

# Adapting to Climate Change in Minnesota

2013 Report of the Interagency Climate Adaptation Team



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## Background

Climate change is already occurring in Minnesota and is affecting our state's environmental, economic and social systems. Minnesota state government is concerned about the impacts of a changing climate on our natural resources, economy, health, and quality of life, and is taking action to address these emerging challenges.

Work on climate change can be categorized into two areas: adaptation and mitigation. Climate *adaptation*, the focus of this report, is defined as developing and implementing strategies, initiatives and measures to help human and natural systems cope with climate change impacts. State agencies are working to adapt to a changing climate and manage its risks by building a more resilient state. Climate change *mitigation* emphasizes reducing greenhouse gas emissions with the goal of limiting the magnitude or progression of climate change. Minnesota state government has many policies and laws in place that have helped us to make significant progress towards our greenhouse gas reduction goals, including the 2007 Next Generation Energy Act.

The State of Minnesota plans to release a comprehensive progress report and action plan in the near future that describes how state agencies are addressing climate change and how these actions are yielding benefits for the state. This plan will address both mitigation and adaptation, and will help to identify additional actions for meeting the state's goals. This 2013 Interagency Climate Adaptation Team (ICAT) report is a first step in this broader planning process, and highlights how state government is working to adapt to a changing climate, reduce risks and impacts, and increase the resilience of our communities.

Since July 2009, Minnesota state agencies have been collaborating on climate adaptation efforts through ICAT. ICAT currently includes representatives from the following Minnesota state departments and agencies: Agriculture, Commerce (Division of Energy Resources), Health, Natural Resources, Pollution Control, Public Safety (Division of Homeland Security and Emergency Management), and Transportation, as well as the Board of Water and Soil Resources and the Metropolitan Council.

ICAT prepared a preliminary report in August 2010, *Adaption to Climate Change in Minnesota: Preliminary Report of the Interagency Climate Adaptation Team*. This 2013 report updates and expands on the 2010 document. The purpose of this updated report is to:

- further describe observed and projected climate impacts in Minnesota;
- outline Minnesota state agency activities helping to adapt to climate change; and
- identify opportunities for future action and interagency collaboration.

Complementary to this interagency effort within state government, University of Minnesota Extension and the University of Minnesota's Water Resources Center coordinate the Climate Adaptation Partnership (CAP), which brings together federal and state agencies, organizations and individuals statewide with an interest in climate adaptation. CAP serves as a valuable networking and educational resource to connect and educate professionals working in the climate adaptation field and sponsors a statewide climate adaptation conference. The year's conference, *Preparing Minnesota for Climate Change: A Conference on Climate Adaptation*, will be held in St. Paul on November 7, 2013.

Minnesota is one of a growing number of state governments working to address climate adaptation. Many of the adaptation activities in other states are described on the Georgetown Climate Center's website at <http://www.georgetownclimate.org/adaptation/state-and-local-plans>, the Center for Climate and Energy

Solutions' website at <http://www.c2es.org/node/9337>, and in the Natural Resources Defense Council's 2012 report, *Ready or Not: An Evaluation of State Climate and Water Preparedness Planning*, available at <http://www.nrdc.org/water/readiness/water-readiness-report.asp>.

## Climate Trends in the Midwest

To summarize climate impacts, this report draws from the National Climate Assessment. This is an important document issued approximately every four years by the U.S. Global Change Research Program, a collaboration between 13 federal government agencies. This national assessment reflects the work of more than 240 authors as overseen by a 60-member Federal Advisory Committee. The most recent National Climate Assessment was issued in draft form in early 2013, to be finalized in 2014, and is available online at <http://ncadac.globalchange.gov/>. Because this national assessment contains timely and thoroughly vetted information, it is being utilized as the primary source of observed climate data and future projections in this report.

According to the draft National Climate Assessment, some of the key elements of climate change observed and projected for the Midwest include:

- Increasing temperatures
- Risks to the Great Lakes
- Change in the amount and character of precipitation

### Increase in annual average temperature

According to the draft National Climate Assessment, U.S. average temperatures have increased by about 1.5 degrees Fahrenheit (F) since recordkeeping began in 1895, with more than 80% of this increase since 1980. The most recent decade was the nation's warmest on record, and temperatures are expected to continue rising.

Figure 1 demonstrates the change in annual average temperature over the past 20 years in degrees F (1991-2011) compared to the 1901-1960 average. The bars on the graphs show the average temperature changes by decade for 1901-2011 (relative to the 1901-1960 average) for each region. The far right bar in each graph (2000s decade) includes 2011.

Most of Minnesota has experienced an increase in the average temperature of greater than 1.5 degrees F, similar to that of the United States. More warming was experienced in the northern portion of the state. Overall, there has been an increase in the warming trend in the Midwest over the past decades.

## Observed U.S. Temperature Change

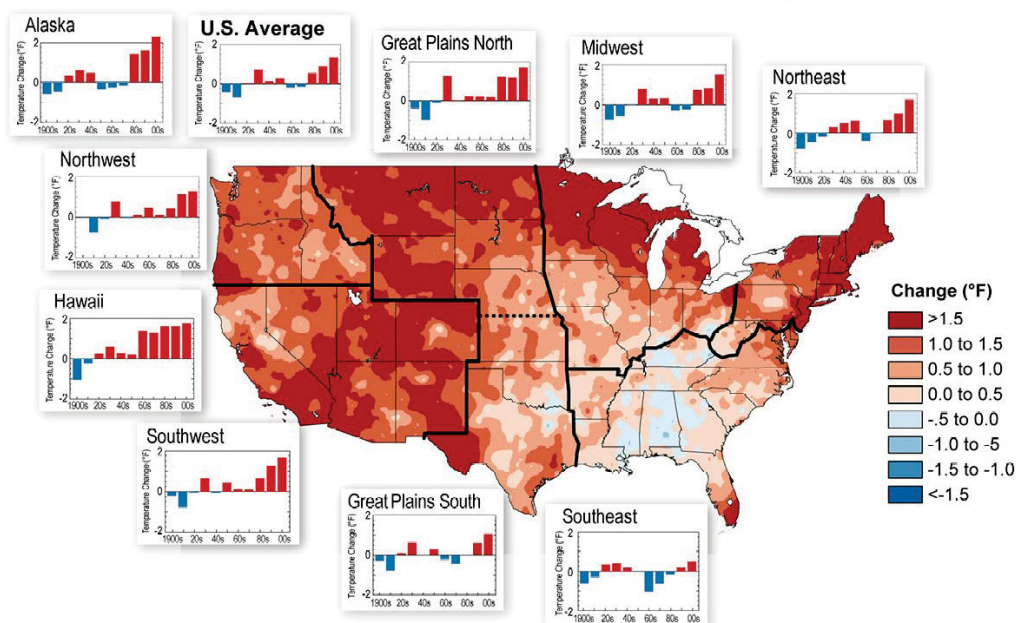


Figure 1 (Figure 2.6, page 36 from draft National Climate Assessment)

Figure 2 shows the annual average temperatures across the Midwest over the period 1895-2010. The chart demonstrates the trend towards increasing temperature. The trend calculated is equal to an increase of 1.5 degrees F.

## Temperatures are Rising in the Midwest

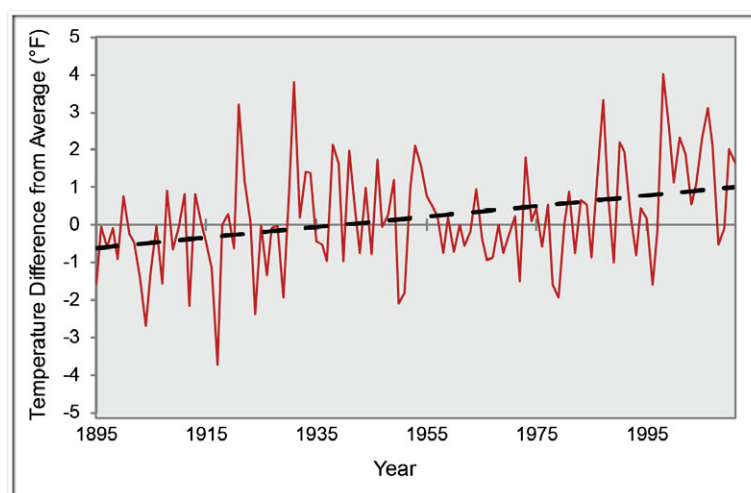


Figure 2 (Figure 18.1, page 619 from draft National Climate Assessment)

Annual average temperatures are projected to rise significantly by mid-century. The Midwest is expected to experience an increase in the number of very hot days (above 95 degrees F), length of the frost-free season, and the number of cooling degree days. (*Cooling degree days* is a measure that relates to the amount of

energy needed to cool buildings when outdoor temperature is warmer than 65 degrees F. It takes into account both the number of days and the number of degrees greater than 65.)

Figure 3 shows four graphics of projected temperature changes and potential impacts in the Midwest, including: increasing annual average temperatures by the mid-century (2041-2070) as compared to the 1971-2000 period (top left); projected increases in the number of hottest days (over 95 degrees F) (top right); increase in cooling degree days (bottom right); and longer growing seasons over this time period (bottom left). Projections are from Global Climate Models.

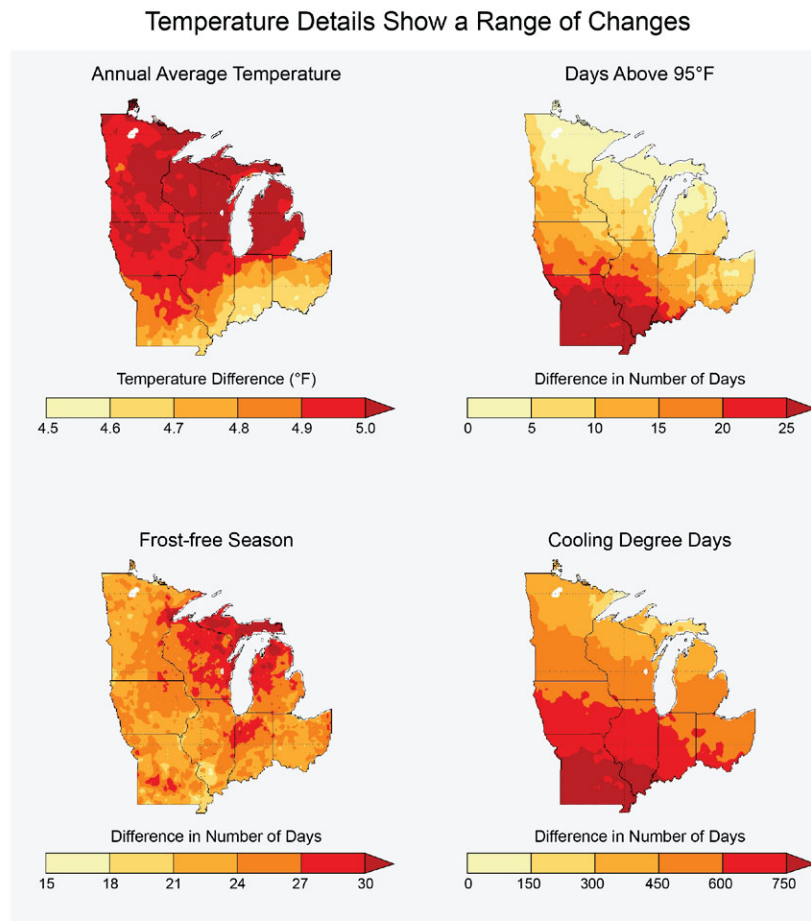


Figure 3 (Figure 18.2, page 620 from draft National Climate Assessment)

### Risks to the Great Lakes

According to the National Climate Assessment, the Great Lakes have recently recorded higher water temperatures and less ice cover due to a changing climate. Temperatures of surface waters in Lake Superior are increasing at a rate much greater than air temperature change. Surface water temperatures in Lake Superior are projected to rise by as much as 12.1 degrees F by 2100. Impacts of higher temperatures and a longer growing season can include changes in the range and distribution of key commercial and recreational fish species, more production of toxic algae, and greater risks of invasive species.

An observed impact of increasing temperature is the decline in the number of days of ice cover in the Great Lakes, including Lake Superior. Figure 4 indicates the annual average Great Lakes ice coverage (blue line), and the decreasing trend in ice coverage (red line), from 1973 to 2011. The two images in Figure 4 are satellite images that show Lake Superior in a high ice year (March 2003) and a more recent low ice year (March 2012). Decreased ice coverage has a number of impacts, including greater vulnerability of shoreland to erosion and flooding, and a longer commercial navigation season.

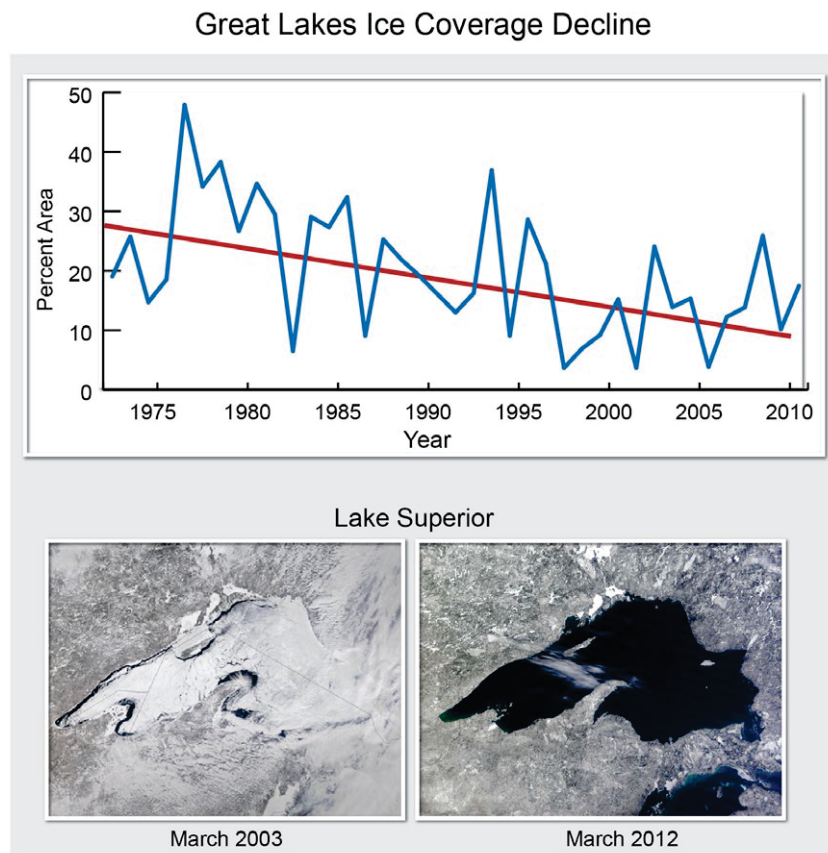


Figure 4 (Figure 2.27, page 66 from draft National Climate Assessment)

### Change in the amount and character of precipitation

Average precipitation has increased in the Midwest since 1900. Figure 5 shows annual total precipitation changes (percent) for 1991-2011 compared to the 1901-1960 average. Bars on the graphs show average precipitation differences by decade for 1901-2011 relative to the 1901-1960 average. The far right bar is for 2001-2011. The increases in precipitation have been larger in recent years in the Midwest.



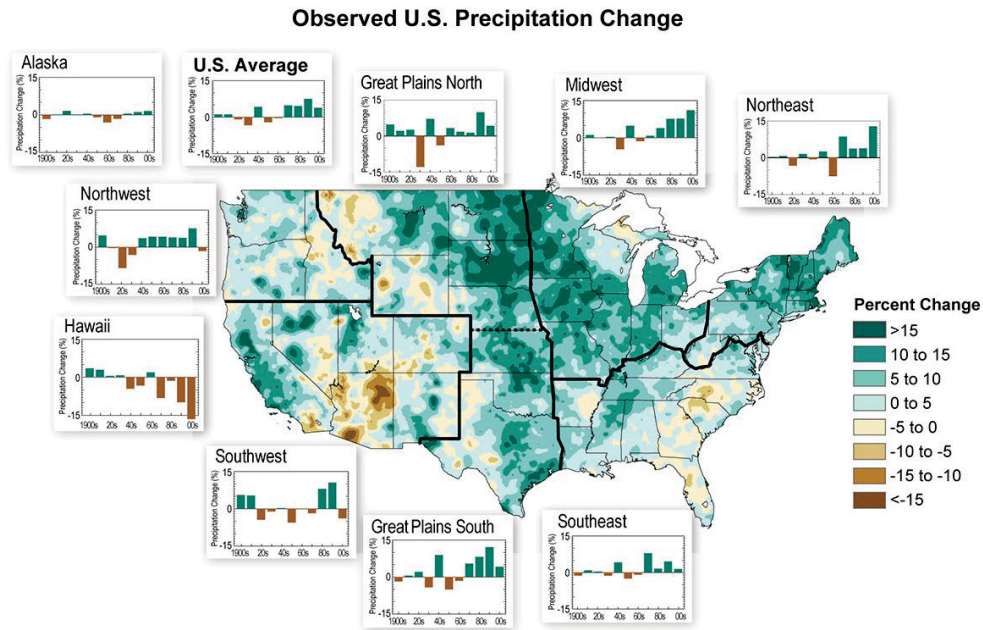


Figure 5 (Figure 2.11, page 42 from draft National Climate Assessment)

In addition to the amount of precipitation change, the character of precipitation is changing. The Midwest has experienced an increase in very heavy precipitation events, defined as the heaviest 1% of all daily events. Figure 6 shows percent increases in the amount of precipitation falling in very heavy events from 1958 to 2011 for each region.

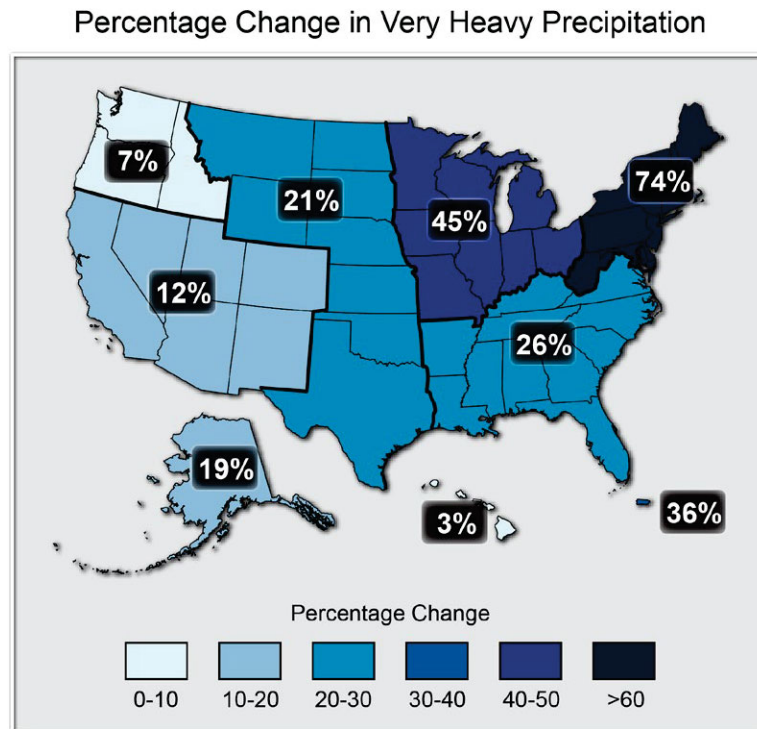


Figure 6 (Figure 2.16, page 50 from draft National Climate Assessment)



One of the resulting impacts of increases in very heavy precipitation events is an increased frequency of floods. There has been an observed increase in flood magnitude in Minnesota. Figure 7 shows the trends in magnitude (triangle size) and direction (green = increasing trend, brown = decreasing trend) of annual flood magnitude from the 1920s through 2008 across the United States. According to this figure, Minnesota has seen an increase in magnitude of floods, particularly in the Northwestern and Southeastern portions of the state, during those years.

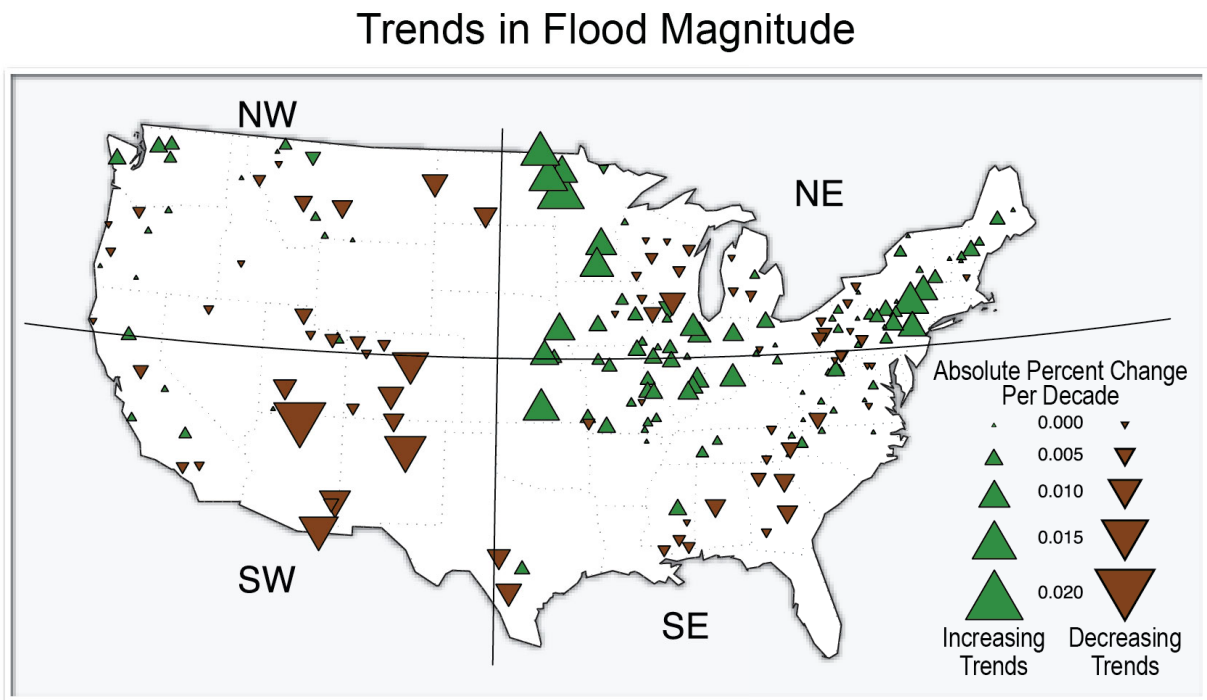


Figure 7 (Figure 2.20, page 56 from draft National Climate Assessment)

Future projections for mid-century for Minnesota indicate a continued trend for greater annual average precipitation and heavy precipitation, and fewer dry days. Figure 8 shows four graphics of projected changes based on Global Climate Model output for the middle of the current century (2041-2070) relative to the end of the last century (1971-2000) across the Midwest. The four graphics include: changes in total annual average precipitation (top left); increase in the number of days with very heavy precipitation (top 2% of all rainfalls) (top right); change in average days with less than one-tenth of an inch of precipitation (bottom right); and increases in the amount of rain falling in the wettest 5-day period (bottom left).

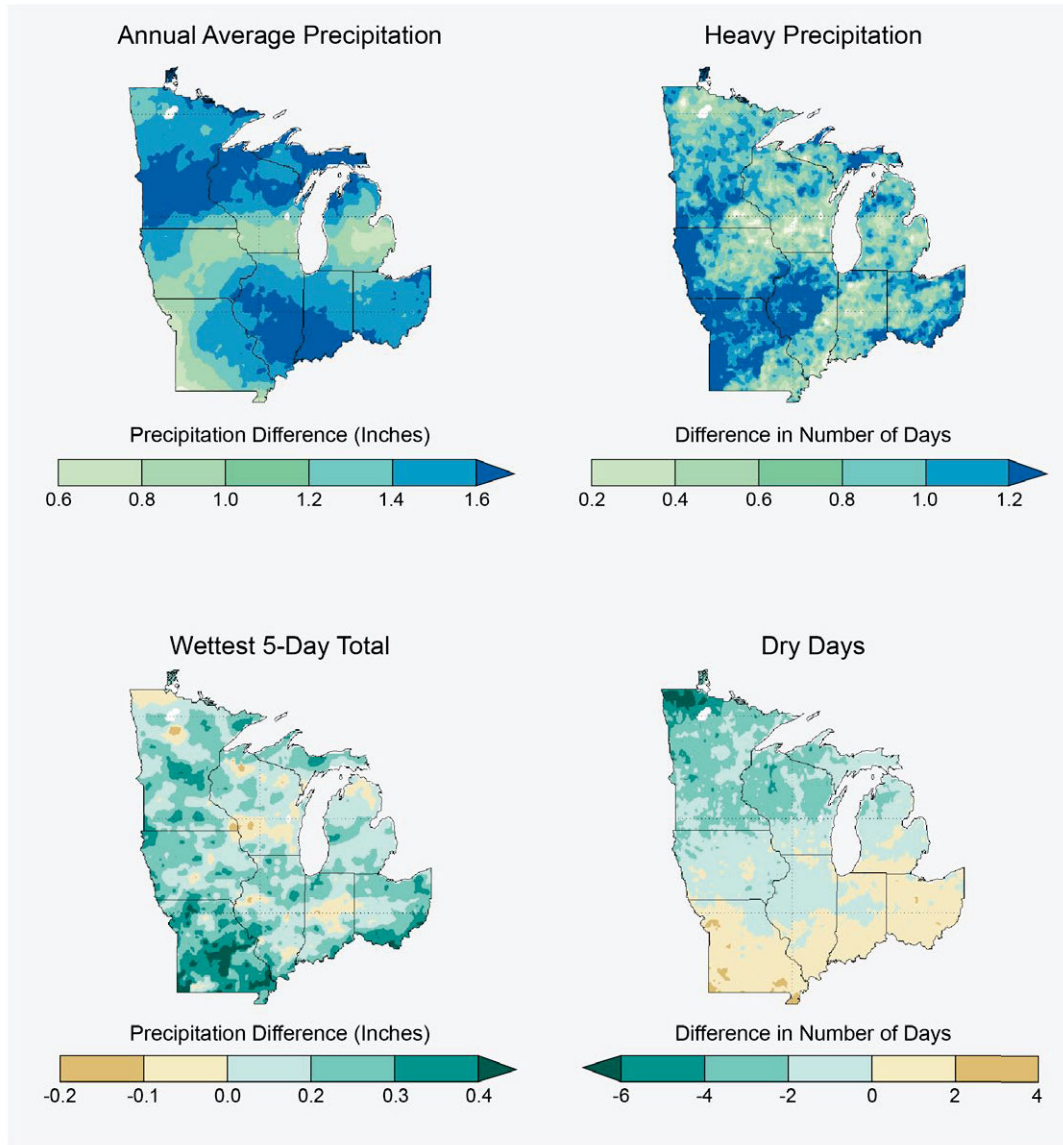


Figure 8 (Figure 18.7, page 628 from draft National Climate Assessment)

In addition to outlining trends of increasing temperature, decreasing ice cover, and changes in precipitation described above, the National Climate Assessment projects a variety of additional phenomena associated with climate change in the Midwestern states, including the following:

- Changing composition of forests as tree species move northward
- Increased heat wave intensity and frequency
- Degraded air quality
- Reduced water quality
- Longer growing seasons and increased yields of crops over the next few decades, but in the long term combined stresses associated with climate change are expected to decrease agricultural productivity

## Overview of Climate Impacts in Minnesota

The observed measurements and future projections described by the National Climate Assessment provide insight into climate trends that are impacting Minnesota now as well as those anticipated in the future. Complicating the varied impacts of climate change is that these changes also interact with and reinforce each other. For example, drought and heat may both contribute to wildfires, which may in turn lead changes in plant and animal populations as well as other ecological shifts. Extreme precipitation may increase flooding, along with the potential for runoff or combined-sewer overflow and contamination of recreational and drinking water sources, which may already be in short supply due to drought. In addition, climate change will amplify the effects of existing public health and environmental challenges, such as impaired air quality, loss of wildlife habitat, invasive species, and limitations to clean water supplies.

As informed by climate data and trends, Minnesota state agencies are identifying significant current and future climate change impacts. These impacts, including variable and extreme changes in temperature and precipitation, are expected to have substantial effects on public health, community infrastructure, ecosystem health, and environment quality. Climate impacts likely to continue include flooding, extreme heat, intense storms, drought, air and water pollution, vector-borne and other infectious diseases, invasive species, and ecological changes, such as alteration of seasonality.

The following descriptions summarize some currently observed and anticipated impacts of climate change by ICAT member agencies.

### Increasing temperature and extreme heat

Climate data for the Midwest show observed increases in average temperatures. Projected temperatures are expected to rise significantly by mid-century, including an increase in particularly hot days. Extreme heat affects human and animal health, agriculture, and infrastructure.

Extreme heat events are linked to a range of illnesses, even death, and can exacerbate pre-existing chronic conditions such as cardiovascular, respiratory, liver, and neurological diseases, endocrine disorders, and renal disease or failure. Populations who are most vulnerable to extreme heat include persons over 65 or under 5 years old; living alone, without air-conditioning, or residing on the topmost floor of a building; and with an income at or below the poverty line. People who are exposed to heat because of recreational activities or job-related activities also are more vulnerable, including athletes, construction workers, and landscape/agricultural workers.

Increasing temperatures also impact Minnesota's agricultural industry. Agriculture is highly dependent on specific climate conditions. As a result of increasing temperature, crop production areas may shift to new regions of the state where the temperature range for growth and yield of those crops is optimal.

According to the National Climate Assessment, the Midwest growing season has lengthened by almost two weeks since 1950 due in large part to earlier timing of the last spring freeze. This trend is expected to continue. While a longer growing season may increase total crop production, other climate changes, such as increased crop losses and soil erosion from more frequent and intense storms, and increases in pests and invasive species, could outweigh this benefit.

There may also be higher livestock losses during periods of extreme heat and humidity. Losses of livestock from extreme heat lead to a challenge in disposal of animal carcasses. Currently there are only two rendering facilities in Minnesota available for livestock disposal. If a rendering facility is not available, lost livestock must be composted on an impervious surface. If losses are high, finding an impervious surface large enough is a challenge. In an attempt to adapt to increased temperatures, livestock areas in Minnesota may shift farther north. As a result of new livestock areas and the resulting manure production, farmers may transition to manure-based fertilizer applications in areas where traditionally only commercial fertilizers have been used, with accompanying environmental advantages and disadvantages.

Increasing air temperatures are causing water temperatures to rise, which impacts aquatic species as well as human health. Increased water temperature results in decreased dissolved oxygen and greater vulnerability of aquatic organisms to water pollution. Shifts of population of fish species from coldwater to warmwater species are expected to occur.

Increased water temperatures also may contribute to the occurrence of harmful algal blooms, including potentially toxic algae, in lakes and waterways where people swim, fish, or engage in other recreational activities. Harmful algal blooms can cause painful skin irritation and upper respiratory health problems.

Permitted wastewater treatment ponds experiencing earlier ice-off face greater problems meeting effluent limits as warmer temperatures increase algal growth which affects total suspended solids, pH, and carbonaceous biochemical oxygen demand. In addition, warmer temperatures in summer impact the biological processes in wastewater treatment plants, as higher temperatures increase bacterial reaction rates and the density of settled sludge.

Additionally, extreme heat can cause roads to buckle and can damage other transportation infrastructure such as rail lines. This may increase expenditures for repairs, dangerous conditions for drivers, and potential for travel disruption.

## **Air quality**

Extreme heat is often associated with degradation of air quality. Climate change may affect air quality directly through changes in seasonal climate and weather, and indirectly through drivers of energy use and resulting emissions. Climate change is expected to have a substantial effect on ambient particulate matter and ozone.

Increased temperatures can:

- Increase pollution from fossil fuel combustion.
- Increase the emission of volatile organic compounds from plants and vegetation that contribute to the formation of ozone.
- Increase formation of ground-level ozone.

Higher temperatures contribute to increased pollution from fossil fuel combustion as a result of electricity generated to run air conditioning. Extreme heat may result in deployment of stationary generators to reduce peak power loads, which further increases air pollution. Also, extreme heat and drought can lead to more wildfires, which create more particulate matter.

Increased ground-level ozone pollution and particulate matter associated with warmer temperatures raises the risk of potential nonattainment of air quality standards and increased air quality alerts in Minnesota. The urban heat island effect can also contribute to decreases in air quality through increased ozone formation and greater use of air conditioning. (This effect occurs because urban areas have less cooling vegetation, more heat-absorbing buildings and concrete surfaces, and greater combustion of fuels than surrounding rural areas, thereby typically leading to higher temperatures in cities.)

Exposure to particulate matter can aggravate illnesses, such as chronic obstructive pulmonary disease (COPD), cardiovascular disease, asthma and development of chronic lung disease. It is also associated with cardiopulmonary mortality. Ozone exposure can exacerbate asthma and COPD.

Air pollution disproportionately impacts certain vulnerable populations. For example, higher ozone levels may cause asthma in children. People with respiratory and cardiovascular diseases and the elderly are particularly susceptible to increases in particulate matter and ozone pollution.

## **Drought**

Although it is not yet clear how climate change will impact the occurrence of drought in Minnesota, drought and dry periods will continue to occur regularly in the state. Drought impacts availability of water for community and industrial purposes, as well as for natural ecosystems. Lack of water has significant economic and ecological effects.

Drought impacts the quality of soil, including the need to manage soils with high shrink/swell potential which can be a possible conduit for groundwater contamination. Drought also has impacts on the quality of crop yields, and leads to increased demand for irrigation, putting additional pressure on already strained aquifers and contributing to groundwater depletion. Drought adversely affects crop moisture and growth and therefore may threaten Minnesota's local food production and access (including availability and potential price increases), as well as feed and pasture supplies for livestock.

Drought has significant impacts on water quality. For example, stream flow lowered by drought reduces dilution of water pollutants, negatively affecting fish and other aquatic organisms.

Discharge periods for stabilization pond type wastewater treatment systems may need to be modified to minimize impacts on receiving waters at lower flows. Low stream flow data for waters receiving continuous discharges from mechanical facilities may need to be modified to insure that the receiving surface water quality is maintained for the local designated uses. Drought periods increase the value of exploring opportunities for treated wastewater reuse.

Drought has implications for air quality and human health. More airborne particulate matter or greater frequency of low air quality in rural areas may result from drier soil/field conditions. Prolonged drought increases risk of wildfires that increase particulate matter and reduce air quality, impacting children, the elderly, and those with a range of chronic health conditions. Wildfires also can directly cause injuries or deaths from smoke inhalation and burns. Rural populations dependent on local food sources (such as fish, wildlife, and wild plants) also experience health impacts from drought when these sources are threatened.

Drought impacts certain contaminated site remediation practices, such as phytoremediation (using plants to remediate or stabilize hazardous wastes). Irrigation may be necessary if drought-tolerant plants are not used.

## Extreme weather events

Both observed climate data as well as future projections indicate increases in very heavy precipitation in Minnesota. Heavy precipitation events, storms, and flooding have significant impacts on Minnesota's communities and ecosystems. This includes effects on water and soil resources, agriculture, drainage infrastructure, human health, stormwater management, wastewater treatment, solid waste management, and emergency response.

More frequent, heavier, or longer-duration rainfall events will increase soil erosion and runoff, thereby increasing deposition of sediment and contaminants in water bodies. Climate change has the potential to impact the quality of water and soil resources throughout Minnesota.

More frequent extreme weather events will impact Minnesota agriculture, resulting in increased runoff, fertilizers, pesticides, and sediment particularly from agricultural fields that do not have best management practices in place such as buffers, grassed waterways, and crop residue left on the fields. Field flooding can result. There are also costs to the state for disaster assistance (e.g., the Minnesota Department of Agriculture's Flood Disaster Assistance Program) which will likely increase as a result of climate change. Damage to feed crops from extreme weather also affects livestock. Greater precipitation increases challenges for applying manure in an environmentally safe manner to fields. Flooding can also cause overflow of manure storage basins which have inadequate storage capacity, leading to contamination of nearby water bodies.

Increased extreme weather events put additional pressure on the state's drainage infrastructure. There is a potential for more erosion within older drainage systems that do not have adequate outlets or erosion controls in place.

Flooding from increased average rainfall, rapid snowmelt, or localized, heavy rainfall can lead to human health impacts such as:

- Persistent mold problems in homes and businesses.
- Injury (particularly due to unsafe structures and clean-up efforts).
- Damaged health care and medical facilities.
- Stress and mental illness due to trauma, relocation, and loss.
- Death from drowning.

Flooding contaminates freshwater sources with untreated or partially treated sewage and can contaminate food crops with waste from nearby livestock or wild animals, threatening food safety. Increased water flow from a flood may disrupt municipal water supplies and sewage treatment facilities, as well as private wells and on-site septic systems. Flooding of private wells is a particularly serious public health concern, given that, in general, well owners do not test or treat their water according to health-protective guidelines.

Changes in amount, frequency, and intensity of precipitation impact stormwater management, potentially exceeding the design capacity of stormwater treatment structures or impacting future structure design. Extreme weather also adds to challenges in monitoring water quality.

Higher peak intensity rainfall events may result in bypass of wastewater treatment facilities or sanitary sewer overflows, leading to the release of minimally treated or untreated wastewater. Wastewater facility staff need to track changes in floodplain elevations as peak rainfall intensities increase so that treatment facility infrastructure can be protected during possible flood events.



There is increased need to properly clean up and manage solid waste, hazardous materials, and debris after floods, storms, and other natural disasters. More frequent occurrences of natural disasters increase the demand for disaster remediation and coordination efforts, as well as for trained staff to meet these specific needs. Design standards for permitted waste management facilities are linked by rule to certain magnitudes of storm events (i.e., 25- or 100-year storms), and as storm severity increases, this impacts facility needs. There is accelerated use of existing waste management capacity due to more waste and debris resulting from extreme weather.

Increasing numbers of floods and storms raise the need for state support and response. A greater demand for response from limited staff reduces time available for internal and external preparedness, including partnering and preparing with local units of government, state agencies, and industry. Infrastructure damage due to flooding and storms, such as flooded roads and power and communication technology outages, can disrupt emergency response in affected areas, which also has health impacts.

Populations particularly vulnerable to flooding and extreme weather events include the elderly and those without the ability to evacuate when necessary. Those living in floodplains or other areas subject to flooding are at particular risk.

### **Changing seasonality and longer term ecological changes**

Climate data indicate significant increases in the growing season, a trend that is anticipated to continue in coming decades. This impacts our state's health, economy and ecosystems.

Climate change has an impact on vector-borne/zoonotic diseases. Temperature and precipitation are key factors that influence the abundance of vector mosquitoes and ticks and the disease agents they carry. For example, the survival of blacklegged ticks (vector of Lyme disease and several other diseases) is enhanced during winters with heavy snowfall (providing insulation from cold temperatures). Warmer and wetter spring and summer seasons provide ticks with sufficient heat and moisture to allow for increased survivability and feeding activity. Additionally, warmer climates facilitate introduction of invasive species of insects and animals that carry diseases not normally observed in Minnesota.

Warmer temperatures can lengthen the allergy season, increase potency of allergens, and introduce plants with more allergenic pollen. Pollen and mold cause mild to severe allergic reactions in many Minnesotans, especially those already burdened with asthma or other respiratory ailments. Allergens can interact with air pollution to amplify their individual effects.

Changing climate also impacts endemic and exotic pests, weeds, and diseases that affect crops and livestock. Many weeds, pests, and fungi thrive under warmer temperatures, wetter climates, and increased carbon dioxide levels. Specifically, there are threats from invasive species such as emerald ash borer and gypsy moth. Some pests are already becoming established farther north, such as kudzu, aphids, soybean rust, wheat rust, corn earworm, and leafhoppers. Also, pests from other areas that travel by wind are moving closer to Minnesota—cutworms, aphids, soybean rust, wheat rust, corn earworm, leafhoppers. Certain pests are able to produce more generations per year due to longer summers, such as European corn borer and brown marmorated stinkbug.

Climate change will lead to changes in agricultural seasons and planting dates. This may present an opportunity in Minnesota, in that longer growing seasons could potentially increase productivity in some regions; however, heavier precipitation can delay planting dates or even drown crops. Changing seasons

may also lead to the potential opportunity or need for developing or using different plant varieties. Climate change amplifies the effects of existing disturbances, such as invasive species, insect pests and diseases, and land-use change in agriculture.

Climate change has broad, sweeping impacts on ecosystems that impact fish, game, and wild plant populations which are used for food. This may have a particularly negative impact on rural, Native American, and other population groups relying more heavily on subsistence hunting and wild plants.

Climate change also is altering Minnesota's natural lands and waters and the uses they sustain. Examples include:

*Lakes, rivers and streams:* Likely climate-induced impacts include earlier ice-out dates; less seasonal ice cover; increases in warmwater fish species and decreases in coldwater fish species, such as ciscoes; increased growth of algae and diatom blooms; warmer surface water temperatures in lakes; and increased variability in the seasonal and annual flow volume in Minnesota watersheds. Climate change also reduces the effectiveness of fish and macroinvertebrate indicators currently used as biomonitors to evaluate the ecological health of water bodies.

*Wetlands:* Climate change threatens to alter physical, chemical, and biological processes. Under projected warming scenarios, prairie pothole wetlands could shrink and shift optimal waterfowl breeding conditions into western Minnesota. Without major restoration efforts to replace drained wetlands in Minnesota, the prairie pothole "duck factory" could largely disappear by the end of the century. Peatlands, which are currently important carbon sinks, may begin to dry out, causing them to add carbon emissions into the atmosphere.

*Forests:* Projected climate changes will shift tree ranges, and some common northern tree species such as spruce and fir may become rare in Minnesota. Depending on whether precipitation rates increase or decrease, Minnesota's forests could either transition to communities dominated by central hardwood trees such as oaks and hickories, or forests could shrink and be replaced by grasslands. In both scenarios, climate change will likely exacerbate and intensify the effects of invasive plant species, insect pests, and tree diseases.

*Prairies:* The less than 1% of remaining native prairie will likely become drier, causing declines in mesic and wet prairie plant and wildlife species. Proliferation of invasive species will make it difficult for Minnesota's prairies to expand and take advantage of potential new habitat conditions created by a warming climate. Intensive human management, such as prescribed burns and seeding, will be necessary to facilitate new native prairie establishment.

# Minnesota State Agency Responses to Climate Impacts

Based on state agency understanding of climate trends, each agency participating in ICAT is implementing programs to address climate impacts as described below:

## Minnesota Department of Agriculture

Agriculture is highly dependent on specific climate conditions and is sensitive to the effects of climate change. The Minnesota Department of Agriculture (MDA) implements the following programs which can help to address climate impacts:

### **Encouraging best practices for conservation, sustainable use of water and soil resources, and fertilizer/pesticide use**

Adoption of recommended best management practices (BMPs) could reduce climate change impacts of water runoff, help maintain healthy soil, and minimize pests. However, severe weather events, significant climate change and seasonal shifts can lead to increased or altered nutrient/pesticide use and different farming practices, requiring new BMPs and adjustments to emergency response efforts and to monitoring and environmental protection efforts. Such changes may also present new regulatory challenges. Programs implemented in this area include conservation and BMP outreach by MDA and its partners, the Minnesota Agriculture Water Quality Certification Program, the AgBMP Loan Program, and rotational grazing technical assistance in collaboration with USDA-NRCS.

### **Supporting demonstration of sustainable agriculture practices**

The department's Energy and Sustainable Agriculture Program offers competitive grants for up to \$25,000 which are awarded to individuals or groups for on-farm sustainable agriculture research or demonstration projects in Minnesota. The purpose of the grant program is to fund practices that promote environmental stewardship and conservation of resources as well as improve profitability and quality of life on farms and in rural areas. Areas funded through these grants include conservation tillage, cover crops to reduce erosion, diversification of production, and nutrient and pesticide management including prevention of entry into water bodies.

### **Providing assistance related to extreme weather events**

MDA's Flood Disaster Assistance Program offers financial assistance to help with losses incurred by flooding. The Department also works to promote all-hazards preparedness for rural communities. MDA also coordinates a Livestock Investment Grant Program, which includes financial assistance for producers who have suffered a loss due to a natural disaster. Producers may also apply through this program to invest in equipment that will make their livestock more resilient (such as sprinkler systems or fans for use in heat waves).

### **Preventing the spread and increasing awareness of pests and invasive species**

The mission of the department's Pest Detection and Response Unit is to prevent new pests from arriving and establishing, with a focus on pests that could cause harm to terrestrial plants. Efforts include prevention, early detection, and rapid response. MDA also participates in the MN Cooperative Agricultural Pest Survey (MN CAPS) to survey for new and emerging plant pests (e.g., insects, nematodes, plants, fungi, bacteria, viruses, etc.) that may harm agricultural or natural systems. MDA also participates in the State Survey Committee, which is an interagency group of plant health experts, to identify pest survey priorities for the state, based on the likelihood of pests invading the state and causing economic or environmental

harm. Education and outreach to stakeholders and the public about invasive species is another important component of this program.

### **Monitoring and incident response to weather-related impacts from agricultural practices**

The MDA Monitoring and Assessment Unit, Fertilizer Management Unit, and Pesticide Management Unit monitor and report on the impacts to surface water and groundwater from nonpoint sources of nutrients/pesticides and sediment. Increasing pesticide and fertilizer use coupled with a lengthening growing season, increasing pest impacts, and the changing nature of weather events will put pressure on monitoring resources to assess the effects of climate change. With changing weather patterns, storm intensity and potentially greater agricultural chemical use come new challenges and responsibilities for the Incident Response Unit and the Inspection and Enforcement Unit, as storm-related spills become a greater threat.

## **Minnesota Department of Commerce**

The Minnesota Department of Commerce plays a significant role in making Minnesota more resilient to the threats posed by our changing climate. In the area of climate adaptation, Commerce maintains the state's energy emergency plan, coordinates with Minnesota's utilities on restoration of service during or after emergencies, including weather-induced outages, and deploys a Consumer Response Team to assist with disaster recovery situations through its Insurance Division. Commerce also is actively collaborating with the National Association of Insurance Commissioners in 2013 to survey Minnesota insurance companies on their preparation for climate change.

Commerce serves as the lead entity to coordinate resources and information between state agencies that have responsibilities for matters related to energy. Climate adaptation-related activities of the department include:

### **Energy reliability**

- Modeling long-term energy needs under changing economic and environmental conditions, including changes in climate.
- Monitoring utilities' generation, transmission and distribution plans to assure that energy reliability is maintained.
- Coordinating activities with regional and federal agencies responsible for assuring reliability in the electricity sector, such as the Midwest Independent System Operator (MISO), the Midwest Reliability Organization, and the North American Electric Reliability Organization.
- Monitoring supplies of liquid fuels (petroleum, biofuels) to assure that adequate supplies are maintained.

### **Energy emergency planning**

- Creating in-house expertise at the state level on energy assurance planning and resiliency, focusing on critical infrastructure interdependencies, cyber security, energy supply systems, energy data analysis, and communications.
- Coordinating the Minnesota's utilities on restoration of utility service during or after a weather-related emergency.
- Developing new, or refining existing, Energy Assurance Plans to incorporate response actions to new energy portfolios, including Smart Grid technologies.
- Revising appropriate state policies, procedures and practices to reflect the Energy Assurance Plans.

- Developing and initiating a process or mechanism for tracking the duration, response, restoration and recovery time of energy supply disruption events.
- Training appropriate personnel on energy infrastructure and supply systems and the content and execution of energy assurance plans.
- Conducting energy emergency exercises (intra and interstate) to evaluate the effectiveness of the energy assurance plans.

#### **Consumer response team**

- Distributing information, answering questions, working with insurance companies on claims.
- Helping individuals make informed decisions after storm damages a home, vehicle or property.

#### **Planning and data analysis**

- Coordinating with the Minnesota Pollution Control Agency to produce an annual report on greenhouse gas emission trends.
- Evaluating impacts of climate change on insurance investments through participation on the National Association of Insurance Commissioners' Climate Change and Global Warming Working Group.

#### **Energy efficiency**

- Administering the federal Weatherization Assistance Program to help low-income families make their homes energy efficient, which can increase adaptation to extreme temperatures.
- Assuring that electric and natural gas utilities offer cost-effective energy efficiency programs for their customers with a goal of reducing electric usage by 1.5% annually, which can help to address peak electric loads in periods of extreme heat.

## **Minnesota Department of Health**

The potential impact of climate change on public health is of rising concern. While there are known, effective public health responses to many of these impacts, the scope, timeline, and complexity of climate change challenges are unprecedented. Critical gaps remain in the resources, programs and expertise in Minnesota's public health system to address the consequences of climate change on public health. The Minnesota Department of Health (MDH) is beginning to address these gaps and build the state's capacity to adapt to climate change and its implications on human health through several different programs.

#### **MN Climate & Health Program**

- **Helping Minnesota's public health system plan for climate change:**
  - Facilitated the State Community Health Services Advisory Committee (SCHSAC) Climate Change Adaptation Workgroup (consisting of local public health directors and local elected officials), which made recommendations to MDH and local public health for incorporating climate change into local planning processes. Final report *Assessment of Health and Climate Preparedness* was approved by SCHSAC:  
[http://www.health.state.mn.us/divs/opi/pm/schsac/wkgrp/2011/climatechange/docs/2012-05\\_f\\_assessmentpreparedness.pdf](http://www.health.state.mn.us/divs/opi/pm/schsac/wkgrp/2011/climatechange/docs/2012-05_f_assessmentpreparedness.pdf)
  - Developed an example heat vulnerability assessment, and provided two trainings in collaboration with the MN Center for Health Statistics and the MN Environmental Public Health

Tracking Program on climate change/extreme heat data tools and resources for local public health to use in developing their community health assessments.

- **Providing tools, trainings and education to public health professionals and the public on the health impacts of climate change:**
  - MDH launched the MN Climate & Health Program website with subpages on particular topics, including water quality and quantity, extreme heat events, air quality, vector-borne diseases, and planning tools & data: <http://www.health.state.mn.us/divs/climatechange/>. The website serves as a communication vehicle with the public and also provides access to resources and tools. The Program also maintains a listserv that has over 650 subscribers and routinely distributes timely and topical information.
  - MDH developed the Minnesota Extreme Heat Toolkit, which contains materials that a public health planner or emergency manager can use to plan for extreme heat, including a draft response plan: <http://www.health.state.mn.us/divs/climatechange/extremeheat.html#toolkit>. MDH provided training on extreme heat preparedness to over 80 local elected officials, emergency managers and local public health.
  - MDH developed and released six climate and health training modules: Climate Change and Public Health 101; Extreme Heat Events; Water Quality and Quantity; Air Quality; Mental Health; and Agriculture and Food Security. Training modules are posted at: <http://www.health.state.mn.us/divs/climatechange/communication.html>
  - Presented information on MDH's program, tools, resources and trainings to over 1,000 people at nine national conferences and webinars, and six state/regional conferences and webinars.
  - Partnered with Twin Cities Public Television (*tpt*) to create a documentary examining climate change impacts on the daily life of Minnesotans, especially related to health impacts. Two programs, the MN Climate & Health Program and the MN Environmental Public Health Tracking Program, developed program content and provided topic expertise. The documentary will highlight the impact of climate change on our day-to-day lives, especially through the lenses of sports, recreation and farming. The purpose is to engage middle-school children, their families, teachers and coaches and empower them to adapt to Minnesota's changing climate. The program will air on the *tpt MN* and *tpt LIFE* channels in April 2014.
- **Identifying vulnerable populations to climate change and health impacts:**
  - Conducted a statewide climate change vulnerability assessment that addresses the climate change areas of extreme heat, air pollution, vector-borne disease, flooding and drought. The vulnerability assessment mapped the location of climate hazards and the populations vulnerable to the climate hazards. The final report will be available on the Program's website at the end of 2013.
  - MDH worked with local public health agencies to jointly develop maps of vulnerable populations for extreme heat for three counties and three cities. MDH also developed statewide maps of vulnerable populations to extreme heat events with a corresponding data table broken down by County subdivisions, which is available on the Program's website.
- **Reviewing comprehensive planning and environmental review processes in MN to plan for public health and climate change:**
  - Launched Healthy Places website: <http://www.health.state.mn.us/topics/places/> with information on tools for incorporating health and climate change into comprehensive plans, environmental review, and health impact assessments (HIAs).



- Reviewed 53 comprehensive plans for public health and climate change indicators and wrote two reports: *Healthy Planning: A Review of the Seven County Metropolitan Area Developed Community Comprehensive Plans*, and *Healthy Planning 2: Incorporating Local Policies and Strategies on Health and Climate Change into Comprehensive Plans*. Findings were presented to the Metropolitan Council and are being considered for future regional planning efforts.
- Created a suite of healthy planning tools that includes strategies for creating climate resilient communities: including the *Minnesota Healthy Planning Training* and the *Minnesota Healthy Planning How-To Guide*. Training was presented at the American Planning Association (APA) MN chapter's annual conference in 2012. Reports and planning tools can be found at: <http://www.health.state.mn.us/topics/places/plans.html>.
- Assessed the environmental review process in MN and wrote report: *Incorporating Health and Climate Change into the Minnesota Environmental Assessment Worksheet (EAW)*. Recommendations from the report were presented to the Environmental Quality Board. Training on incorporating health and climate change into the EAW was presented at the APA MN chapter's annual conference in 2012. Report and training can be found at: <http://www.health.state.mn.us/topics/places/review.html>.
- **Fostering new partnerships to plan for the public health impacts of climate change:**
  - Co-facilitates the Climate & Health Syndromic Surveillance System Workgroup, which has over 40 people participating from North America, including Canada & the Centers for Disease Control and Prevention.
  - Participates on the Minnesota Interagency Climate Adaptation Team (ICAT).
  - Participates on Climate Adaptation Partnership (CAP) facilitated by the University of Minnesota.
  - Participated on the Steering Committee to update the Minneapolis Climate Action Plan. <http://www.minneapolismn.gov/sustainability/climate/index.htm>.
  - Participated in international meetings with North Dakota, Manitoba Health, Health Canada, the Public Health Agency of Canada, and CDC to discuss ways of collaborating across borders to prevent morbidity and mortality associated with climate change.
  - Partnered with a national team of public health researchers from CDC and practitioners to produce the manuscript: *An Evidence-Based Public Health Approach to Climate Change Adaptation*.

### Minnesota Environmental Public Health Tracking Program

- Provides data on a variety of health and environment topics related to climate change such as: air quality, asthma, chronic obstructive pulmonary disease, drinking water quality, heart attacks, and heat-related illness. Heat-related illness data, for example, are being used to inform efforts to protect vulnerable populations for extreme heat events. Learn more about available data at MDH's data portal: <https://apps.health.state.mn.us/mndata/>.

### Vector-Borne Disease Program

MDH has an extensive vector-borne disease program. The program performs the following activities that may relate to climate change:

- Monitors the number of cases of each vector-borne disease (i.e., mosquito and tick-transmitted disease) over time and space within the state.
- Collects field surveillance data (e.g., tick infection prevalence with various disease agents) to determine how vector distribution and infection prevalence changes over time and space.

- Disseminates disease prevention information to the public, medical providers, high-risk groups, and other health agencies.
- Conducts vector-borne disease research. In particular, the program has efforts to describe new or emerging disease agents, changes in endemic disease patterns, and the burden of vector-borne diseases on society.

## **Asthma Program**

The MDH Asthma Program has been involved in a number of activities related to climate change and respiratory/allergic disease.

- The Program staff serves on a multi-state collaborative, the State Environmental Health Indicators Collaborative (SEHIC) of the Council of State and Territorial Epidemiologists (CSTE), that has developed a suite of indicators related to climate change <http://www.cste.org/?page=EHIndicatorsClimate>, including a pollen indicator that states can use to track changes in the length of pollen seasons, pollen levels and pollen types over time.
- The Program provides technical reviews of materials, including those related to climate change, that reference allergies and asthma.

## **Emergency preparedness and incident response to weather-related incidents**

The MDH Office of Emergency Preparedness helps prepare public health and healthcare for all types of hazards, including natural disasters and weather-related impacts. More specifically, the Office provides support for the following activities:

- Providing tools, resources and trainings to individuals, local public health departments, hospitals and other health care delivery services to develop emergency preparedness plans.
- Designing and implementing emergency preparedness exercises with partners, using weather-related scenarios that include ice storms, blizzards, unusually heavy snowfalls, drought-induced wildfires and forest fires that impact air quality, flash flooding, straight-line winds and tornadoes.
- Providing situational awareness, coordination of resources and risk communications in times of an emergency.

## **Protecting Minnesota's sources of drinking water**

Rivers, lakes and groundwater aquifers currently used for drinking water supply may be affected by climate change through disruption of the long-term equilibrium of the hydrologic cycle. Declining recharge, increasing demand, competing uses, and changing land and water uses may affect the quality and quantity of drinking water sources and present challenges for public water suppliers as well as private well owners. MDH Drinking Water Protection and Well Management staff are actively engaged with their regulated communities and agency partners in managing potential future changes in a manner that protects human health and safeguards our drinking water sources. Specifically, staff provide technical assistance to public water suppliers in planning for source water protection, conducting assessment and monitoring of water quality; and supporting implementation of source water protection plans.

## **Partnering with public water suppliers**

About 80% of Minnesotans are provided with drinking water in their homes by a public water supply. MDH partners with public water suppliers to ensure safe and sufficient drinking water through a series of

strategic safeguards. Water treatment challenges arising from climate change include water quality changes (algal-related taste and odor issues) that require increased use of granular/power activated carbon and increased levels of total organic carbon due to extreme flows, drought, and run-off. MDH provides technical assistance to public water suppliers in order to increase their technical, financial, and administrative capacity to manage change. MDH strengthened the resilience of public water systems by hosting a workshop on the Minnesota Water/Wastewater Agency Response Network, and providing training on emergency preparedness and incident response. MDH also encourages the development of green water infrastructure by awarding grant money through the State Drinking Water Revolving Fund Loan program.

## **Minnesota Department of Natural Resources**

Minnesota's climate is changing. Strong evidence suggests that recent global climate changes are increasing growing seasons, shifting the ranges of plant and wildlife species, and increasing the occurrence of fires, insect pests, disease pathogens, and invasive weed species. With accelerating climate change, the Minnesota Department of Natural Resources (DNR) will need to evaluate its most basic management work. We will need to incorporate future climatic conditions into our decisions. DNR will base management decisions on the best available science and adapt its actions as new information is developed.

**Departmental-wide adaptation actions include:**

### **Climate and Renewable Energy Steering Team (CREST)**

DNR chartered this team and its five work teams to provide agency-wide coordination and guidance on climate change and renewable energy strategies. CREST produced its 82-page Management Foundations report ( <http://files.dnr.state.mn.us/aboutdnr/reports/conservationagenda/crest-ccref.pdf> ) in August 2011 to synthesize information on climate and energy trends, and to provide a framework that integrates mitigation and adaptation for protecting Minnesota's natural resources. This document was featured in two DNR staff "Conservation Science Chats" in 2012.

### **Adaptation Strategy Project**

DNR's Climate Change Adaptation Team is completing the identification and evaluation of adaptation strategies for forests, wetlands, open systems, and aquatic systems this summer. Adaptation strategies for water resources will be identified in early 2014.

### **Regional Staff Climate Change Adaptation Workshops**

The adaptation team conducted four regional climate change adaptation workshops for a total of 200 staff in September 2013. These workshops advanced DNR's implementation of climate change adaptation by gaining a regional perspective on proposed adaptation strategies and beginning the process of developing regional adaptation "roadmaps".

**Actions by DNR divisions include:**

#### ***Division of Ecological and Water Resources***

##### **Assessments**

- Conducted Climate Vulnerability Assessment for aquatic, open, and forested systems using panels of internal and external experts.

- Compiling information on the vulnerability of species of greatest conservation need.

#### **Planning and decision support**

- Using the U.S. Fish and Wildlife service risk assessment for invasive species to inform a rapid response plan that includes information on species that may move into the state as climate changes.
- Raising awareness of changing climate conditions and risk through local floodplain management training.

#### **Management response**

- Promoting higher standards in local floodplain and shoreland ordinances to keep development and infrastructure out of unstable/flood-prone areas, and to protect and restore the natural beneficial functions of floodplains and shoreline vegetation.
- Providing technical assistance in the design of critical facilities to provide a higher level of protection to address increased flood risk.
- Accounting for increased precipitation and changing landscape conditions in floodplain modeling and regulation.
- Promoting BMPs that protect the channel and its floodplain against changes in its watershed as a result of both development and climate.

#### **Monitoring**

- Providing climatology monitoring data important for tracking climate trends.
- Working with Division of Forestry to develop standard protocols for monitoring plots as a step towards developing permanent plots for change monitoring.
- Established 20 permanent monitoring plots in the peatlands to track changes in the system due to climatic conditions and other stressors.
- Expanded monitoring of both groundwater and surface water to help us understand these resources as an integrated system so that that stresses to the system can be better managed.

### ***Division of Fish and Wildlife***

#### **Assessments**

- Working to better understand how cisco, pike and walleye respond to thermal and dissolved oxygen gradients.
- Collaborating with UMN on North Shore streams vulnerability analysis.
- Collaborating with UW-Madison researchers to understand causes of potential fish community shifts.
- Conducted focus groups and survey of residents in 2011 in northeastern Minnesota to identify public perceptions of climate change and support for various adaptation strategies.
- Conducting moose research to investigate the causes of adult and calf moose mortality.
- Co-designing and implementing a survey of state activity on climate change via Midwest Association of Fish and Wildlife Agencies.

#### **Planning and decision support**

- Conducted climate change impacts plenary session for 300 staff and a climate change vulnerability for wildlife populations workshop for 30 staff at the May 2013 staff Wildlife School.

- Provided staff support for two National Conservation Training Center courses -- Climate Academy and Decision Analysis for Climate Change.
- Explored the social dimensions of climate change adaptation with stakeholders using structured decision making focused on one northeastern Minnesota lake undergoing many changes.

#### **Management response**

- Working with the Division of Forestry to develop a grant program for private forest landowners in regions with vulnerable cisco lakes to use forestry BMPs to improve downstream water quality.

#### ***Division of Parks and Trails (PAT)***

#### **Planning and decision support**

- PAT has incorporated climate change into various planning documents such as the recently completed Itasca State Park unit resource management plan and Minnesota State Parks and Trails: Direction for the Future (2011).

#### **Management response**

- The division is implementing a variety of natural resource management strategies to increase the resilience of State Park and Trail lands to climate change. As an example, the division annually controls invasive plant species on about 8,000 acres per year in order to reduce the stress on existing and restored native plant communities.
- The division has, and continues to provide, opportunities for scientists to conduct climate change research on lands administered by the division.
- The division has been working with the Operations Services Division to install a variety of renewable energy sources (solar panels, wind, wood heaters, etc.) at state park units to reduce energy use.
- New construction is incorporating increased energy conservation strategies.
- PAT spearheaded efforts in the DNR to use electric vehicles for work within units, such as at Itasca State Park.

#### ***Division of Forestry***

#### **Assessments**

- Conducting various assessments of various forest management issues that involve many factors, including climate. As tree species or native plant communities show signs of stress on a large scale (e.g. tamarack), we are conducting reviews including recommendations to share with other land managers so that they can best manage their forest lands.
- Participating in departmental climate change vulnerability assessments.

#### **Planning and decision support**

- Participating in the Northwoods Climate Change Response Framework (<http://www.nrs.fs.fed.us/niacs/climate/northwoods/>) The framework includes a detailed assessment of the vulnerability of tree species and forest plant communities as well as a decision approach and compilation of strategies that will help forestland owners determine appropriate management goals and work toward those goals in the face of climate change.
- Participating in revision of the MN Forest Resources Council Northeast Landscape Plan

( [http://www.frc.state.mn.us/initiatives\\_llm\\_committees\\_northeast.html](http://www.frc.state.mn.us/initiatives_llm_committees_northeast.html) ). The revised plan will incorporate information on climate change impacts as well as recommend management strategies that take those impacts into account.

- Incorporating adaptation strategies into DNR Sustainable Forest Resource Management Plans.
- Revising tree suitability tables to reflect anticipated vegetation shifts due to climate change. The goal is to provide foresters with additional information on which tree species would be favored in a warmer and/or drier climate.
- Developing a plan to utilize the state's forest nurseries to help protect the fitness and resilience of native forest ecosystems from invasive species and climate change.

#### **Management response**

- Supporting DNR Adaptive Forest Management Projects as demonstration areas for enhancing forest resilience to climate change.
- Using the invasive species control program to maintain and enhance forest resilience to impacts of climate change.
- Maintaining the State Tree Nursery in order to continue our seed source control program and ensure adequate supply of needed species.
- Using the Minnesota Tree Improvement Program to ensure orchard seed is adapted to a variety of biotic and abiotic conditions.
- Modeling the effects of state forest management on carbon stocks and assessing any tradeoffs with adaptation strategies.

## **Minnesota Pollution Control Agency**

The Minnesota Pollution Control Agency (MPCA) is responding to climate change impacts which affect environmental quality in a number of areas:

#### **Stormwater management**

The MPCA's Stormwater Program has been addressing the issues related to climate change adaptation since 2005 with the first issuance of the Minnesota Stormwater Manual. It advanced the concept of treating water on site, using low impact design, and volume control best management practices (BMPs). Since then, stormwater permits have advanced these BMPs, and MPCA has worked to set goals and quantify credits for using these BMPs through the Minimal Impact Design Standards (MIDS) Project. Consistent with MIDS are BMPs that can increase infiltration and reduce runoff (including green infrastructure like rain gardens, urban forestry/trees, pervious pavement, swales, etc.)

Local units of government have traditionally worked to get water off the landscape as quickly as possible. In the last couple of decades, the MPCA has started addressing pollutant and rate control. We are now beginning to address volume control. Volume control, and working to mimic natural hydrology, helps to result in less dramatic runoff events, which reduces stream erosion and scouring. Impervious surfaces are increasing faster than population growth. This increase in impervious surface coupled with larger storm events will have a significant impact on receiving waters. Stormwater capture and reuse is an opportunity to reduce runoff and reap benefits from heavier rainfalls while reducing demands on the potable water supply.

NOAA Atlas 14 updates are being utilized to more accurately reflect precipitation intensities and durations. NOAA Atlas 14 incorporates 50 additional years of data into the estimate of precipitation



intensity and durations, and could account for changes that may be related to climate change. These estimates, used as an engineering standard, are vital to ensure proper design of culverts, storm sewers, and water quality devices.

In August 2013, the reissued Municipal Separate Storm Sewer System (MS4) General Permit became effective, which regulates stormwater discharge from counties, cities, townships and other publicly owned entities in urbanized areas. The goal of the MS4 program is to prevent or reduce the discharge of pollutants to stormwater, and ultimately, surface waters. This permit's provisions will help to address problems of erosion and water pollution associated with heavy precipitation events.

### **Wastewater treatment**

MPCA reviews climate-related issues on a regular basis either due to reissuance of National Pollutant Discharge Elimination System (NPDES) permits (approximately every 5 years), or at times when the municipality is looking to either upgrade/expand the wastewater collection or treatment facilities. While reviewing the permit reissuance (or modification) or the proposed modifications to the collection system or treatment facility MPCA staff can ask that the municipal staff or their consultants review or consider climate-related concepts (changing peak flows, changing flood elevations, wastewater reuse opportunities).

MPCA encourages wastewater permittees to join MnWARN, an emergency response mutual assistance program for water utilities, in order to help them to address flood and other disaster response and recovery.

MPCA encourages wastewater permittees to explore reuse of wastewater, which can extend water supplies in drought conditions.

MPCA works with wastewater treatment plants in ways that can include infrastructure improvements to manage increasing rainfall intensities. The Clean Water Revolving Fund prioritizes financial assistance for infrastructure improvements that would fix problems such as bypassing.

### **Water quality monitoring**

MPCA conducts watershed-focused monitoring to help provide spatial resolution of stressors, and conducts a statewide random monitoring program to develop long-term trends on a large scale. Biological, physical, and chemical monitoring are integrated to develop relationships between environmental factors (including climate) and aquatic life. Biological indices for fish and invertebrates help to measure response.

### **Sustainable community assistance**

Minnesota GreenStep Cities is a voluntary challenge, assistance and recognition program to help cities achieve their sustainability and quality-of-life goals. This continuous improvement program, managed by a public-private partnership and supported by MPCA, is based upon 28 best practices. MPCA indirectly includes climate adaptation actions in its GreenStep Cities best practices, but there is opportunity to further emphasize these and for GreenStep Cities to better challenge and assist cities on adaptation actions. In addition, all of the best practices could be reviewed for climate change implications and strategies to increase community resiliency.

Launched in 2009, Minnesota GreenCorps is a statewide program of the MPCA to help preserve and protect Minnesota's environment while training a new generation of environmental professionals. This program places AmeriCorps members with local governments, educational institutions, and non-profit organizations around Minnesota, where they serve for 11 months on focused environmental projects. Minnesota

GreenCorps is currently seeking to incorporate climate change adaptation and community resiliency more explicitly in its existing and new topic areas.

Additionally, MPCA's green building program facilitates partnerships to lessen the environmental impact of Minnesota's built environment. Increasingly, resiliency is viewed as an important component of green building practice, including adaptations to the changing climate. The MPCA is working to further focus the green building program in this area.

### **Air quality**

In 2013, Minnesota completed a multistakeholder Clean Air Dialogue process with the goals of identifying new opportunities for emissions reductions, laying the groundwork for future collaboration to improve air quality in Minnesota, and preparing for potential nonattainment designations of air quality standards. Some of the options recommended through this process have potential for addressing and adapting to climate change challenges. MPCA also conducts monitoring for climate-influenced air pollutants.

### **Solid and hazardous waste management**

MPCA works with communities to collect household hazardous wastes (HHW) after disaster events, which may be one of the most important steps a local community can take to prevent chemicals from entering local drinking water supplies. HHW coordination efforts require team collaboration with various MPCA programs, including solid waste, hazardous waste, and emergency response staff. Coordination with county, city, and other local units of government is also necessary and essential following a disaster event.

## **Minnesota Department of Public Safety, Division of Homeland Security and Emergency Management**

The Division of Homeland Security and Emergency Management (HSEM) helps Minnesotans prevent, prepare for, respond to and recover from disasters among its other responsibilities. This includes efforts to reduce the risk to people and property from natural and human-caused hazards by developing and implementing long-term mitigation measures that will reduce or eliminate the severe effects of future disasters.

Minnesota's most common disaster threat is severe weather. Changes in our dominant weather patterns/climate will exacerbate that threat and we are likely to see more dramatic shifts in weather extremes. Increases in the frequency and intensity of severe weather events that HSEM is most concerned about include:

- Torrential rains and flash flooding.
- Tornadoes.
- Drought and associated wildfires.
- Ice storms with extended power outages.

Minnesota will continue to see more extreme weather events as the climate changes. Emergency managers will need enhanced plans that better address extreme weather conditions which are now seen with greater frequency throughout the state. Emergency managers need to continuously assess these threats and ensure their jurisdictions have adequate response capabilities and take mitigation measures to reduce the impacts of these evolving severe weather events.

Jurisdiction planning needs to be enhanced for a greater likelihood of ice storms and the impacts of widespread, long-duration power outages. This will include:

- Promote hazard mitigation to eligible electricity providers to reduce risk by retrofitting power lines.
- Purchasing, or identifying rental sources of, back-up power generators.
- Encouraging critical public and private facilities, as well as homeowners, to invest in back-up generators and/or emergency generator hook-ups.
- Identifying, equipping, testing, and exercising public shelters.
- Conducting public awareness campaigns on how to prepare for ice storms and power outages.

HSEM will continue to collaborate and share information with stakeholders and develop climate adaptation goals, strategies and actions plans for inclusion in the upcoming State All Hazard Mitigation Plan update due in April 2014.

## **Minnesota Department of Transportation**

The impacts of climate change on the Department of Transportation (MnDOT) are significant. MnDOT is committed to addressing climate change adaptation in our statewide vision: that Minnesota's multimodal transportation system, "is flexible and nimble enough to adapt to changes in society, technology, the environment and the economy." Climate issues will affect many functional groups within MnDOT, including Bridge Hydraulics, Water Resources, Maintenance, Design, Construction, Materials, and Freight, Rail and Waterways.

The predictions for increased frequency and intensity of rainfall events, extreme heat events resulting in decreased air quality, and an increased number of freeze/thaw cycles will affect the way MnDOT designs, builds and maintains the state's multi-modal transportation infrastructure. It will also compel MnDOT to inventory all transportation assets, assess which ones are most vulnerable to the impacts of climate change and determine a cost-effective method to mitigate and minimize those impacts. Emergency preparedness plans will be updated to reflect those lessons learned as a result of recent flash flooding events.

MnDOT is responding to climate change impacts in a number of areas:

### **Climate vulnerability assessment pilot project**

Secured funding in 2013 from the Federal Highway Administration and internally to conduct a climate vulnerability assessment pilot project in two of MnDOT's flood prone areas to better understand extreme weather impacts to the transportation assets and identify cost-effective options to make the transportation system more resilient to extreme weather-related flooding.

### **Bond-funded projects**

\$50 million of Chapter 152 bonds were dedicated to fund projects that mitigate and ensure long-term sustainability for flood prone highways. All projects must be constructed by fiscal year 2016.

### **Bridge scour-related efforts**

Scour may leave bridges vulnerable to damage and failure during flooding by undermining bridge foundations or removing the protection from the abutment slopes. MnDOT is addressing bridge scour through efforts including: managing a webpage that provides bridge scour monitoring information: <http://www.dot.state.mn.us/bridge/hydraulics/scour.html> ; developing a Bridge Scour Plan of Action for all

bridges that are scour critical or need to be monitored for scour; developing a Bridge Office Flood Response Plan; and setting up a cooperative agreement with the U.S. Geological Survey (USGS) that allows MnDOT to hire them to monitor bridges during floods.

### **Support up-to-date hydrology**

While this is not predictive for future changes, MnDOT is participating in keeping precipitation frequency estimates and discharge regression equations up to date. This included developing a cooperative agreement with the USGS where MnDOT provides funding to maintain crest gages to collect data that is used to develop stream regression equations, develop new regression equations every 10 years, develop and maintain Streamstats, and perform hydrologic studies. MnDOT also works to update precipitation frequency data, and provided funding to NOAA to help develop Atlas 14, as well as created an outreach webpage on the implementation of Atlas 14 <http://www.dot.state.mn.us/bridge/hydraulics/atlas14.html> NOAA Atlas 14 is an important new data source that fully documents the changing frequency of extreme precipitation in Minnesota, updating previous precipitation frequencies which in some cases are decades old.

### **Funding for research projects**

Provide funding for research projects, including ditch or swale infiltration to reduce runoff, roadway overtopping protection, scour monitoring implementation, drought tolerant sod, and natural flocculants to reduce total suspended solids and phosphorous discharge during extreme weather events that occur during project construction.

### **Other MnDOT climate adaptation activities include:**

- Incident management planning, including flood events and any other weather-related incidents, into MnDOT incident management plans; expanding on lessons learned from recent flood events.
- Asset management activities – developing more efficient ways to inventory our transportation assets that may be impacted by extreme climate events.
- Participation in state climate change, climate adaptation and air quality groups to better understand how climate issues directly affect Minnesota and to collaborate with other state agencies on how to minimize the impacts and increase our resilience.
- Participation in national committees facilitated by the Federal Highway Administration, American Association of State Highway and Transportation Officials and the Transportation Research Board to stay informed on transportation-related climate strategies.
- Flood Mitigation Program dedicated funding: <http://www.dot.state.mn.us/floodmitigation/>
- Partnered with the DNR and BWSR to develop flood and drought tolerant seed mixtures that are being implemented on our roadsides and stormwater pond facilities.
- Implemented Context Sensitive Solutions and Complete Streets in project planning and design, leading to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, low impact development and infrastructure conditions.

## Board of Water and Soil Resources

The Board of Water and Soil Resources (BWSR) supports “no-regret” conservation efforts. The agency strives to stay attuned to current scientific advancements and understanding of climate adaptation and to promote practices that will be resilient into the future.

BWSR’s mission is to improve and protect Minnesota’s water and soil resources by working in partnership with local organizations and private landowners. Local governments are a key line of defense with regard to climate adaptation. BWSR works in partnership with them on the following:

### **Comprehensive local water management**

BWSR supports and promotes Integrated Water Resources Management that uses a watershed approach to solving soil and water resource issues.

### **Conservation easement restoration projects**

Wetland and upland buffer restoration and protection conducted through the Reinvest in Minnesota Reserve Program (RIM) and the RIM-Wetlands Reserve Program wetland restoration partnership, Wetlands Conservation Act implementation, and Clean Water Fund projects, help to restore and maintain water retention, runoff reduction, wildlife habitat, and water quality in Minnesota. This, in turn, enhances adaptation to climate change. The ecosystem services provided by wetlands also protect against intense storm events and periods of drought. Associated upland buffers protect wetland ecosystems, and provide landscape connectivity and other functions that promote landscape resiliency.

### **Carbon sequestration**

The primary purpose of RIM-WRP, Native Buffers, and other BWSR programs is to reduce soil erosion, restore native landscapes, improve water quality and improve wildlife habitat. Carbon sequestration is a secondary benefit of many of these conservation implementation activities. Atmospheric carbon dioxide is transformed to organic carbon and is stored in soils via soil organic matter. The increase of soil organic carbon in Minnesota landscapes provides many ecosystem services that enhance our adaptability to a changing climatic regime. Soils rich in organic carbon are better able to:

- Increase infiltration rates and reduce surface runoff.
- Store water on the landscape (for every 1% increase in soil organic matter, the soil can hold an additional 22,000-30,000 gallons of water per acre to a depth of 30 inches).
- Tolerate drought conditions.

### **Restoring native vegetation for landscape resiliency**

The strategic use of native vegetation can play an important role in restoring resilient landscapes. The following are some key strategies:

- Restoring healthy natural systems where they can have the greatest landscape benefits.
- Decreasing fragmentation of intact plant communities, and creating genetic corridors.
- Restoring plant communities that fit site conditions.
- Promoting vegetation sources that fit current and expected project site conditions (in some cases this may mean selecting sources from south of projects rather than north of projects).
- Promoting individual species for projects that can handle expected conditions (such as prairie species for drought, and rhizomatous emergent plants for fluctuating water levels) and provide ecological functions.

- Promoting species diversity to increase resiliency and promote habitat for a wide range of wildlife species including pollinators.
- Use of deep rooted plants in stormwater systems to promote infiltration and groundwater recharge.
- Managing invasive species across geographic and ownership boundaries to minimize their competitive advantage.
- Conducting outreach through the BWSR What's Working webpage <http://www.bwsr.state.mn.us/grants/WhatsWorking.html> as well as other vehicles on successful strategies for installing and managing native vegetation.
- Study how our landscapes and plant species adapt in the future.
- Continue adapting our approaches based on what we learn.
- BWSR has modified vegetation guidance policies to provide project guidance.

### **Cooperative Weed Management Areas**

Weed species have a competitive advantage over native plant species due to the disturbances associated with climate change. Cooperative weed management groups are local organizations that provide a mechanism for sharing invasive species management expertise and resources across jurisdictional boundaries in order to achieve widespread invasive species prevention and control in a broader geographic region. Through limited state cost-share, BWSR has helped start up and/or support 23 CWMAs in Minnesota covering 33 counties in recent years. These cooperative groups help to control invasive species and noxious weeds on public and private lands, which in turn helps improve native vegetation areas, including species diversity, which improves climate adaptation. These efforts help make conservation lands more resilient and sustainable.

### **Soil Health Initiative**

BWSR is coordinating with the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), other agencies, and local government units to develop and accelerate a Soil Health Initiative, including connection with multipurpose drainage management, nutrient management and soil erosion reduction. Through information and education sharing, momentum is growing for this initiative. These efforts address several aspects of landscape resiliency and sustainability, including infiltration, erosion reduction, soil water holding capacity, runoff reduction, nutrient management, and agricultural productivity. Soil health best management practices such as conservation crop rotation, cover crops, no till, mulch till, mulching, nutrient management, and pest management improve soil characteristics that allow soils to adapt to a changing climate, including drought, intense storm events, and increased soil temperatures.

### **Multipurpose drainage management**

BWSR promotes and supports implementation of traditional and new conservation practices for multiple purposes, including conservation drainage and drainage water management practices. These practices help reduce runoff and nutrient loss, avoid runoff concentration, protect areas where runoff concentrates, reduce peak flows to reduce erosion, maintain agricultural productivity, improve water quality and habitat, and reduce flooding. The FY 2013 CWF Conservation Drainage Management Program included cost-share for targeted drainage water management in tiled agricultural land and for development of multipurpose drainage management plans for public drainage systems. Multipurpose drainage practices help make working lands, including artificial and natural drainage systems, more resilient to high intensity rainfall.



## Metropolitan Council

The Metropolitan Council's efforts to adapt to the effects of a changing climate and extreme weather resiliency include the following:

### **Comprehensive planning initiatives**

This year, the council launched the *Thrive MSP 2040* initiative, working with partners and the public to fashion the region's long-range plan for ensuring the region remains vital, prosperous, and competitive long into the future. As the result of strong interest expressed by the public during information sessions on the initiative, adaptation to climate change is a placeholder in the "Thrive MSP" Regional Plan, to potentially be addressed in the development of new land use plans by metropolitan communities. A Thrive MSP 2040 Workgroup Session on Climate Change Adaptation was held on June 18, 2013, and was attended by local officials and staff, as well as other agencies and organizations that expressed interest. A further discussion of climate change within the Thrive MSP 2040 framework was held in late July at the council, which included staff presentations on current work within the wastewater treatment and transit operating areas of the council on mitigation, adaptation, and improving resiliency. On August 28, 2013, the Metropolitan Council's Committee of the Whole confirmed a proposed policy direction for Climate Change Mitigation, Adaptation and Resilience as representing ideas they would like to see incorporated into the Thrive MSP 2040 long-range planning effort and related systems and policy plans. These plans include the Regional Parks and Trails Policy Plan, the Transportation Policy Plan, the Water Resources Policy Plan and the Water Supply Master Plan.

### **Regional parks**

Regional parks are developing winter recreational areas that use artificial snow to provide reliable cover for popular winter sports during drought periods. Nighttime lighting is used to extend use hours, with use and equipment fees paying for higher operation/maintenance costs. Parks are also planting native plants to replace bluegrass turf to reduce maintenance costs and improve likelihood of surviving drought. The Minnesota Department of Natural Resources Parks and Trails Division staff meets quarterly with staff from the 10 regional park implementing agencies to discuss park and trail management issues of common concern, including the topic of climate change adaptation.

### **Regional wastewater treatment system**

The council will continue to address potential effects of extreme wet weather events through reduction in excess inflow and infiltration of clear water flow in the system through long-range planning. 44 of 47 communities participating in an Inflow/Infiltration (I/I) Reduction Project over the past several years have completed over \$100 million in infrastructure improvements and eliminated millions of gallons of excess flow in the system, with three communities continuing requirements and on schedule to complete improvements. Reduction of I/I preserves needed water resources in Minnesota and avoids about \$1 billion in unnecessary capital spending for the regional sewer system. Combined sewer overflow events that were once over a billion gallons a year have been reduced to a total of 211,000 gallons over the past three years.

Dikes to protect wastewater facilities from flood have also been upgraded recently. Flood losses in the industry over the past few years contributed to an increase in property insurance premiums in 2012 and are expected to contribute to another increase in 2013.

Selected council managers with major responsibilities for wastewater treatment, water supply planning and stormwater management attended a national *Climate Leadership Academy on Adaptive Water Resource Management and Infrastructure* in June 2013 in Philadelphia. Those attending formed a council working group, including representatives of local governments and communities who also attended the academy. The early focus of the team is to identify opportunities to work together on climate change adaptation and improving resiliency to extreme weather events. One such opportunity being actively explored by team members representing a metro community, a local watershed district and council staff is a stormwater reuse project.

### **Water supply planning**

The council developed the Twin Cities Master Water Supply Plan which serves as the framework for water supply development in the metropolitan area. The goal of this plan is to ensure that regional water supplies are sustainable to support current and future generations. The plan calls for wiser use of the region's water sources, including conservation and an increase in the diversity of our regional water supply sources to increase the resiliency of our communities. Having the ability to use either surface water or groundwater will be a key component of adapting to increasing temperatures, more frequent, intense precipitation events, or extreme drought in our region.

### **Transit**

The council will continue to address potential effects of extreme wet weather events at transit properties by following best management practices of stormwater ponds, rain gardens and other stormwater retention structures. The council will continue to monitor and implement landscaping, plantings, and irrigation that better tolerate the projected climate conditions.

## **Opportunities for Interagency and Collaborative Action in Climate Adaptation**

ICAT's vision is of a resilient, economically thriving, and healthy Minnesota that is prepared for both short- and long-term climate changes and weather extremes. ICAT's goal is to encourage state agencies to identify and implement measures to assist the state and its communities in adapting to climate change. The team recognizes that building a resilient Minnesota in the face of a changing climate is a complex challenge.

While Minnesota state agencies are carrying out a wide range of activities related to adaptation (as described in this report), additional opportunities also exist for agencies to increase their work together on this issue. Agencies will continue to seek avenues of collaboration in the following seven priority areas (these are not ranked in terms of importance):

1. Building resilience to extreme precipitation
2. Implementing best practices that achieve multiple benefits
3. Protecting human health
4. Strengthening existing ecosystems by addressing ongoing challenges and risks
5. Building partnerships with local governments
6. Quantifying climate impacts
7. Conducting public and community outreach, education, and training

## 1. Building resilience to extreme precipitation

Data from observed climate trends as well as from future projections point clearly to increases in the incidence of extreme precipitation events in Minnesota. The state has experienced numerous storms and floods recently, which have resulted in significant environmental damage and costly recovery efforts. New NOAA Atlas 14 precipitation frequency estimates for Minnesota are providing valuable information for engineers and others who design infrastructure ([http://www.dnr.state.mn.us/climate/noaa\\_atlas\\_14.html](http://www.dnr.state.mn.us/climate/noaa_atlas_14.html)). Therefore, actions that can be taken to prepare Minnesota communities and ecosystems for extreme precipitation events are of particularly high priority.

Actions addressing extreme precipitation may include the following:

- Promoting low impact development/green infrastructure as consistent with stormwater best management practices.
- Collaborating on flood plain management, modeling, and regulation to design better protection strategies, stormwater management/storm sewer design, bridge sizing, risk communication, flood modeling, and hazard mitigation.
- Encouraging complete streets design that incorporates trees and vegetation.
- Restoring wetlands.
- Strengthening urban forests.
- Comprehensive urban planning.
- Supporting agency partnerships to promote the implementation of traditional and new conservation practices, including conservation drainage and drainage water management practices.
- Identifying additional opportunities to utilize NOAA Atlas 14 precipitation frequency estimates.

There is also opportunity to increase collaboration on emergency response to heavy precipitation events, including:

- Increasing participation in coordinated response with communities after extreme weather events, such as the Minnesota Recovers Task Force.
- Increasing communication and awareness around the safety hazards present during floods (water safety, injury, wells, roads, and infrastructure).
- Planning and exercising plans for municipal water supply system emergencies.
- Collaborating on emergency response efforts and hazard mitigation efforts, utilizing an all-hazards approach.

## 2. Implementing best practices that achieve multiple benefits

Given continued uncertainty in assessing future climate trends, agencies see benefits in identifying and promoting adaptation responses which will build resilience and simultaneously help the state to meet a variety of existing environmental, economic and health related goals. Greater recognition, description, and prioritization of adaptation responses with co-benefits will strengthen climate adaptation efforts in the state.

For example, water conservation efforts aimed specifically at reducing drought impacts are also associated with the benefits of reducing utility costs to households and ensuring an adequate supply of this essential resource for industry and recreation, as well as Minnesota farmers. One opportunity for conserving water concerns the potential reuse of treated wastewater, involving the Department of Natural Resources (water

appropriation), the Department of Health (eliminating/minimizing human health impacts) and the Department of Labor and Industry (proper handling based on the requirements of the plumbing code).

Another example of an adaptation practice with co-benefits is cool roofs. “Cool roofs” or “white roofs” are lighter colored and more reflective than typical black roofs, and are a climate adaptation measure that can help with addressing hotter summer temperatures. Co-benefits of using cool roofs can include reducing peak energy demand on hot days therefore improving air quality and reducing greenhouse gas emissions, increasing building energy efficiency, and helping to mitigate the urban heat island effect which in turn lowers risks to vulnerable populations from extreme heat.

In addition to promoting a wide range of available adaptation practices, when appropriate, agencies can also integrate adaptation into regulatory programs thereby further encouraging best practices and promoting co-benefits. An example is to explore the role that building codes play in encouraging or limiting innovation to address climate change, adaptation, and resiliency.

### **3. Protecting human health**

Given critical gaps remaining in Minnesota’s public health system to address the consequences of climate change on public health, this is an important area for state agency cooperation.

Specific interagency collaboration actions that can be taken include the following:

- Identifying vulnerable populations and targeting climate change assistance efforts to these populations.
- Developing tools and/or models to identify exposure thresholds for climate-sensitive health outcomes, such as heat stress.
- Monitoring and evaluating current climate change preparedness measures, including costs and benefits of interventions.
- Assisting the emergency management community with identifying and selecting effective response strategies and planning for long-term recovery.
- Identifying and developing strategies to cope with new or emerging climate impacts on health, such as food security.

### **4. Strengthening existing ecosystems by addressing ongoing challenges and risks**

Ecosystems facing challenges of pollution, habitat loss, invasive species and other threats are less resilient to climate impacts. In order to strengthen ecosystems across Minnesota, the following actions can be taken:

- Strengthening interagency partnerships that promote soil and ecological health as well as agricultural resiliency.
- Working across all agencies with water-related responsibilities to fully integrate climate change and its impacts into assessment, monitoring, planning, and management actions. This would include work implemented by state and federal agencies as well as guidance that agencies provide to local units of government, such as:
  - Integrating climate change and adaptation strategies into comprehensive local water management planning and other clean water activities.
  - Considering climate trends and projections in assessments of groundwater recharge and flux values used to set potential water withdrawal thresholds.

- Working across agencies to better understand the relationships between climate change, aquatic invasive species, and water quality.
- Fostering climate smart, cooperative management of wetland complexes, forests, and other natural communities across agency and jurisdictional boundaries.
- Development of stress-tolerant plant and animal varieties.

## 5. Building partnerships with local governments

Building community partnerships to support adaptation actions is critical, given local governments' key role in maintaining Minnesota's environment, infrastructure, public health, and economy. State agencies can support local governments by:

- Providing funding to support local adaptation measures.
- Increasing interagency collaboration on the financial and technical assistance provided to communities.
- Helping local communities to understand the impacts of climate change and what assistance is available to address these impacts.
- Supporting development of comprehensive land use and other plans, including those coordinated by the Metropolitan Council.
- Providing assistance or support for local level adaptation plans.

## 6. Quantifying climate impacts

A major challenge faced by all agencies is the lack of data needed to inform agency responses to climate change. To help address this problem, the following actions can be taken:

- Supporting interagency climate-related research projects.
- Assessing environmental costs of climate impacts.
- "Adding up" the total effects of climate change, e.g., Does climate change affect certain populations disproportionately? What are the cumulative effects of climate change in Minnesota? What are the economic impacts?
- Filling data gaps about vulnerability of and damage to various populations and communities related to climate impacts.
- Gathering more concrete data about climate change (temperature, precipitation, drought), including ongoing monitoring.

## 7. Conducting public and community outreach, education, and training

Another key gap relates to outreach and education to the public and local stakeholders. A wide variety of actions can be taken to better address this opportunity:

- Conducting outreach, education, and research to develop risk management tools and knowledge.
- Developing consistent core messages for local governments and private interests to inform them of potential risks and consequences of a changing climate that enables informed decision making.
- Developing case studies (e.g., the 2012 Northeast Minnesota floods), planning tools and outreach materials to promote effective climate adaptation strategies.
- Fostering interagency partnerships between MDH, MPCA, and others to help ensure timely, consistent, and accurate health information on air quality alert days.

- Conducting a coordinated campaign across agencies to communicate the impacts of climate change to the general public - from health to food prices to changes in animal communities (e.g., Climate Wisconsin: Stories from a State of Change <http://climatewisconsin.org/>).
- Developing an interagency public website on climate change adaptation to provide information on climate trends and projections, current and potential impacts, and also as a resource for local units of government, businesses, organizations, and individuals. The website could include campaigns and highlight examples of what is being done to adapt to climate change.
- Co-hosting training and adaptation strategy development workshops for state agency professionals and local officials.
- Collaborating between agencies to offer joint training events for state agency staff.
- Developing a broader range of authoritative educational and informational tools targeted at both state and local partners as well as local community members on the topic of climate adaptation.
- Utilizing a united approach on public outreach and education, including emergency preparedness and safety during extreme weather events.
- Creating a tool kit based on lessons learned from previous events that may be used as guidance for communities, cities and counties to adapt and prepare for the impacts of the changing climate.
- Building public and community awareness of the connections between agency activities and climate change.