the potential to **simultaneously mitigate climate change and improve air quality**.



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