Highlights

- Brief printed overview of the report (~80+ pages)
- Organized around 12 key findings + regions
- Sectors etc. covered in key findings
- All chapters represented
- Derivative – both text and graphics
- Review and production issues

- Other products (12-16 page brochure, regional 2-sided sheets)

National Climate Assessment

CLIMATE TRENDS

Global climate is changing now and this change is apparent across a wide range of observations. Much of the climate change of the past 50 years is primarily due to human activities. Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the climate is to those emissions.

Temperature

U.S. average temperature has increased by about 1.5°F since record keeping began in 1895; more than 80% of this increase has occurred since 1980. The most recent decade was the nation's warmest on record. U.S. temperatures are expected to continue to rise. Because human-induced warming is superimposed on a naturally varying climate, the temperature rise has not been, and will not be, smooth across the country or over time.

Precipitation

Precipitation averaged over the entire U.S. has increased during the period since 1900, but regionally some areas have had increases greater than the national average, and some areas have had decreases. The largest increases have been in the Midwest, southern Great Plains, and Northeast. Portions of the Southeast, the Southwest, and the Rocky Mountain states have experienced decreases. More winter and spring precipitation is projected for the northern U.S., and less for the Southwest, over this century.

Extreme Weather

Certain types of extreme weather events have become more frequent and intense, including heat waves, floods, and droughts in some regions. The increased intensity of heat waves has been most prevalent in the western parts of the country, while the intensity of flooding events has been more prevalent over the eastern parts. Droughts in the Southwest and heat waves everywhere are projected to become more intense in the future.

Heavy Downpours

Heavy downpours are increasing in most regions of the U.S., especially over the last three to five decades. Largest increases are in the Midwest and Northeast. Further increases in the frequency and intensity of extreme precipitation events are projected for most U.S. areas.

Frost-free Season

The length of the frost-free season (and the corresponding growing season) has been increasing nationally since the 1980s, with the largest increases occurring in the western U.S., affecting ecosystems and agriculture. Continued lengthening of the growing season across the U.S. is projected.

Hurricanes

There has been an increase in the overall strength of hurricanes and in the number of strong (Category 4 and 5) hurricanes in the North Atlantic since the early 1980s. The intensity of the strongest hurricanes is projected to continue to increase as the oceans continue to warm; ocean cycles will also affect the amount of warming at any given time.

Ice Melt

Rising temperatures are reducing ice volume and extent on land, lakes, and sea. This loss of ice is expected to continue.

Severe Storms

With regard to other types of storms that affect the U.S., winter storms have increased slightly in frequency and intensity, and their tracks have shifted northward over the U.S. Other trends in severe storms, including the numbers of hurricanes and the intensity and frequency of tornadoes, hail, and damaging thunderstorm winds are uncertain and are being studied intensively.

Sea Level

Global sea level has risen by about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 to 4 feet by 2100.

Ocean Acidification

The oceans are currently absorbing about a quarter of the carbon dioxide emitted to the atmosphere annually and are becoming more acidic as a result, leading to concerns about potential impacts on marine ecosystems.

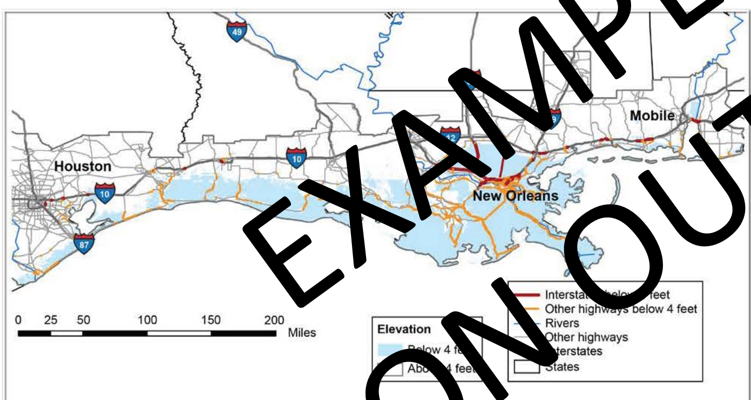
6 INFRASTRUCTURE AT RISK

KEY FINDING

Infrastructure across the U.S. is being adversely affected by phenomena associated with climate change, including sea level rise, storm surge, heavy downpours, and extreme heat.

Sea level rise and storm surges, in combination with the pattern of heavy development in coastal areas, are already resulting in damage to infrastructure such as roads, buildings, ports, and energy facilities. Infrastructure associated with military installations is also at risk from climate change impacts. Floods along the nation's rivers, inside cities, and on lakes following heavy downpours, prolonged rains, and rapid melting of snowpack are damaging infrastructure in towns and cities, farmlands, and a variety of other places across the nation. Extreme heat is damaging transportation infrastructure such as roads, rail lines, and airport runways. Rapid warming in Alaska has resulted in infrastructure impacts due to thawing of permafrost and the loss of coastal sea ice that once protected shorelines from storms and wave-driven coastal erosion (Ch. 2, 3, 5, 6, 11, 16, 17, 18, 19, 20, 21, 22, 23, 25).

Gulf Coast Transportation Hubs at Risk



Within this century, 2,400 miles of major roadway are projected to be inundated by sea level rise in the Gulf Coast region. The map shows roadways at risk in the event of a sea level rise of about 4 feet, which is within the range of projections for this region in this century In total, 24% of interstate highway miles and 28% of secondary road miles in the Gulf Coast region are at elevations below 4 feet. Source: 2009 NCA/CCSP SAP 4.7

Urban Systems, Infrastructure, and Vulnerability Take Home Messages

Climate change and its impacts threaten the well-being of urban residents in all regions of the U.S. Essential local and regional infrastructure systems such as water, energy supply, and transportation will increasingly be compromised by interrelated climate change impacts.

In urban settings, climate-related disruptions of services in one infrastructure system will almost always result in disruptions in one or more other infrastructure systems.

Climate vulnerability and adaptive capacity of urban residents and communities are influenced by pronounced social inequalities that reflect age, ethnicity, gender, income, health, and (dis)ability differences.

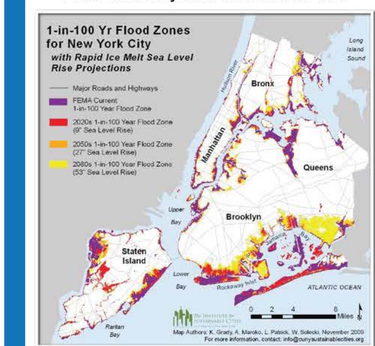
City government agencies and organizations have started urban adaptation efforts that focus on infrastructure systems and public health. However, these efforts face many barriers to implementing and incorporating wider governmental, general public, and private efforts.

Climate change poses a series of interrelated challenges to the country's most densely populated places: its cities. The U.S. is highly urbanized, with about 80% of its population living in cities and metropolitan areas. Many cities depend on infrastructure, like water and sewage systems, roads, bridges, and power plants, that is aging and in need of repair or replacement. Rising sea levels, storm surges, heat waves, and extreme weather events will compound those issues, stressing or even overwhelming these essential services.

Cities have become early responders to climate change challenges and opportunities due to two simple facts: First, urban areas have large and growing populations that are vulnerable for many reasons to climate variability and change; and second, cities depend on extensive infrastructure systems and the resources that support them, which often extend to, or derive from, rural locations at great distances from urban centers.

Urban dwellers are particularly vulnerable to disruptions in essential infrastructure services, in part because many of these infrastructure systems are reliant on each other to function. For example, electricity is essential to power multiple systems, and a failure in the electrical grid can affect water treatment, transportation services, and public health. These infrastructure systems – lifelines to millions – will be affected by various climate-related events and processes.

New York City and Sea Level Rise



Map shows areas in New York's five boroughs that are projected to face increased flooding over the next 70 years, assuming an increased rate of sea level rise from the past century's average. As sea level rises, storm surges reach further inland. Map does not represent precise flood boundaries, but illustrates projected increases in areas flooded under various sea level rise scenarios.

As climate change impacts increase, climate-related events will have large consequences for significant numbers of people who live in cities or suburbs. These changing conditions also create opportunities and challenges for urban climate adaptation, and many cities have begun adopting plans to address these changes.

Transportation Take Home Messages

The impacts from sea level rise and storm surge, extreme weather events, higher temperatures and heat waves, precipitation changes, Arctic warming, and other climatic conditions are reducing the reliability and capacity of the U.S. transportation system in many ways.

Sea level rise, coupled with storm surge, will continue to increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, ports and harbors, roads, rail lines, tunnels, and bridges.

Extreme weather events currently disrupt transportation networks in all areas of the country; projections indicate that such disruptions will increase.

Climate change impacts will increase costs to transportation systems and their users, but these impacts can be reduced through rerouting, mode change, and a wide range of adaptive actions.

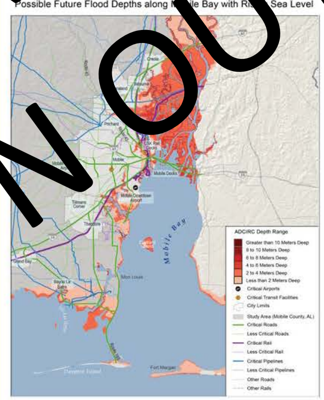
Tropical Storm Impact on Vermont Road

Vermont Route 131, outside Cavendish, a week after Tropical Storm Irene unleashed severe precipitation and flooding that damaged many Vermont roads, bridges, and rail lines. Photo courtesy of Vermont Agency of Transportation.

Transportation systems influence future climate characteristics and are also affected by changes in the climate. In 2010, the U.S. transportation sector accounted for 27% of U.S. greenhouse gas emissions (also called heat-trapping gas emissions) (Source: EPA 2011). Petroleum accounts for 93% of the nation's transportation energy use (EIA 2011), while cars and trucks account for 65% of transportation emissions (EPA 2011).

Transportation systems are already experiencing costly climate change related impacts. Many inland states – for example, Vermont, Tennessee, Iowa, and Missouri – have experienced severe precipitation events and flooding during the past three years, damaging roads, bridges, and rail systems. Over the coming decades, all modes and regions will be affected by increasing temperatures, more extreme weather events, and changes in precipitation. Concentrated transportation impacts are likely in Alaska and along seacoasts.

Possible Future Flood Depths along Mobile Bay with Rising Sea Level



Energy Supply and Use Take Home Messages

Extreme weather events are affecting energy production and delivery facilities, causing supply disruptions of varying lengths and magnitudes and affecting other infrastructure that depends on energy supply. The frequency and intensity of extreme weather events are expected to increase.

Higher summer temperatures will increase electricity use, causing higher summer peak loads, while warmer winters will decrease energy demands for heating. Net energy use is projected to increase as rising demands for cooling outpace declining heating energy demands.

Both episodic and long-lasting changes in water availability will constrain different forms of energy production.

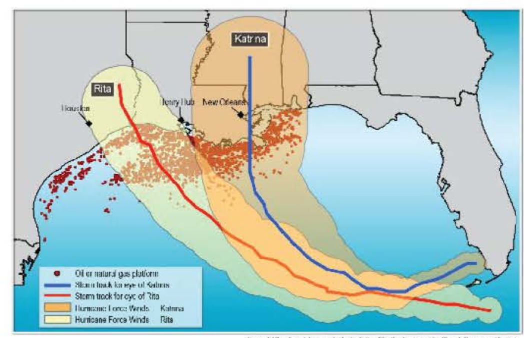
In the longer term, sea level rise will affect coastal facilities and infrastructure on which many energy systems, markets, and consumers depend.

As new investments in energy technologies occur, future energy systems will differ from today's in uncertain ways – depending on the character of changes in the energy mix, climate change will introduce new risks as well as opportunities.

The U.S. energy supply system is diverse and robust in its ability to provide a secure supply of energy with only occasional interruptions. However, projected impacts of climate change will amplify seasonal patterns of energy use and affect energy infrastructure, posing additional risks to energy security. Extreme weather events and water shortages are already interrupting energy supply, and impacts are expected to increase in the future. Most vulnerabilities and risks to energy supply and use are unique to local situations; others are national in scope.

The impacts of climate change in other countries will also affect U.S. energy systems through global and regional cross-border markets and policies. Increased energy demand within global markets due to industrialization, population growth, and other factors will influence U.S. energy costs through competition for imported and exported energy products.

Paths of Hurricanes Katrina and Rita Relative to Energy Production Facilities



A substantial portion of U.S. energy facilities are located on the Gulf Coast as well as off-shore in the Gulf of Mexico, where they are particularly vulnerable to hurricanes and other storms and sea level rise. (Source: Wilbanks et al. 2012a).

MIDWEST

Take Home Messages

In the next few decades, longer growing seasons and rising carbon dioxide levels will increase yields of some crops, though those benefits will be increasingly offset by the occurrence of extreme events such as heat waves, droughts, and floods. In the long term, combined stresses associated with climate change are expected to decrease agricultural productivity, especially without significant advances in genetic and agronomic technology.

The composition of the region's forests is expected to change as rising temperatures drive habitats for many tree species northward. The region's role as a net absorber of carbon is at risk from disruptions to forest ecosystems, in part due to climate change.

Increased heat wave intensity and frequency, degraded air quality, and reduced water quality will increase public health risks.

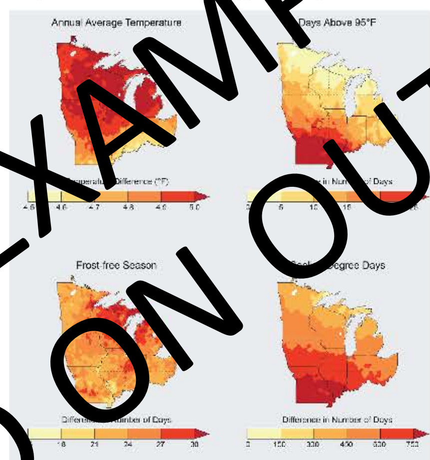
The Midwest has a highly energy-intensive economy with per capita emissions of greenhouse gases more than 20% higher than the national average. The region also has a large, and increasingly utilized, potential to reduce emissions that cause climate change.

Extreme rainfall events and flooding have increased during the last century, and these trends are expected to continue, causing erosion, declining water quality, and negative impacts on transportation, agriculture, human health, and infrastructure.

Climate change will exacerbate a range of risks to the Great Lakes region, including changes in the range and distribution of important commercial and recreational fish species, increased invasive species, declining beach health, and harmful blooms of algae. Declines in ice cover will continue to lengthen the commercial navigation season.

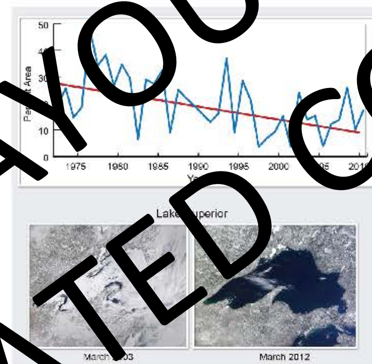
The Midwest's agricultural lands, forests, Great Lakes, industrial activities, and cities are all vulnerable to climate variability and climate change. Climate change will tend to amplify existing risks climate poses to people, ecosystems, and infrastructure. Direct effects will include increased heat stress, flooding, drought, and late spring freezes. Climate change also alters pests and disease prevalence, competition from non-native or opportunistic native species, ecosystem disturbances, land-use change, landscape fragmentation, atmospheric pollutants, and economic shocks such as crop failures or reduced yields due to extreme weather events. These added stresses, when taken collectively, are projected to alter the ecosystem and socioeconomic patterns and processes in ways that most people in the region would consider detrimental.

Temperature Details Show a Range of Changes



Projections by mid-century (2041-2070) compared to 1971-2000, assuming emissions of heat-trapping gases continue to rise (A2 scenario). The increase in cooling degree days (bottom right) suggests increasing energy use for air conditioning.

Ice Cover in the Great Lakes is Declining



Blue line shows annual average Great Lakes ice coverage from 1973 to 2011 and red line shows the trend. Satellite images show Lake Superior in a high ice year and a more recent low ice year.

Climate change may also intensify other stresses on urban vegetation, including increased atmospheric pollution, heat island effects, salt damage, a highly variable water cycle, and frequent exposure to new pests and diseases. Most of the Midwest's population lives in urban environments, with aging infrastructure, that are particularly vulnerable to climate-related flooding and life-threatening heat waves. Much of the region's fisheries, recreation, tourism, and commerce depend on the Great Lakes and expansive northern forests, which already face pollution and invasive species pressure – pressures exacerbated by climate change.

Extreme weather events will influence future crop yields more than changes in average temperature or annual precipitation. High temperatures during early spring, for example, can decimate fruit crop production when early heat causes premature bud break that exposes flowers to later cold injury*, as happened in 2002 and again in 2012, to Michigan's $60 million tart cherry crop. Springtime cold air outbreaks are projected to continue to occur throughout this century*. As a result, any increased productivity of some crops due to higher temperatures, longer growing seasons, and elevated CO_2 concentrations could be offset by increased freeze damage*. Heat waves during pollination of field crops such as corn and soybean also reduce yields*. Wetter springs may reduce crop yields and profits*, especially if growers are forced to switch to late-planted, shorter-season varieties.

Rising temperatures across the U.S. have reduced lake ice, sea ice, glaciers, and seasonal snow cover over the last few decades*. In the Great Lakes, for example, total winter ice coverage has decreased by 63% since the early 1970s*.

Adaptation

The City of Cedar Falls' new floodplain ordinance expands zoning restrictions from the 100-year floodplain to the 500-year floodplain to better reflects the flood risks experienced by the city during the 2008 floods.

The Michigan Department of Community Health's Michigan Climate and Health Adaptation Plan has a goal of "preparing the Public Health System in Michigan to address the public health consequences of climate change in a coordinated manner." Implementation is funded for three years as part of the Climate-Ready States and Cities Initiative of the Centers for Disease Control.

The City of Chicago was one of the first cities to officially integrate climate adaptation into a citywide Climate Adaptation Plan. Since its release, a number of strategies have been implemented to help the city manage heat, protect forests, and enhance green design, such as their work on green roofs.