U.S. Global Change
Research Program

Climate in Crisis: Implications and Strategies

Martha D Shulski, Ph.D.

Nebraska State Climatologist
Associate Professor, School of Natural Resources

University of Nebraska – Lincoln

mshulski3@unl.edu
402-472-6711

@mshulski3

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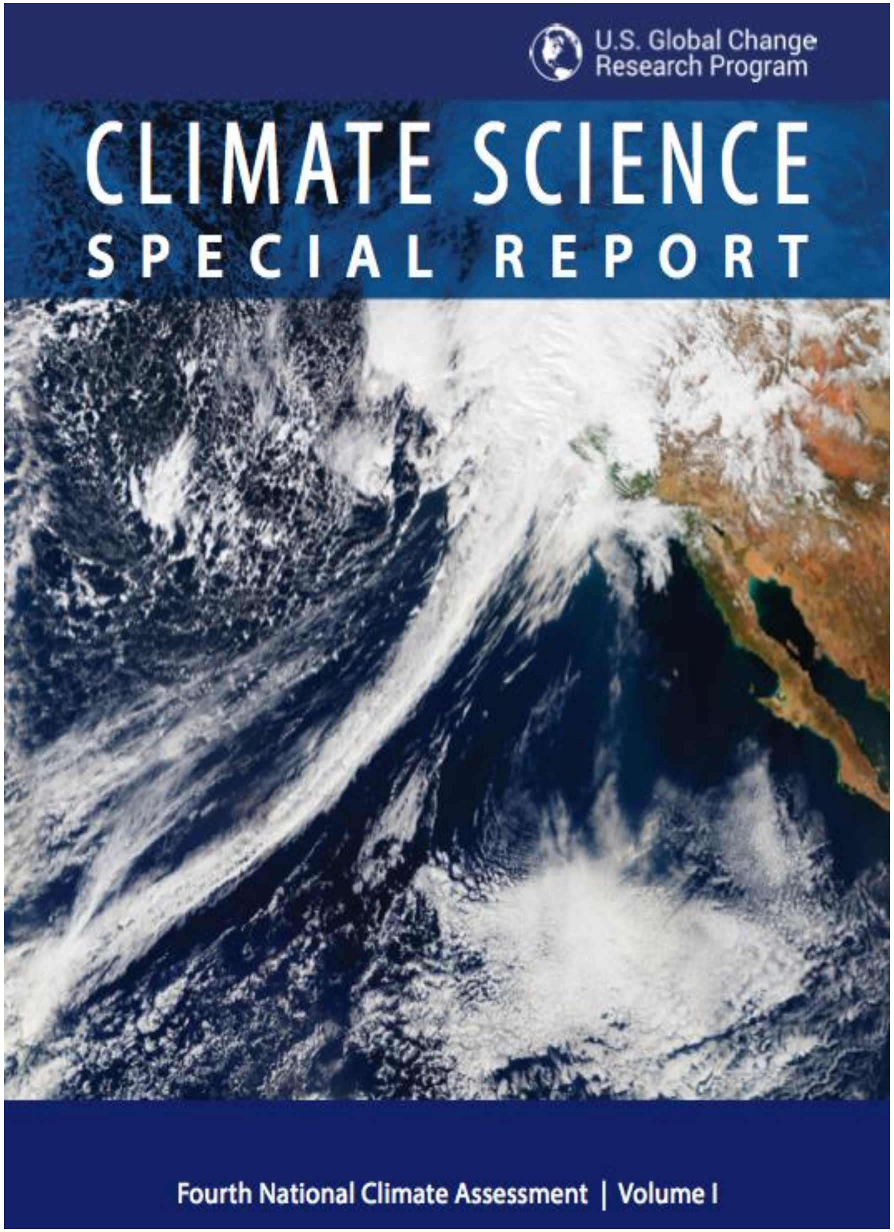
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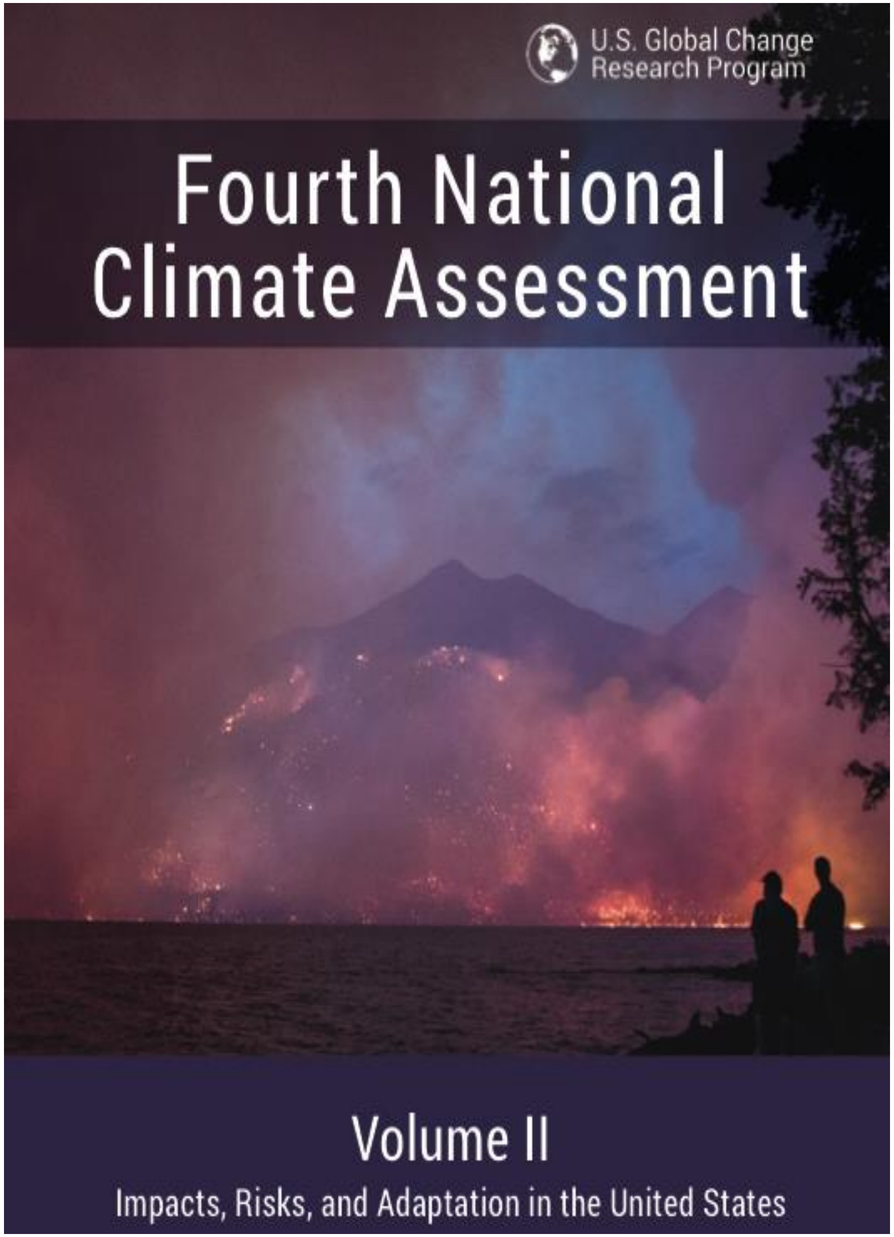
U.S. Global Change Research Program
Fourth National Climate Assessment
Volume II
Impacts, Risks, and Adaptation in the United States

US Global Change Research Program

Global Change Research Act (1990):

"To provide for development and coordination of a comprehensive and integrated United States research program which will assist the Nation and the world to **understand, assess, predict, and respond** to human-induced and natural processes of global change."

United States Global Change Research Program

13 Federal Departments & Agencies + Executive Office of the President

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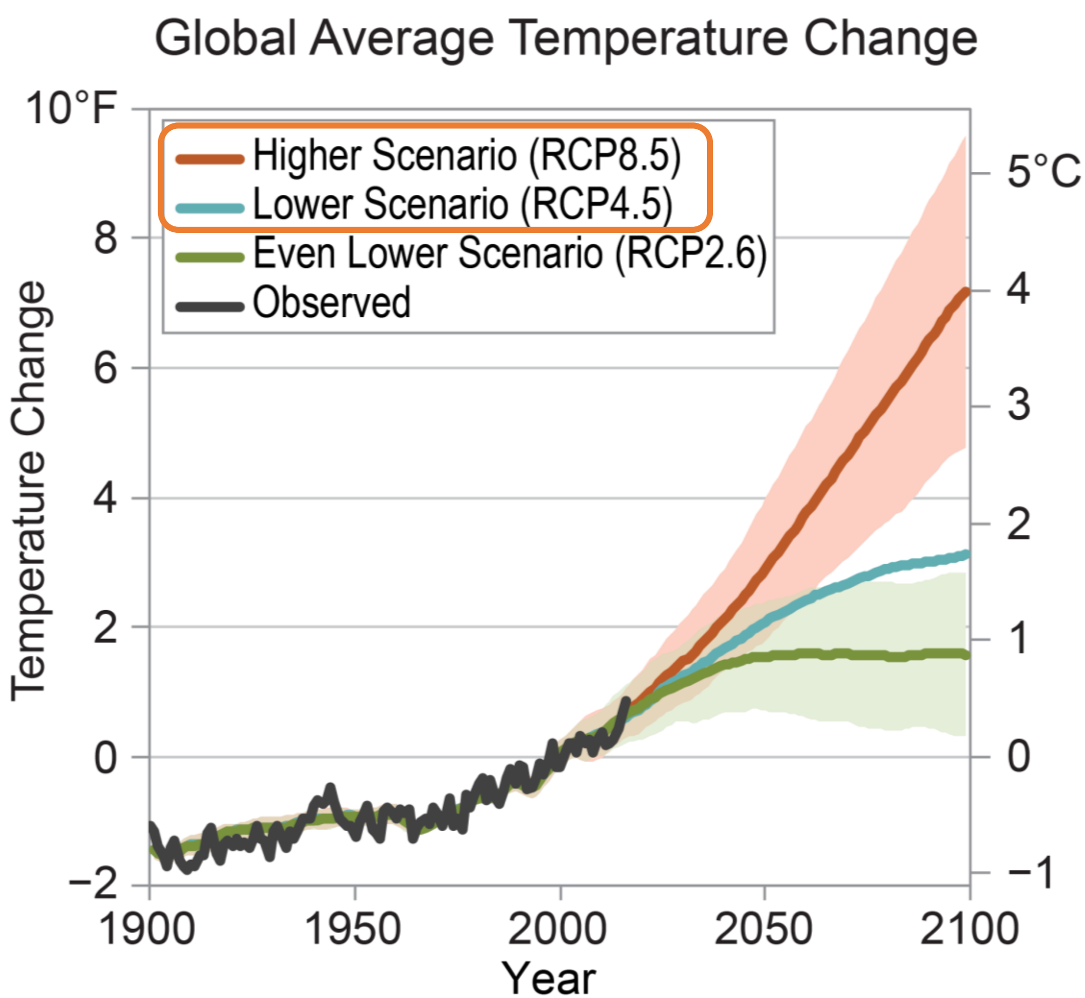
1 Introduction: NCA4 Vol II

- Earth's climate is now **changing faster** than at any point in modern civilization.
- These changes are primarily **the result of human activities**.
- The impacts of climate change are **already being felt** across the country.
- Americans are **responding**.

- However, neither global efforts to mitigate the causes of climate change nor regional efforts to adapt to the impacts currently approach the scales needed to **avoid substantial damages**.

1 Our Changing Climate: *Scenarios*



1 Our Changing Climate: *Regions*

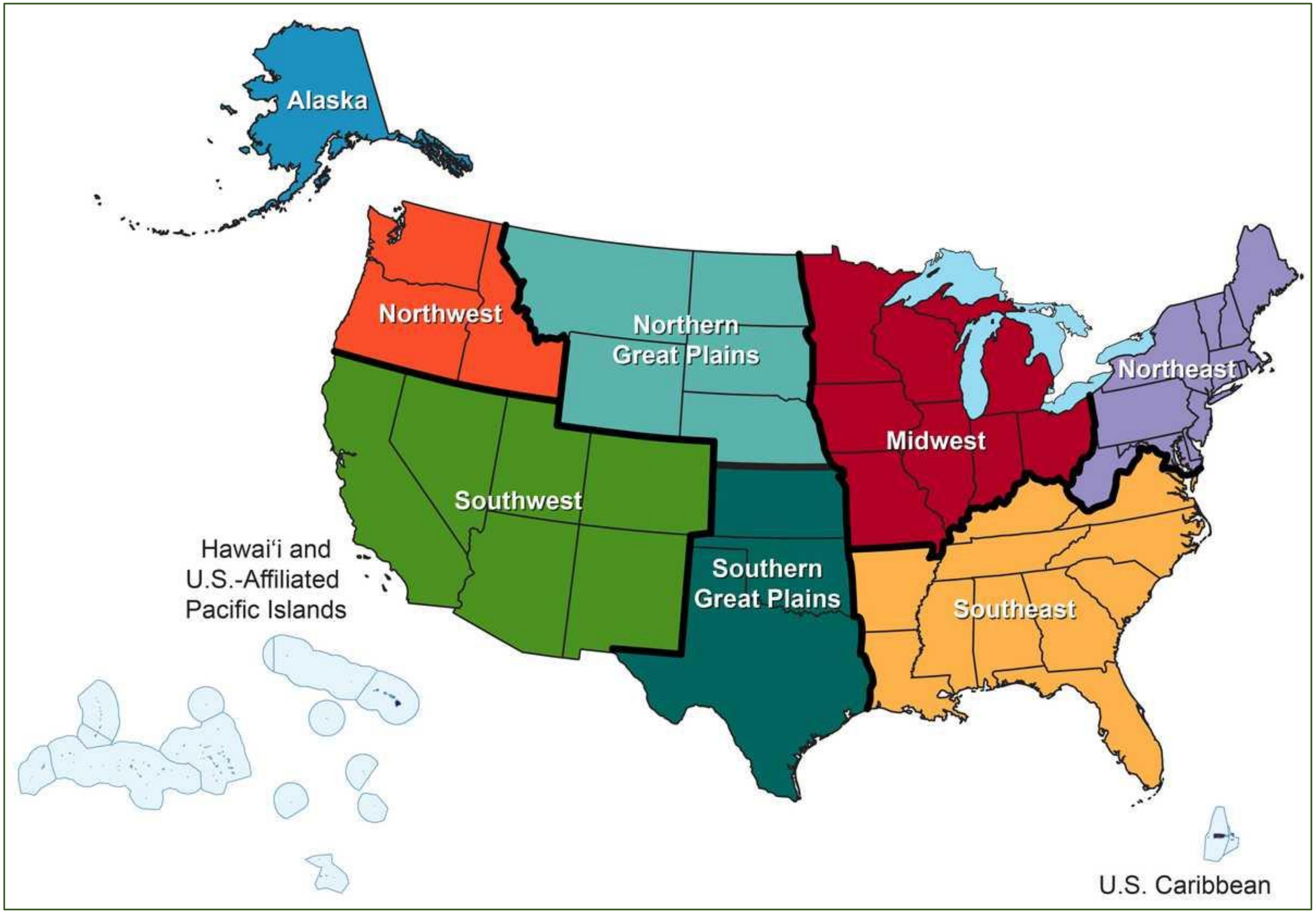
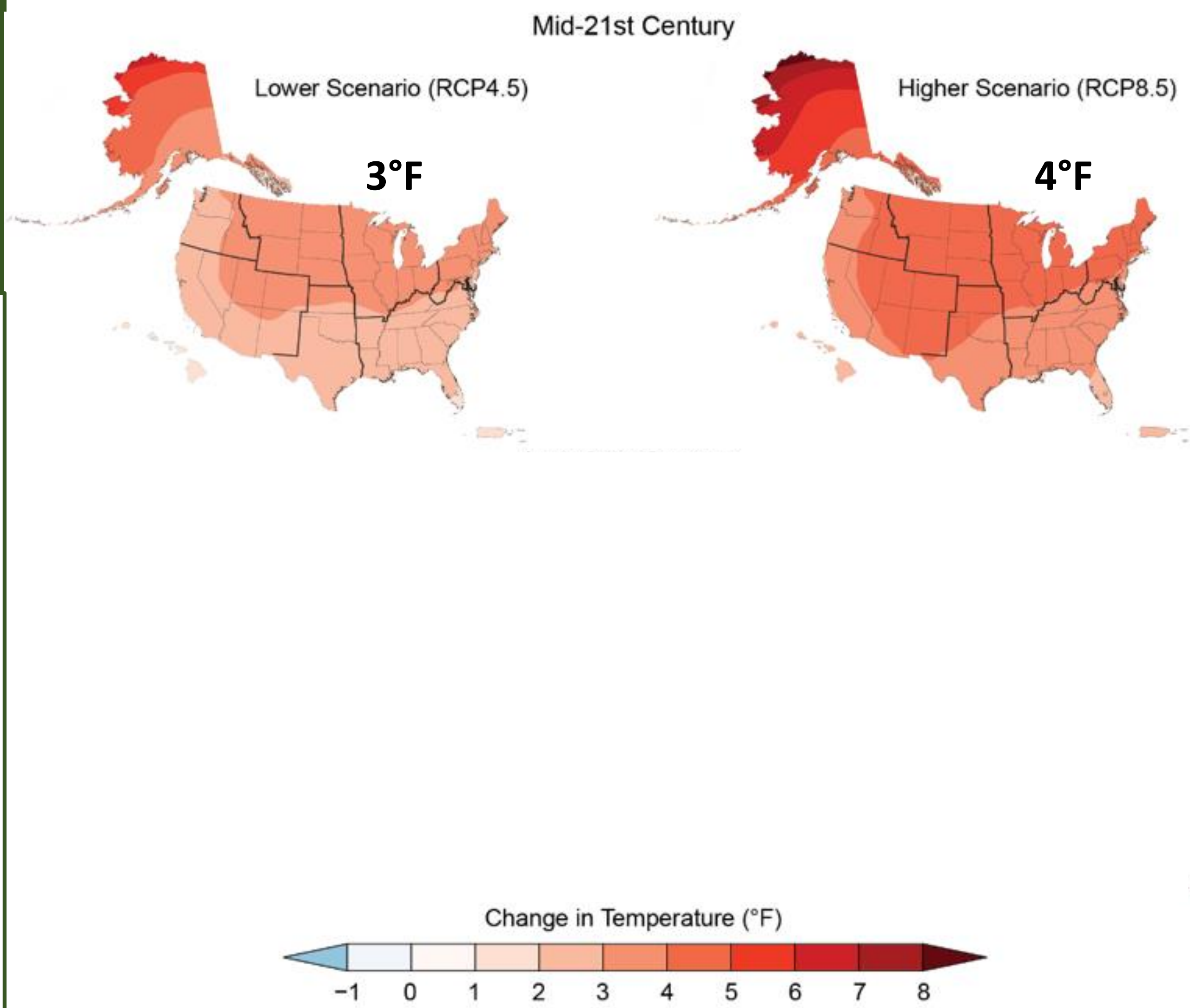


Fig. 1.3: Projected Changes in U.S. Annual Average Temperature

Annual average temperatures across the United States are projected to increase over this century, with greater changes at higher latitudes as compared to lower latitudes, and under a higher scenario (RCP8.5; right) than under a lower one (RCP4.5; left). This figure shows projected differences in annual average temperatures for **mid-century (2036–2065; top)** and end of century (2071–2100; bottom) relative to the near present (1986–2015). *From Figure 2.4, Ch. 2: Climate (Source: adapted from Vose et al. 2017).*



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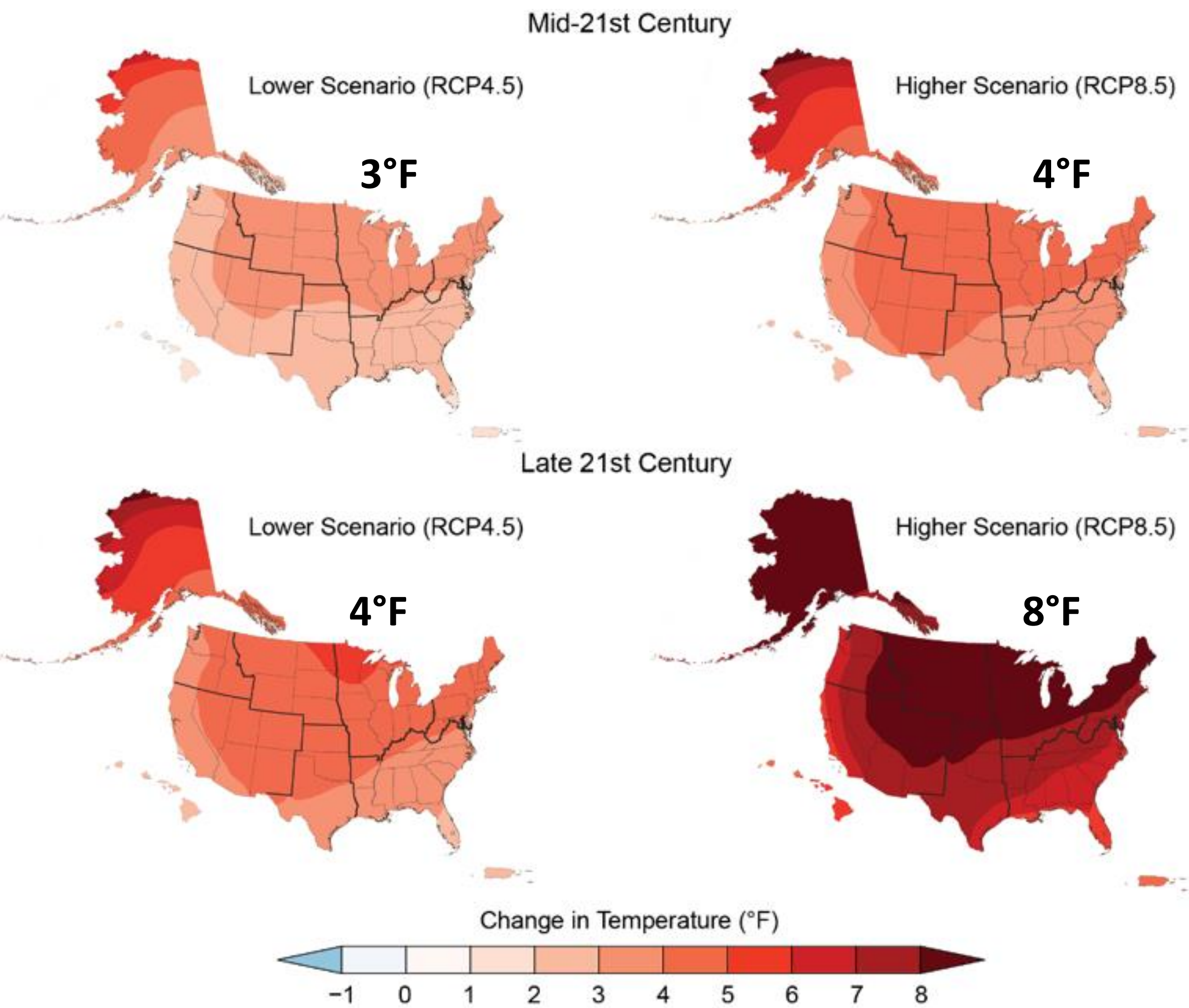
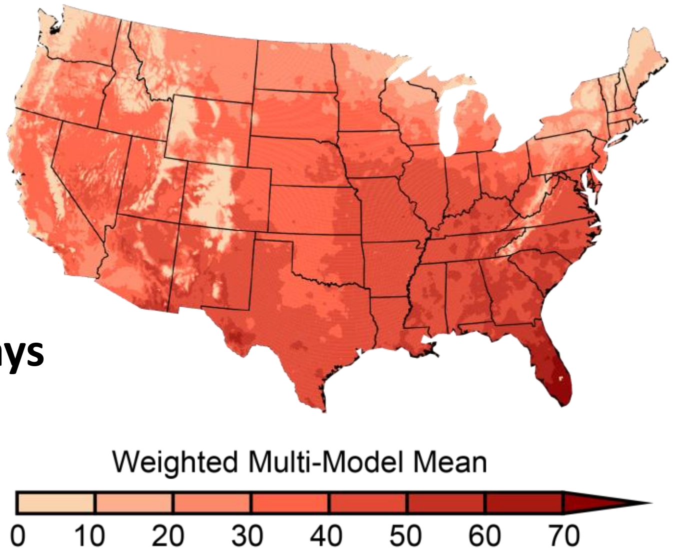


Fig. 6.9: Projected Changes in U.S. Temperature Extremes

Projected changes in the number of days per year with a **maximum above 90°F (top)** and a minimum temperature below 32°F (bottom) in the U.S. Changes represent the difference between the average for mid-century (2036-2065) and the near-present (1976-2005) under the higher scenario (RCP8.5). *Image from the Climate Science Special Report, 2017*.

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

20 – 40 more days



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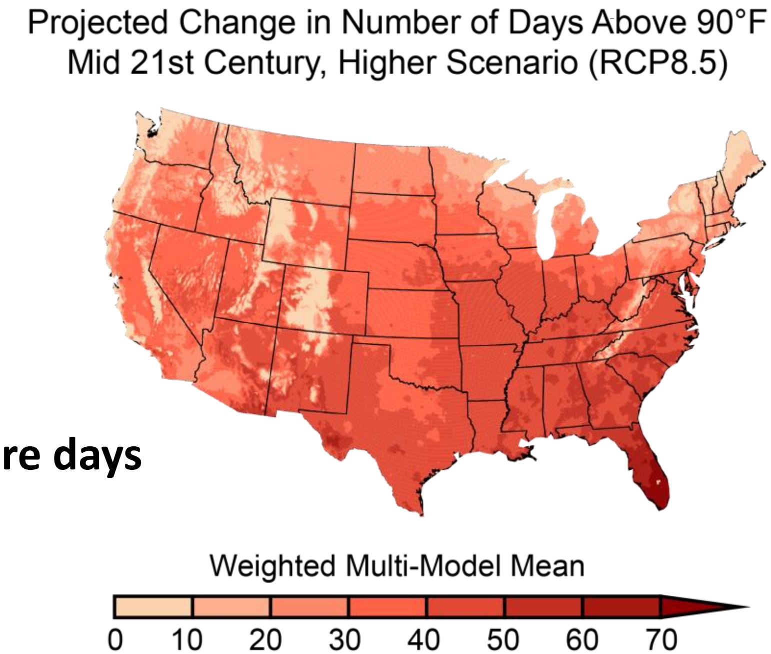
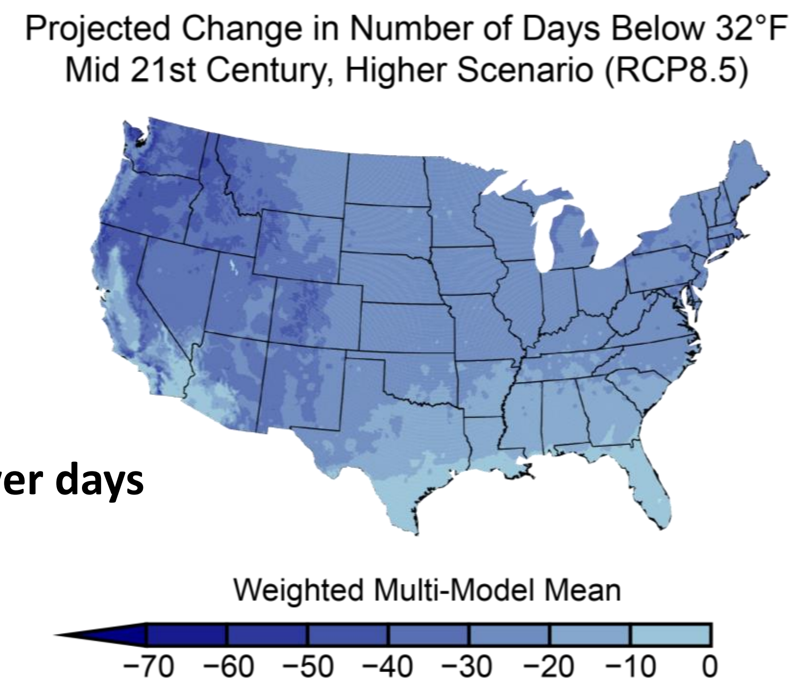


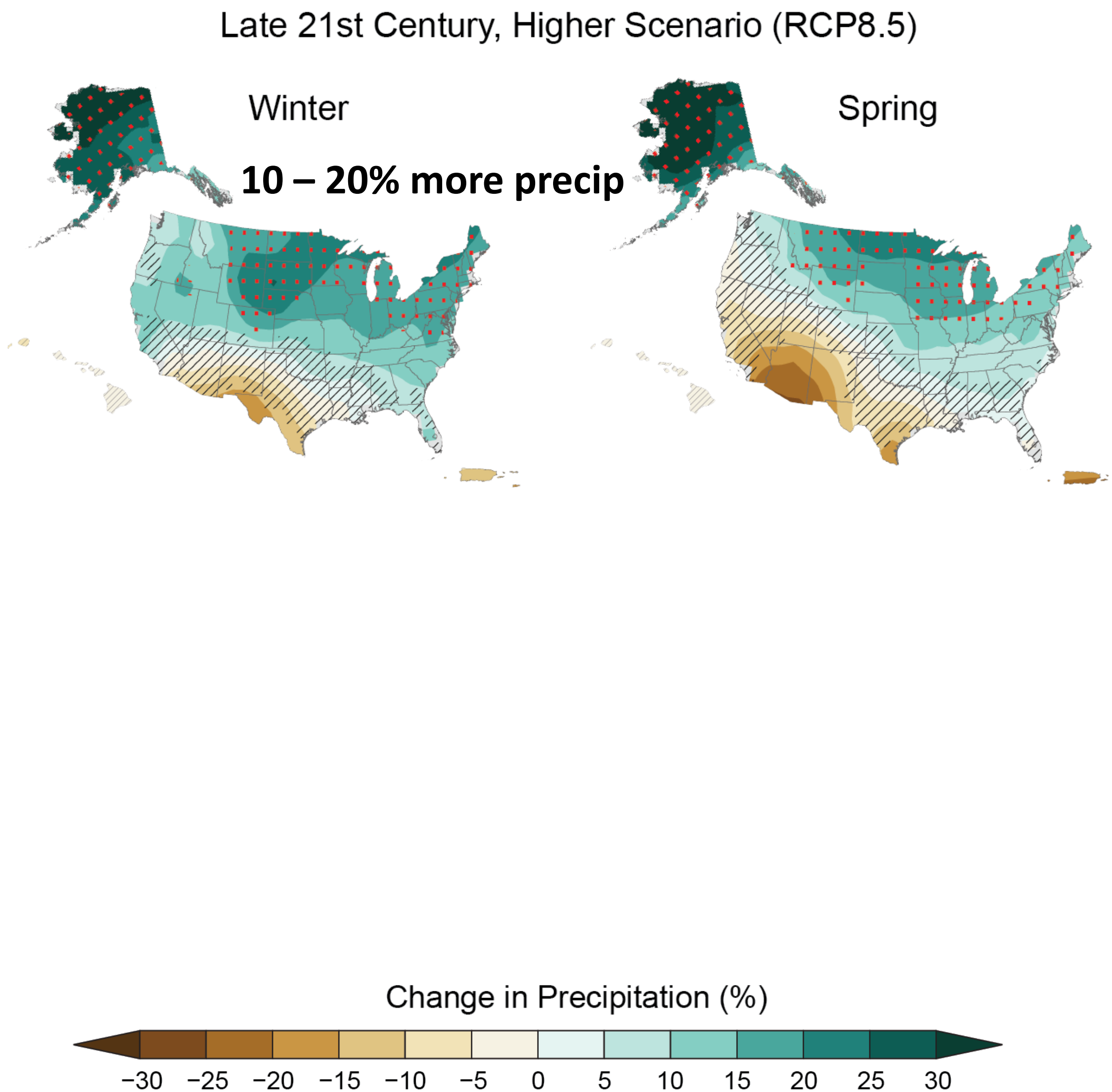
20 – 40 more days



20 – 40 fewer days

Fig. 2.5: Projected Changes in U.S. Seasonal Precipitation Amounts

In the future, under the higher scenario, the northern U.S. is projected to receive **more precipitation, especially in winter and spring** by 2070-2099, relative to 1986-2015. Areas with red dots show where projected changes are large compared to natural variations; areas that are hatched show where projected changes are small and relatively insignificant. *Adapted from Easterling et al. 2017.*



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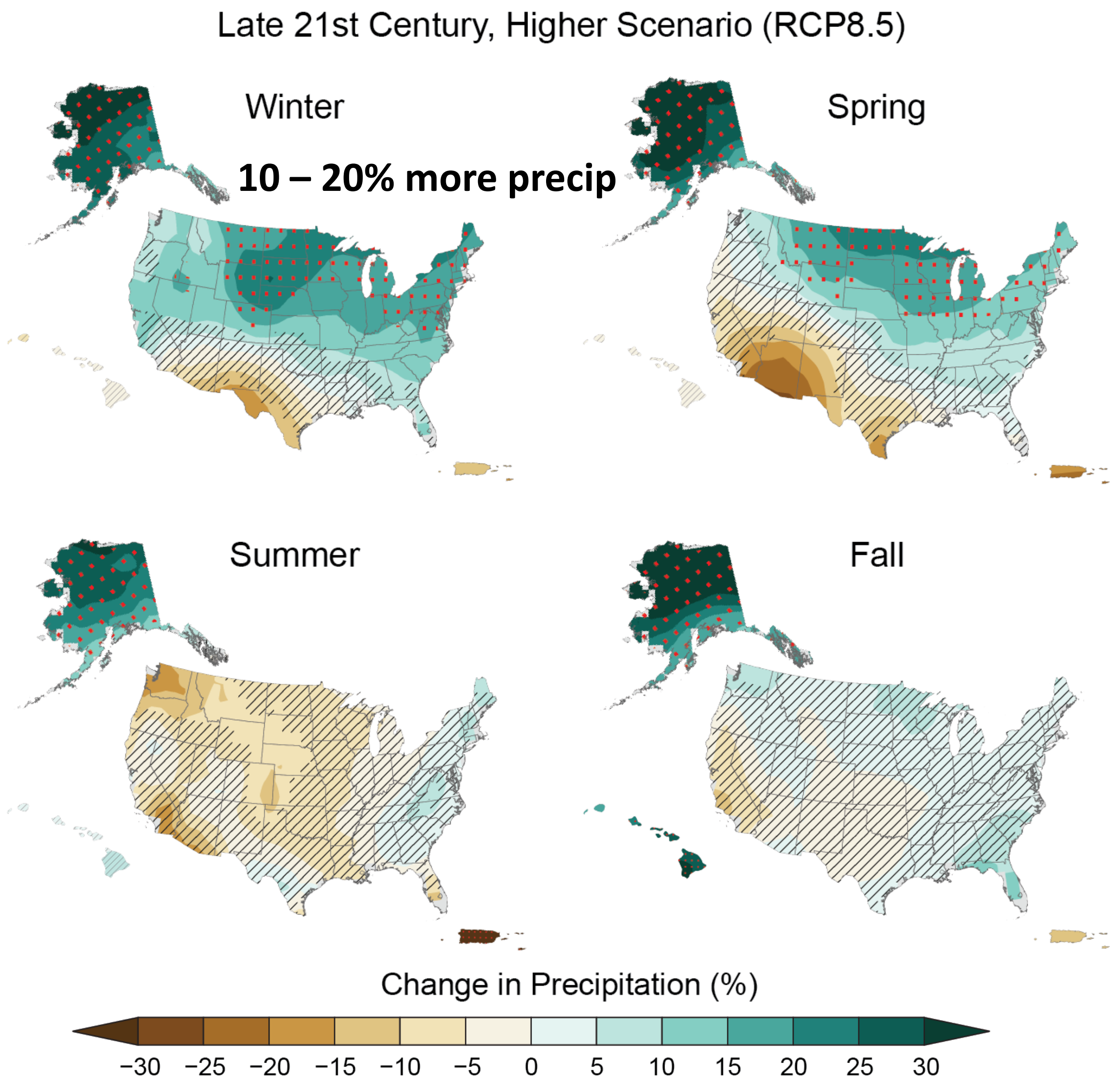


Fig. 2.6: Projected Changes in U.S. Heavy Precipitation Events

Heavy precipitation is becoming more intense and more frequent across most of the U.S., and these trends are projected to continue in the future. Projected trends are shown for a lower and a higher scenario for the period 2070-2099 relative to 1986-2015. *Adapted from Easterling et al. 2017.*

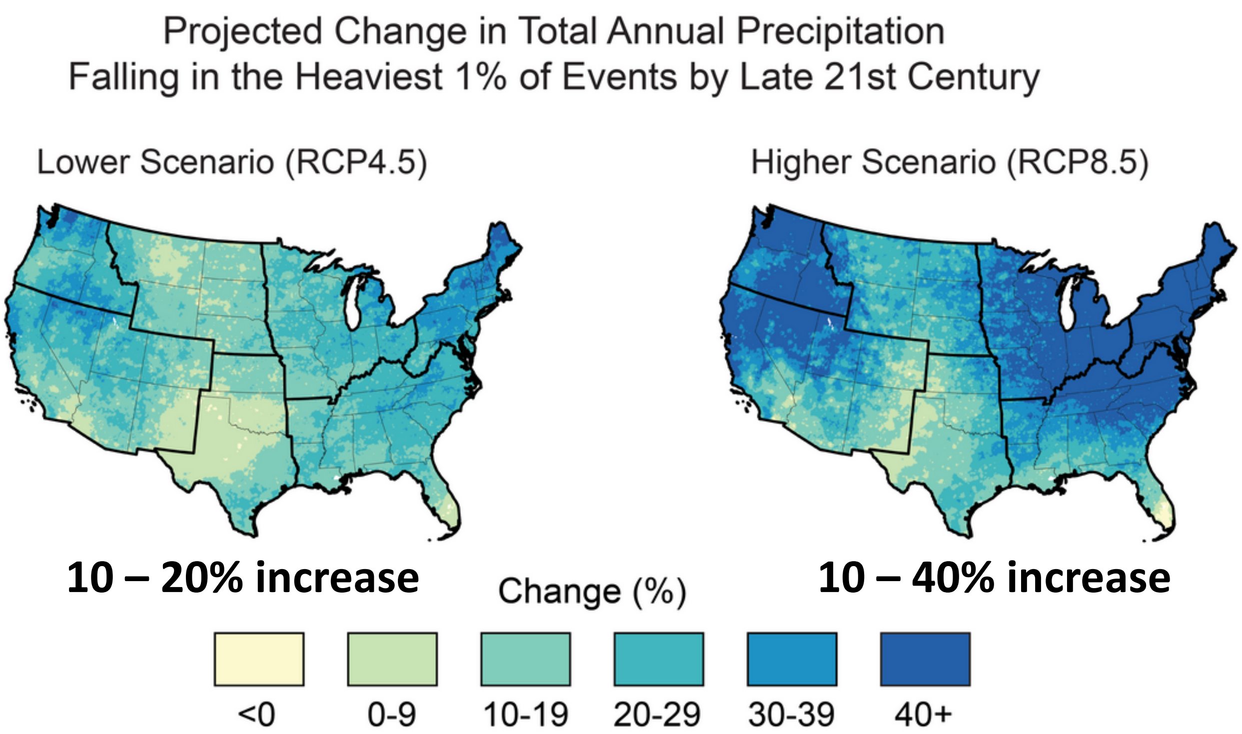


Fig. 22.1: Climate Change Impacts and Adaptation Across the Northern Great Plains

The Northern Great Plains exhibits a high amount of geographical, ecological, and climatological variability, in part because of the dramatic elevation change across the region. The impacts of climate change throughout the Northern Great Plains include changes in flooding and drought, rising temperatures, and the spread of invasive species. **Ranchers, tribal communities, universities, government institutions, and other stakeholders from across the region have taken action to confront these challenges.** *Photo credits: 1) Justin Derner, USDA Agricultural Research Service, 2) Kenton Rowe Photography, 3) Kurrie Jo Small, 4) Eugene Wilson ([CC BY-NC 2.0](CC BY-NC 2.0)), 5) Jacob Byk, 6) Benjamin Rashford, 7) Chris Carparelli, 8) Mariah Lundgren, University of Nebraska Platte Basin Timelapse Project.*

1

Impact: Flash droughts and high heat events illustrate challenges for sustainability of ranching operations, with emergent impacts on rural prosperity and mental health.

Response: Adaptive management frameworks, developed through management–science partnerships, proactively increase flexibility in operational decision-making to reduce economic and ecological risk.

2

Impact: Consecutive years of drought across the region force ranchers to consider selling off their herds.

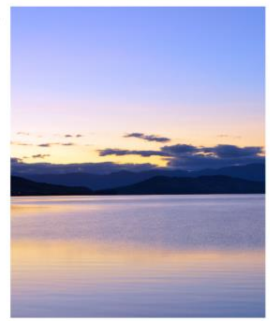
Response: Montana's Matador Ranch establishes a "grassbank" that allows local ranchers to pay discounted fees for access to additional grass during droughts in exchange for wildlife-friendly practices on their own operations.

3

Impact: Rising temperatures hasten the spread of invasive species in riparian ecosystems, threatening culturally significant native species and food sources in the Crow Indian (Apsaalooké) Reservation.

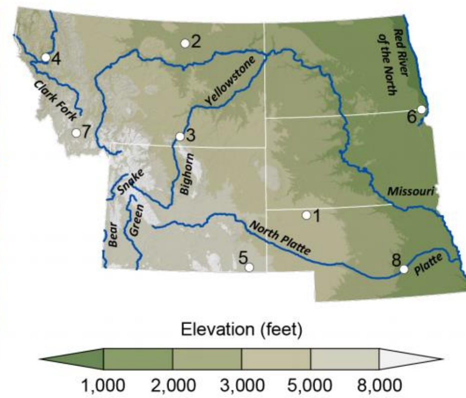
Response: The USDA NRCS Crow Agency worked with Little Big Horn College students to remove invasive populations along the Little Big Horn River. They also revegetated plains cottonwood in sandbars and developed riparian buffer zones.

4



Impact: Anticipated climate change impacts on cultural resources raise concerns within the leadership of the Confederated Salish and Kootenai Tribes.

Response: Tribal leaders developed their climate change strategic plan to address climate impacts and vulnerabilities drawing heavily on Traditional Ecological Knowledge.



5

Impact: Greenhouse gas emissions from petroleum and natural gas production across the Northern Great Plains are among the highest in the Nation.

Response: Potential wind energy resources are among the largest in the Northern Great Plains.

6

Impact: The Prairie Pothole Region, considered the world's most productive habitat for waterfowl, is threatened by warming temperatures.

Response: The Prairie Pothole Joint Venture implements wetland and grassland protection, restoration, and enhancement projects to sustain populations of waterfowl, shorebirds, and prairie landbirds.

7

Impact: Changing runoff characteristics and increasing stream temperatures threaten water and ecological resources.

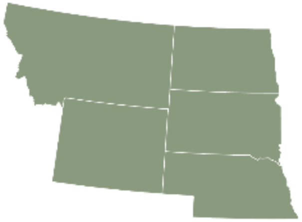
Response: The Beaverhead Drought Resiliency Plan was written to improve preparedness by reducing vulnerabilities to future drought events.

8

Impact: Increased growing season length and greater variability in temperature and precipitation stress critically important natural resources.

Response: The Platte Basin Timelapse project (PBT) uses time-lapse photography and multimedia storytelling to document life across the Platte River watershed.

22 Key Message Themes



Water

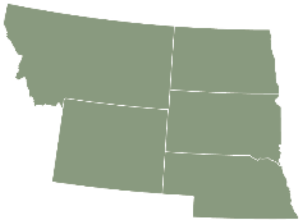
Agriculture

Recreation and Tourism

Energy

Indigenous Communities

22 Key Message #1



Water

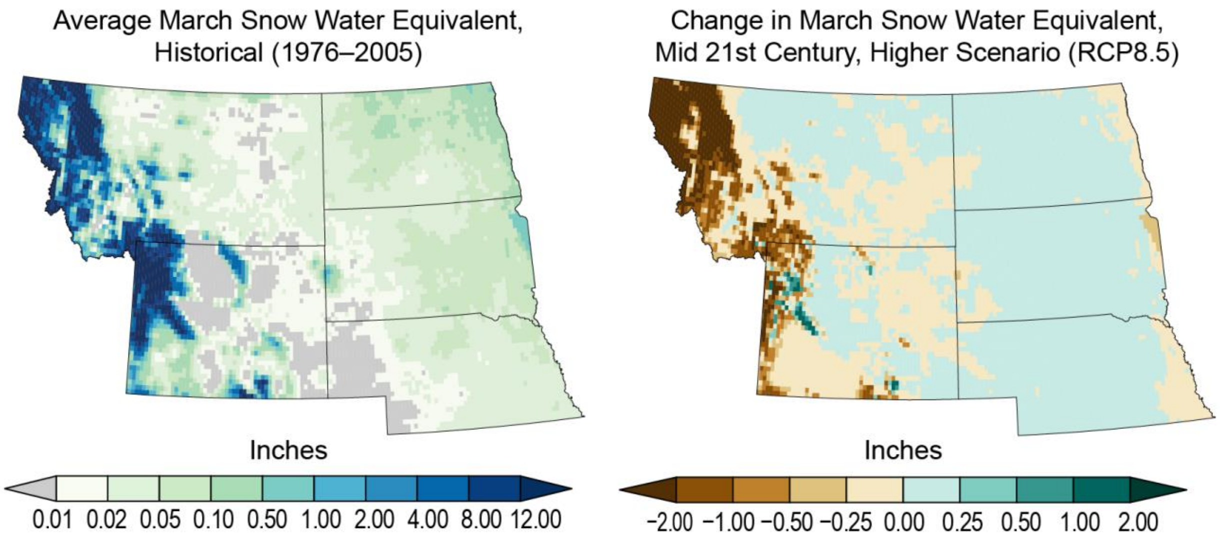
Water is the lifeblood, effective management is critical.

Small changes can have big impacts, making management a challenge.

Future changes are very likely to exacerbate these challenges.

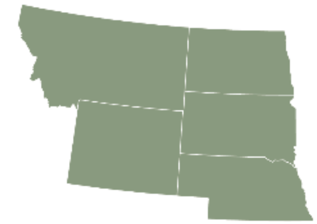
Fig. 22.3: Hydrologic Changes Across the Northern Great Plains

These maps show historical (left; 1976–2005) and projected changes (right; 2036-2065) under a higher scenario (RCP8.5) in average snowpack. Snowpack is measured in terms of snow water equivalent, or SWE—the depth in inches of the amount of water contained in the snowpack. The top two maps show average values for March to provide historical and future end-of-season estimates of SWE. This illustrates projected warming and potential snow loss. Projected decreases in snowpack across montane western regions in the upper-right plot are primarily the result of projected warming at the highest elevations. Projected increases in snow at lower elevations are less important, since those changes are relative to a much lower average (left) than in montane regions. *Sources: NOAA NCEI and CICS-NC.*



Reservoir and groundwater storage are expected to be increasingly important as buffers against the impacts of increasing variability and to meet water demands during periods of shortage, especially in light of warming-driven losses in snowpack water and higher evapotranspiration rates, which reduce the total amount of water availability.

22 Key Message #2



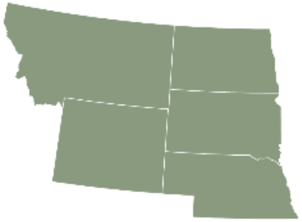
Agriculture

Agriculture is an integral component for the region.

Rising temperatures and changes in extreme weather events are very likely to have negative impacts on parts of the region.

Adaptation will likely require transformative changes in management, including regional shifts of agricultural practices and enterprises.

22 Agricultural Impacts



Warmer, generally wetter, elevated CO_2

Increase soil water availability in the north, decrease in the south.

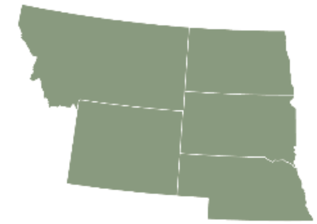
Increase extreme high temperatures during pollination and grain fill periods, reducing crop yields.

Increase abundance of weeds and invasive species and range of crop pests.

Alteration of plant phenology (earlier onset of spring).

Decrease quality of forage.

22 Key Message #3



Recreation and Tourism

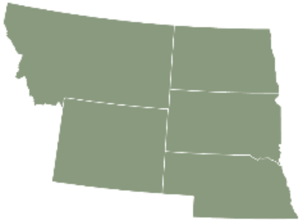
Ecosystems provide recreational opportunities and other valuable goods and services that are at risk in a changing climate.

Impacts are already evident for local economies that depend on winter or river-based recreational activities.

Climate-induced land-use changes in agriculture can have cascading effects on closely entwined natural ecosystems, such as wetlands, and the diverse species and recreational amenities they support.

Federal, tribal, state, and private organizations are undertaking preparedness and adaptation activities, such as scenario planning, transboundary collaboration, and development of market-based tools.

22 Key Message #4



Energy

Fossil fuel and renewable energy production and distribution infrastructure is expanding.

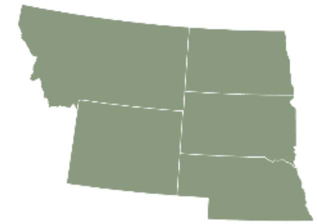
Climate change put this infrastructure and supply of energy at risk.

The energy sector is also a significant source of gases that contribute to climate change and ground-level ozone pollution.

Fig. 22.5: Flooding at Fort Calhoun Nuclear Station

Floodwaters from the Missouri River surround the Omaha Public Power District's Fort Calhoun Station, a nuclear power plant just north of Omaha, Nebraska, on June 20, 2011. The flooding was the result of runoff from near-record snowfall totals and record-setting rains in late May and early June (NWS 2012).[115] A protective berm holding back the floodwaters from the plant failed, which prompted plant operators to transfer offsite power to onsite emergency diesel generators. Cooling for the reactor temporarily shut down, but spent fuel pools were unaffected.[116] *Photo credit: Harry Weddington, U.S. Army Corps of Engineers.*

22 Key Message #5



Indigenous Peoples

Indigenous peoples are at high risk from a variety of climate change impacts.

These changes are already resulting in harmful impacts to tribal economies, livelihoods, and sacred waters and plants used for ceremonies, medicine, and subsistence.

Many tribes have been very proactive in adaptation and strategic climate change planning.

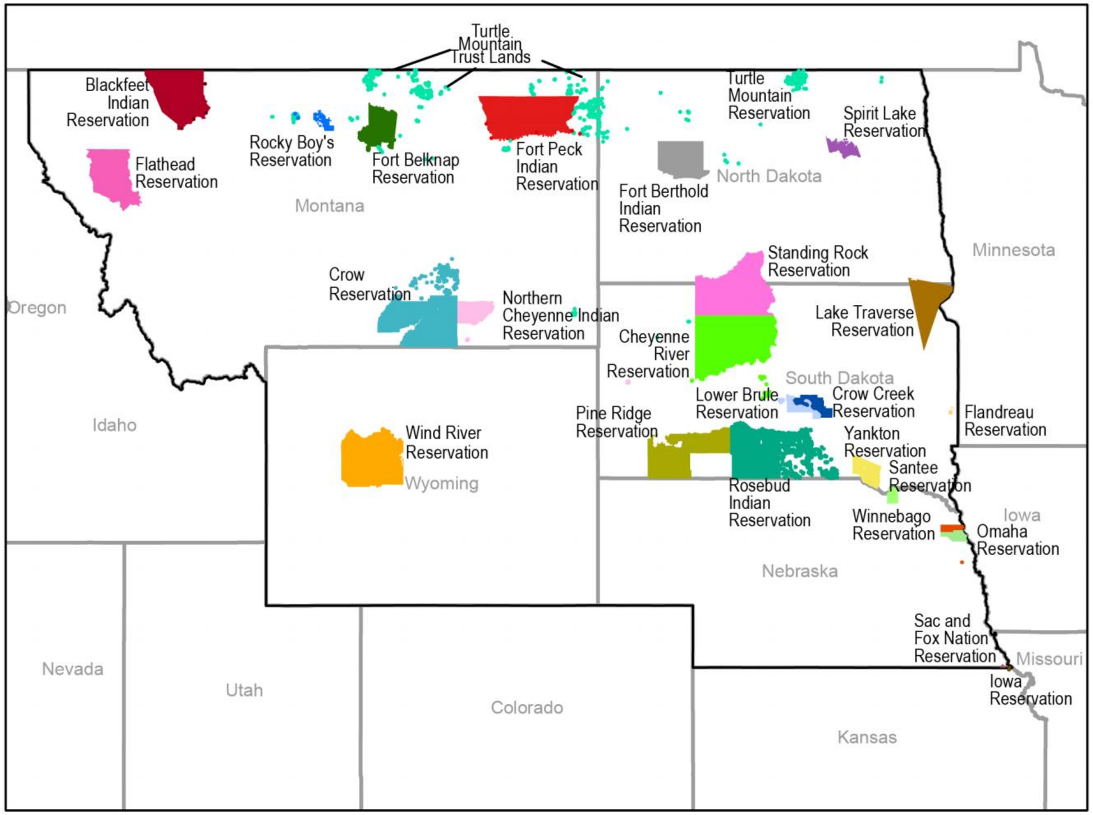


Fig. 22.7: Northern Great Plains Tribal Lands

The map outlines reservation and off-reservation tribal lands in the Northern Great Plains, which shows where the 27 federally recognized tribes have a significant portion of lands throughout the region. Information on Indigenous peoples' climate projects within the Northern Great Plains are described in Chapter 15: Tribes and Indigenous Peoples. *Sources: created by North Central Climate Science Center (2017) with data from the Bureau of Indian Affairs, Colorado State University, and USGS National Map.*

21 Key Message Themes

Agriculture

Forestry

Biodiversity and Ecosystems

Human Health

Transportation and Infrastructure

Community Vulnerability and Adaptation

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 benefits, yet threats are interacting with existing stressors to increase tree mortality and reduce forest productivity.

Without adaptive actions, these will result in the loss of economically and culturally important tree species.

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 #4

Human Health

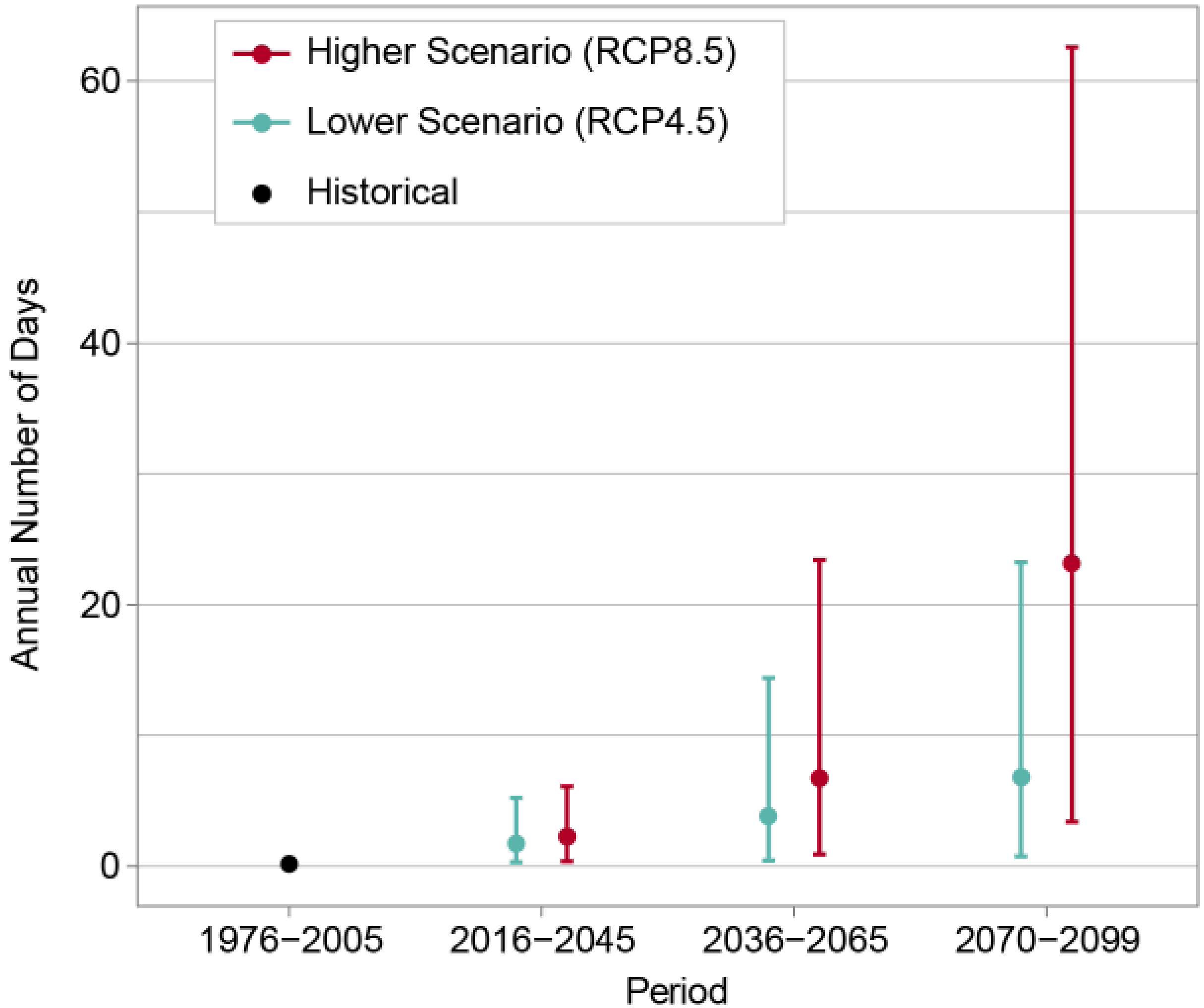
Climate change is expected to worsen existing health conditions and introduce new health threats (poor air quality, extreme heat and heavy rainfalls; extending pollen seasons; and modifying the distribution of disease-carrying pests and insects).

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. 21.10: 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.*



1 Reducing the Risks of Climate Change

- Many impacts can be substantially reduced through **global-scale** reductions in greenhouse gas emissions **complemented by regional and local** adaptation efforts.
- Since the Third National Climate Assessment (2014), a growing number of states, cities, and businesses have pursued or expanded upon **initiatives aimed at reducing greenhouse gas emissions,** and the scale of **adaptation implementation across the country has increased**.
- However, these efforts **do not yet approach the scale needed** to avoid substantial damages to the economy, environment, and human health expected over the coming decades.

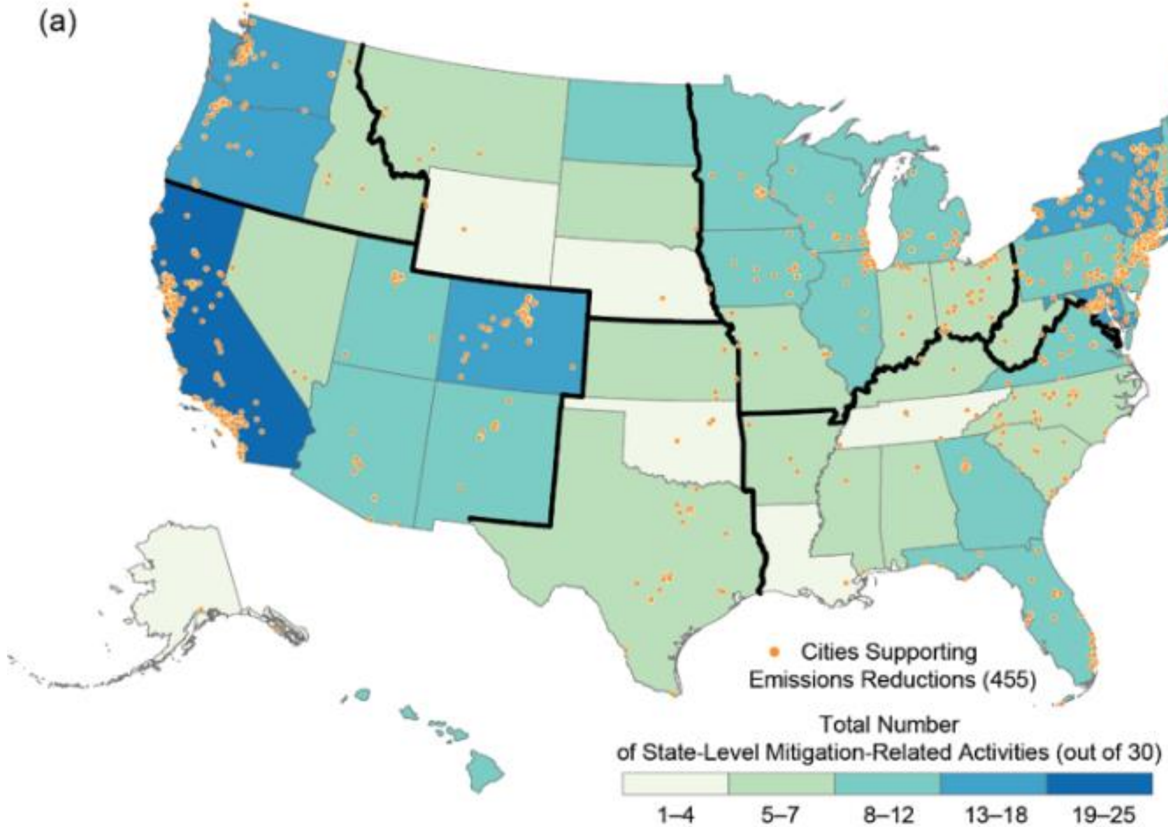


Fig. 1.19: Mitigation-Related Activities at State and Local Levels

The map shows the number of mitigation-related activities at the state level (out of 30 illustrative activities) as well as cities supporting emissions reductions;

Several territories also have a variety of mitigation-related activities, including American Sāmoa, the Federated States of Micronesia, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands. *From Figure 29.1, Ch. 29: Mitigation (Sources: EPA and ERT).*

Fig. 1.20: Adaptation Stages and Progress

Adaptation entails a continuing risk management process. With this approach, individuals and organizations become aware of and assess risks and vulnerabilities from climate and other drivers of change, take actions to reduce those risks, and learn over time. The gray arced lines compare the current status of implementing this process with the status reported by the Third National Climate Assessment in 2014; darker color indicates more activity. *From Figure 28.1, Ch. 28: Adaptation (Source: adapted from National Research Council, 2010. Used with permission from the National Academies Press, © 2010,National Academy of Sciences. Image credits, clockwise from top: National Weather Service; USGS; Armando Rodriguez, Miami-Dade County; Dr. Neil Berg, MARISA; Bill Ingalls, NASA).*

Parting Thoughts (Martha's, not the NCA)

- **It's already here.**
- **We are the cause, but we're also the solution.**
- **The sooner we act, the less risky it is.**
- **There are great examples to follow. Look to lessons learned from other regions and sectors.**

Parting Thoughts (Martha's, not the NCA)

- The NCA only scratches the surface in terms of impacts but serves as an **excellent starting point**.
- **Climate impacts are local**… Know your local or regional climatologist.
- The best thing we can do going forward is **work together** and start or continue the **dialogue**.

U.S. Global Change Research Program

Recommended chapter citation

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