Minnesota Northeast Region

City of
Chisholm

City of
Mountain Iron

City of Ranier

Population Vulnerability Assessment and Climate Adaptation Framework

March 2018

Provided by:
Minnesota Pollution Control Agency

Prepared by:
making change personal
paleBLUEdot LLC

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Acknowledgments

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Section 01

Introduction

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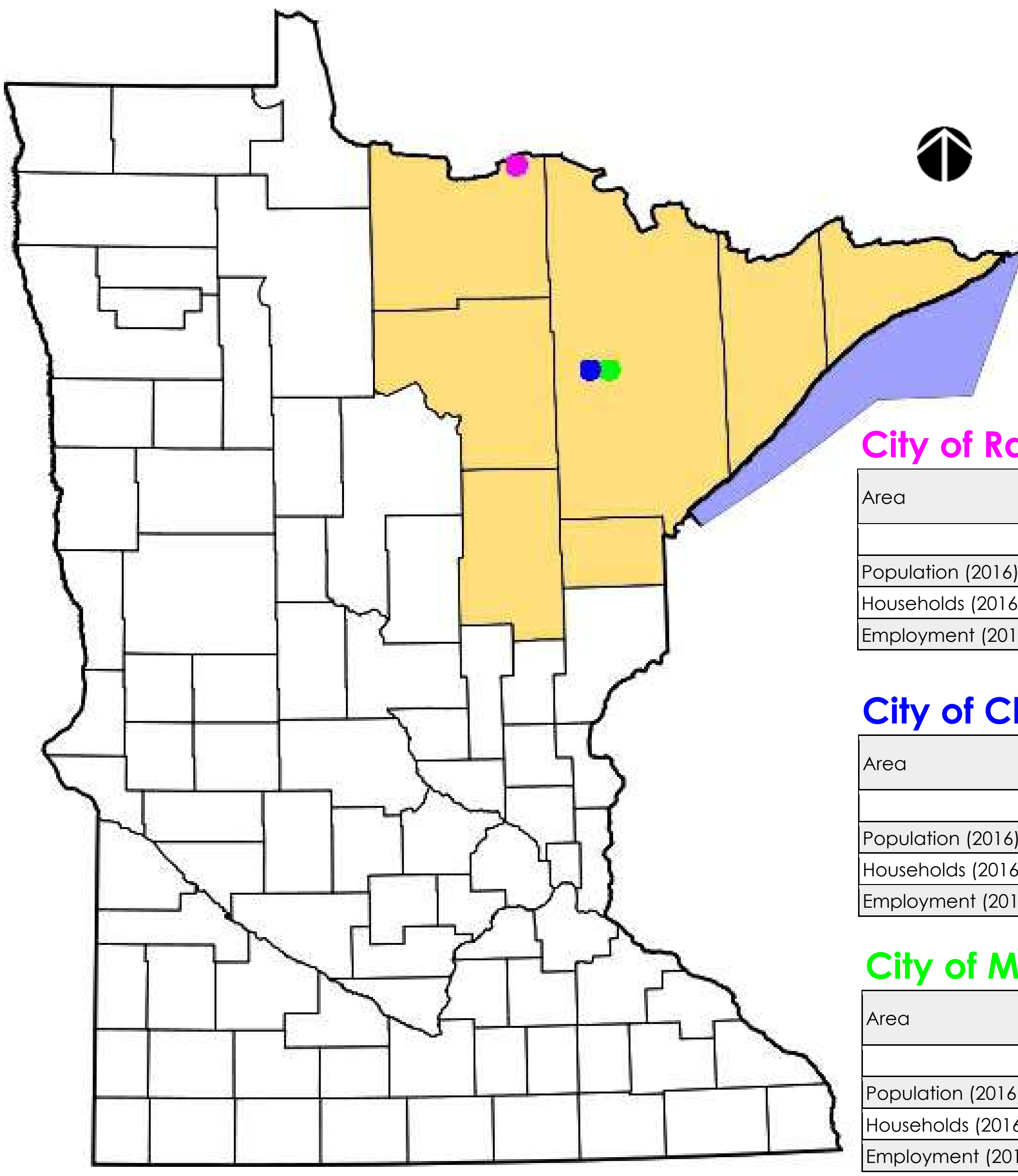
Introduction

Climate change is a global phenomenon that creates local impacts. Two changes to Minnesota's climate are occurring already: shorter winters with fewer cold extremes, and more heavy and extreme precipitation. In the future, there is relatively high confidence that those two changes will continue to increase in frequency and intensity, and also that Minnesota will begin to experience heat extremes beyond the historical variability of the climate. There is somewhat lower confidence that drought, and also tornadoes, hail and straight-line wind will increase in frequency and/or intensity as a result of climate change in the future. (Source: Minnesota Department of Natural Resources State Climatology Office)

While the science behind climate change is complex, many of the solutions to reducing impacts are already a part of Minnesota municipal government expertise. In many instances, responding to climate change does not require large scale changes to municipal operations, but simply requires adapting exiting plans and polices to incorporate knowledge about changing levels of risk across key areas such as public health, infrastructure planning and emergency management.

Incorporating this knowledge not only protects our communities from growing risk, but climate adaptation strategies can also increase jobs, improve public health and the overall livability of our communities. Strategies which strengthen resilience in time of emergency also help communities thrive even more during good times.



City of Ranier

Area	0.14 sq miles 89.6 Acres
Population (2016)	521
Households (2016)	224
Employment (2016)	210

City of Chisholm

Area	4.74 sq miles 3,033 Acres
Population (2016)	5,006
Households (2016)	2,256
Employment (2016)	2,022

City of Mountain Iron

Area	71.3 sq miles 45,638 Acres
Population (2016)	2,873
Households (2016)	1,336
Employment (2016)	1,359

What is Climate Change Vulnerability?

According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability is "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes". Vulnerability is a function of both impacts (the effects of climate change and variability on a given system or resource) as well as adaptive capacity (the ability of the economy, infrastructure, resources, or population to effectively adapt to such events and changes).

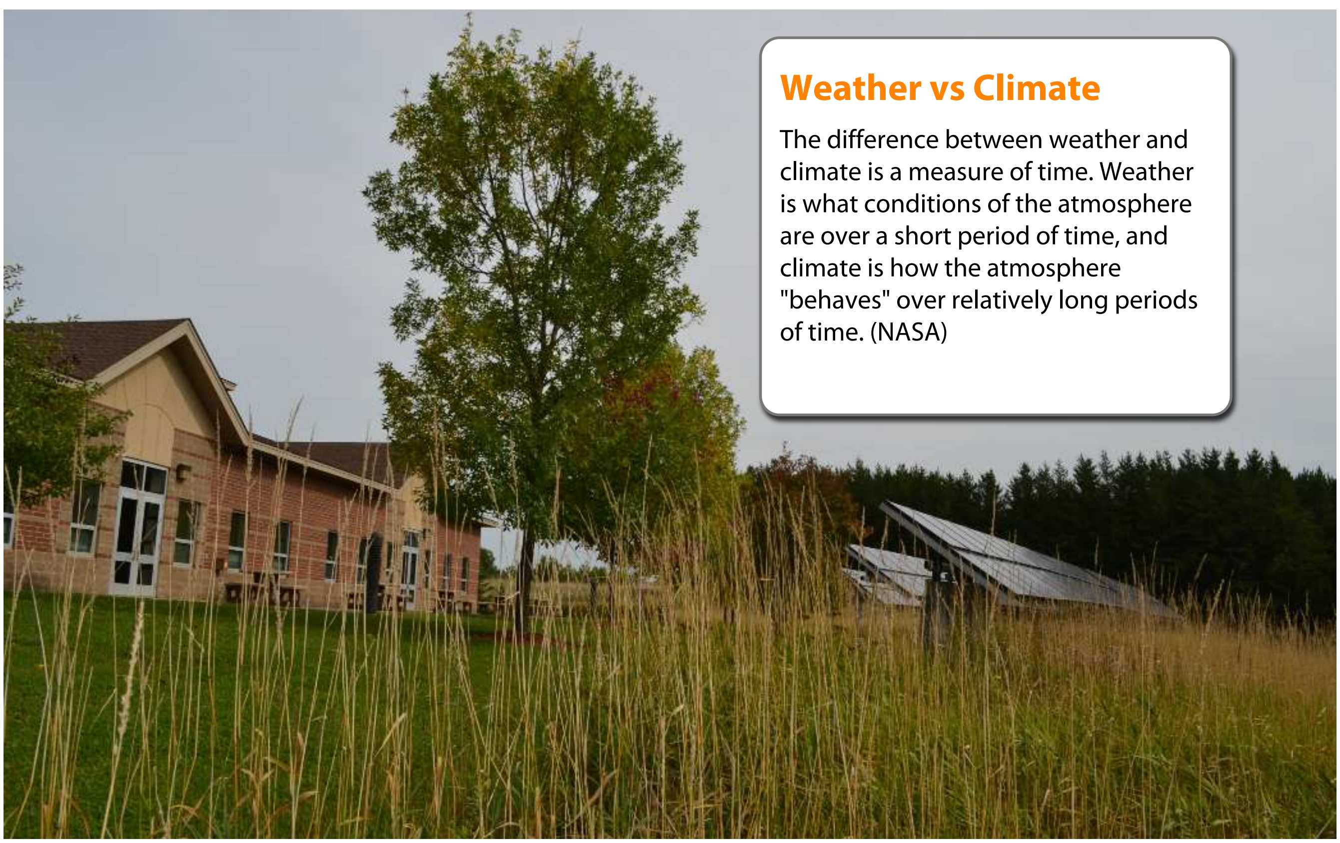
Why Study Climate Change Vulnerability?

Increases in the global surface temperature and changes in precipitation levels and patterns are expected to continue and intensify for decades, regardless of mitigation strategies currently being implemented. In turn, these changes in climate have impacts on the economy and health of local communities.

Weather and climate shape our economy. Temperature impacts everything from the amount of energy consumed to heat and cool homes and offices to the ability for some workers to work outside. Temperature and precipitation levels not only determine how much water we have to drink, but also the performance of entire economic sectors, from agriculture to recreation and tourism. Extreme weather events, like tornadoes, hail storms, droughts, and inland flooding can be particularly damaging. In the last ten years alone, extreme weather events have cost Minnesota and the Midwest $96 billion in damage and resulting in 440 deaths. (NOAA National Centers for Environmental Information).

In addition, climate conditions effect the quality of life and life safety of communities – particularly those populations especially sensitive to climate impacts. Extreme weather events linked to climate change have the potential to harm community member health in numerous ways. Rising temperatures, for example, can result in a longer-than-average allergy season, erode air quality, and prolong the stay and increase the population of insects increasing the risk of vector-borne diseases. Climate impacts also exacerbate additional economic challenges that can directly impact the ability of at-risk populations to cope with the additional risks exacerbated by climate conditions while creating more exposure to dangerous living/working conditions and poor nutrition.

Strengthening community resilience is rooted in an on-going assessment of potential vulnerabilities, anticipating potential climate impacts, development and implementation of strategies to address those vulnerabilities, and in communication and outreach to the members of the community.



Weather vs Climate

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time. (NASA)

About This Report

This Population Vulnerability Assessment and Climate Adaptation Framework has been made possible by a 2017 Environmental Assistance Grant provided by the Minnesota Pollution Control Agency. This report seeks to:

- Increase awareness of potential climate impacts and population vulnerabilities.
- Increase inclusion of climate adaptation dialogue within City planning and decision making processes.
- Strengthen adaptive capacity based on the best available information on regional climate change projections and impacts.
- Outline priority risks, vulnerabilities, and possible near-term actions.
- Lay the foundation for the development of implementation plans that consider available resources and prioritize the most effective actions from a cost and benefit perspective.
- Prevent or reduce the risks to populations most vulnerable to the impacts of climate change.

The Population Vulnerability Assessment portion of this report describes how climate affects the region today, the changes and impacts expected over the coming decades, and identifies population vulnerabilities.

The Climate Adaptation Framework sections of this report recommend Adaptation Goals as well as a Menu of Adaptation Strategies. The City can enact these climate resilience goals and strategies to reduce the impact of climate change, improve public health, and expand the local economy. Across all of these goals, there are four priority areas of action.

1) Assess vulnerabilities - especially among populations most vulnerable to climate change impacts.
2) Train and educate local officials, planners, and community organizations
3) Incorporate climate vulnerabilities into existing planning documents.
4) Develop partnerships to fund on-going research and implementation

Section 02

Climate Change In The Midwest

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Climate Change in The Midwest

According to the United States National Climate Assessment on the Midwest Region:

“In general, climate change will tend to amplify existing climate-related risks to people, ecosystems, and infrastructure in the Midwest. Direct effects of increased heat stress, flooding, drought, and late spring freezes on natural and managed ecosystems may be multiplied by changes in pests and disease prevalence, increased competition from non-native or opportunistic native species, ecosystem disturbances, land-use change, landscape fragmentation, atmospheric pollutants, and economic shocks such as crop failures or reduced yields due to extreme weather events. These added stresses, when taken collectively, are projected to alter the ecosystem and socioeconomic patterns and processes in ways that most people in the region would consider detrimental. Much of the region’s fisheries, recreation, tourism, and commerce depend on the Great Lakes and expansive northern forests, which already face pollution and invasive species pressure that will be exacerbated by climate change.

Most of the region’s population lives in cities, which are particularly vulnerable to climate change related flooding and life-threatening heat waves because of aging infrastructure and other factors. Climate change may also augment or intensify other stresses on vegetation encountered in urban environments, including increased atmospheric pollution, heat island effects, a highly variable water cycle, and frequent exposure to new pests and diseases. Some cities in the region are already engaged in the process of capacity building or are actively building resilience to the threats posed by climate change. The region’s highly energy-intensive economy emits a disproportionately large amount of the gases responsible for warming the climate.

Primary Issues for Midwest

1: Impacts to Agriculture
Increases will continue in growing seasons, likely boosting some crop yields. Increases in extreme weather, number of very-hot days, flooding, and days without precipitation will likely decrease other yields. Overall, Midwest productivity is expected to decrease through the century.

2: Forest Composition
Rising air and soil temperatures, and variability in soil moisture will stress tree species. Forest compositions will change as habitats are driven Northward by as much as 300 miles. Due to these ecosystem disruptions, the region’s forests may cease acting as a carbon sink, exacerbating greenhouse gas emission impacts.

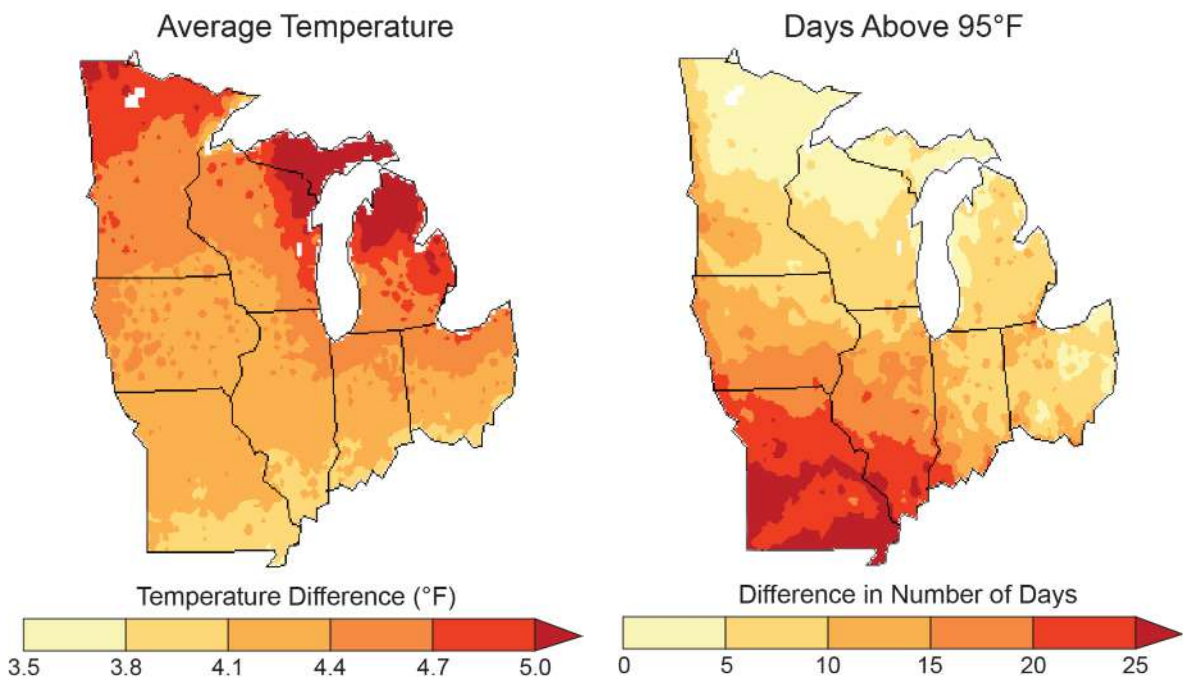
3: Public Health Risks

Increases incident rate of days over 95 degrees, and humidity are anticipated to contribute to degradations in air and water quality. Each of these will increase public health risk, especially for at-risk populations.

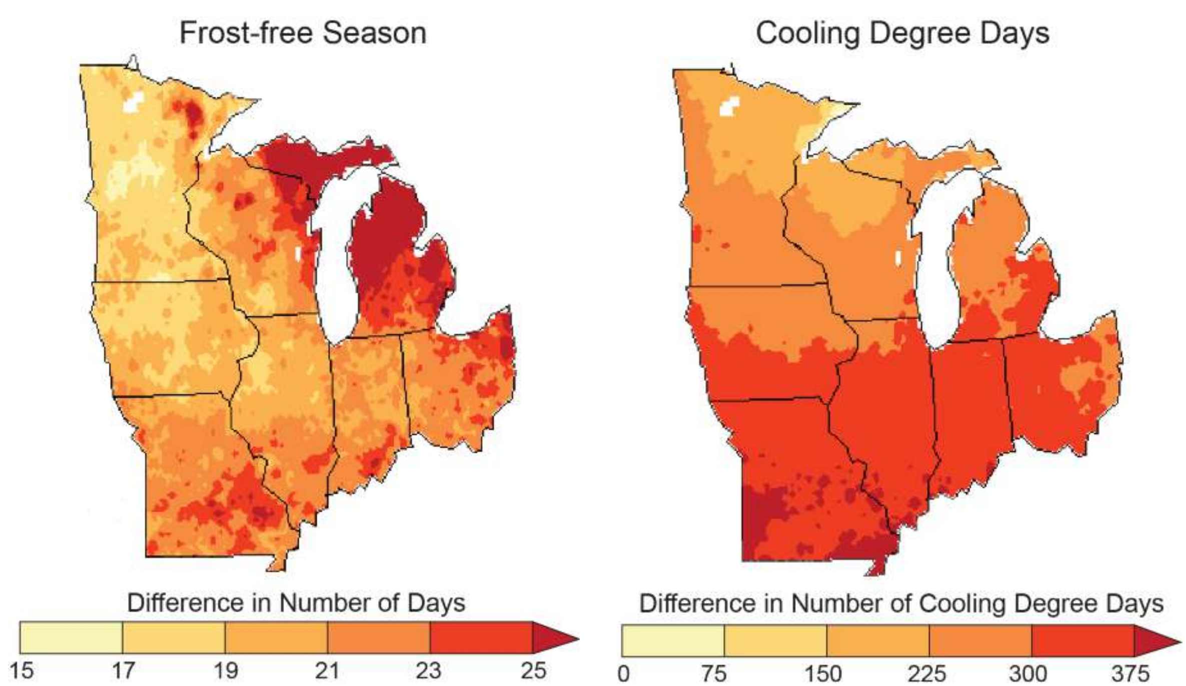
4: Increased Rainfall and Flooding
The frequency and size of extreme rainfall events and flooding has increased over the last century. In addition, the number of days without precipitation have increased. These trends are expected to continue, causing erosion, declining water quality, and impacts on human health, and infrastructure.

According to the US National Climate Assessment, based on current emissions trends, by mid-century (2040 - 2070) the Midwest region is projected to experience a climate that is…

Hotter…



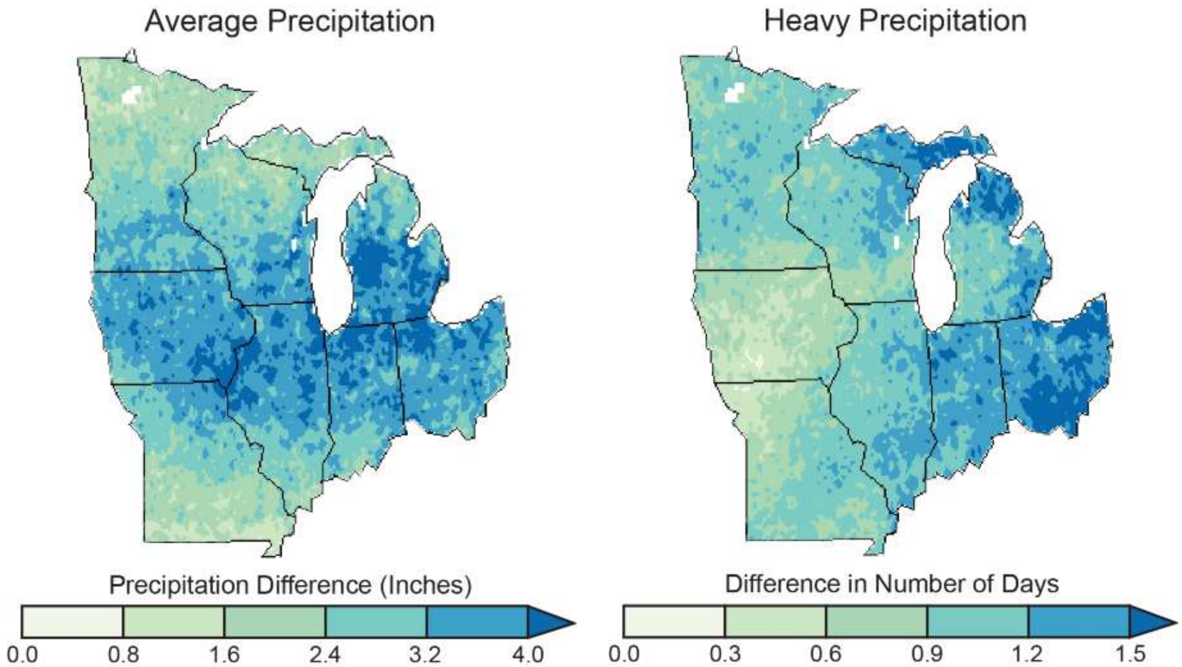
(Source: United States National Climate Assessment)



(Source: United States National Climate Assessment)

According to the US National Climate Assessment, based on current emissions trends, by mid-century (2040 - 2070) the Midwest region is projected to experience a climate that is…

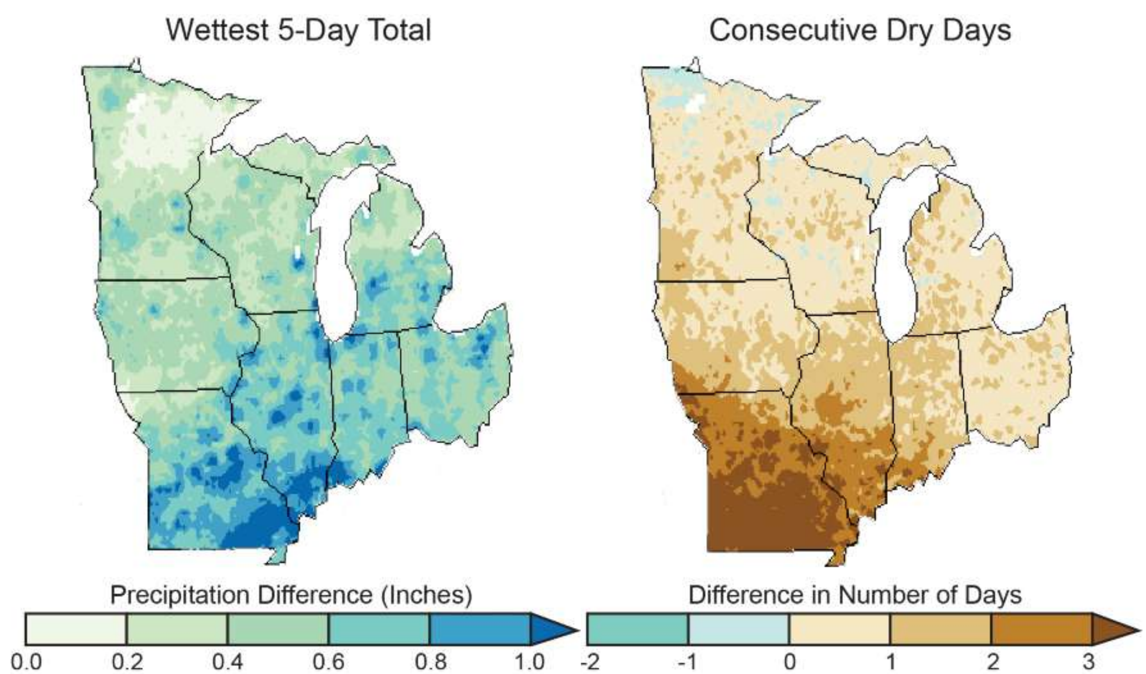
Hotter…with more rain



The Midwest can expect continued increases in annual average precipitation, the number of days with heavy precipitation, making the wettest days of the year even wetter.

(Source: United States National Climate Assessment)

…and drought



The Midwest can also expect an increase in the average number of days between rainfall events. This, combined with heavier rain events which have a higher tendency of "runoff" means that the potential for drought and reduced water tables will increase .

(Source: United States National Climate Assessment)

Section 03

Climate Change In Minnesota

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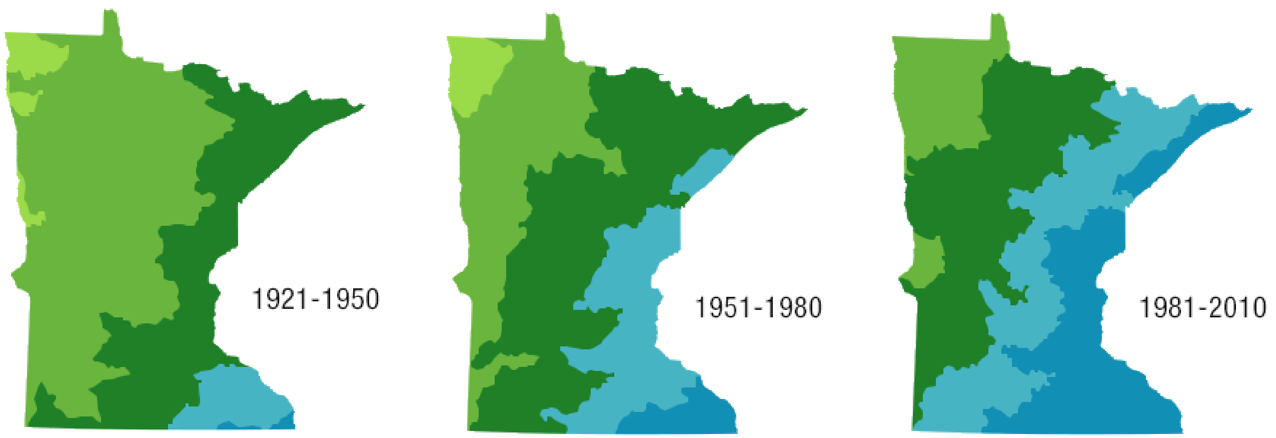
Climate Change in Minnesota

Annual Rainfall

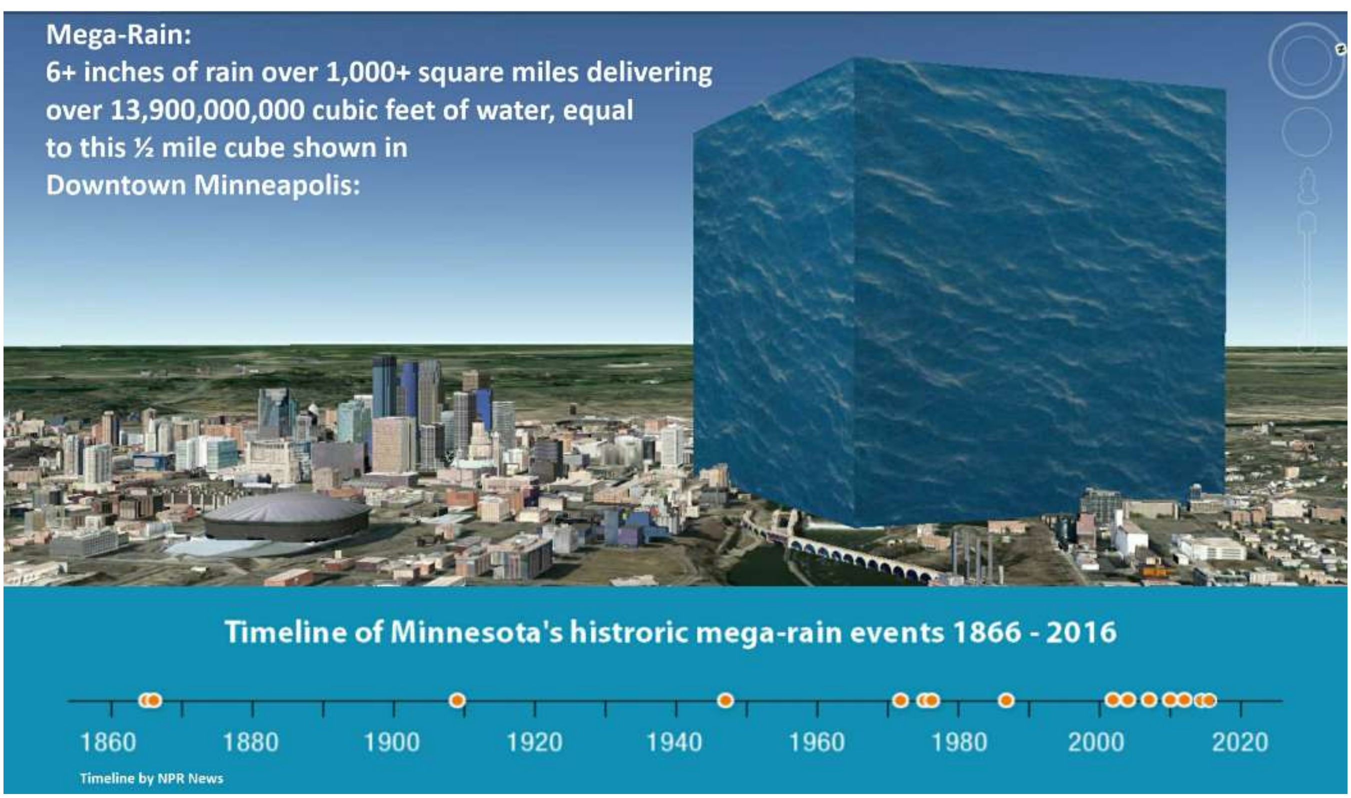
According to the State of Minnesota Climatology office, DNR and the National Climate Assessment, the majority of the State receives 5-15% more annual rainfall than a century ago, with annual totals increasing at an average rate of just over a quarter inch per decade statewide since 1895.

(Graphic: Jaime Chrismar MPRnews.org)



Mega-Rains

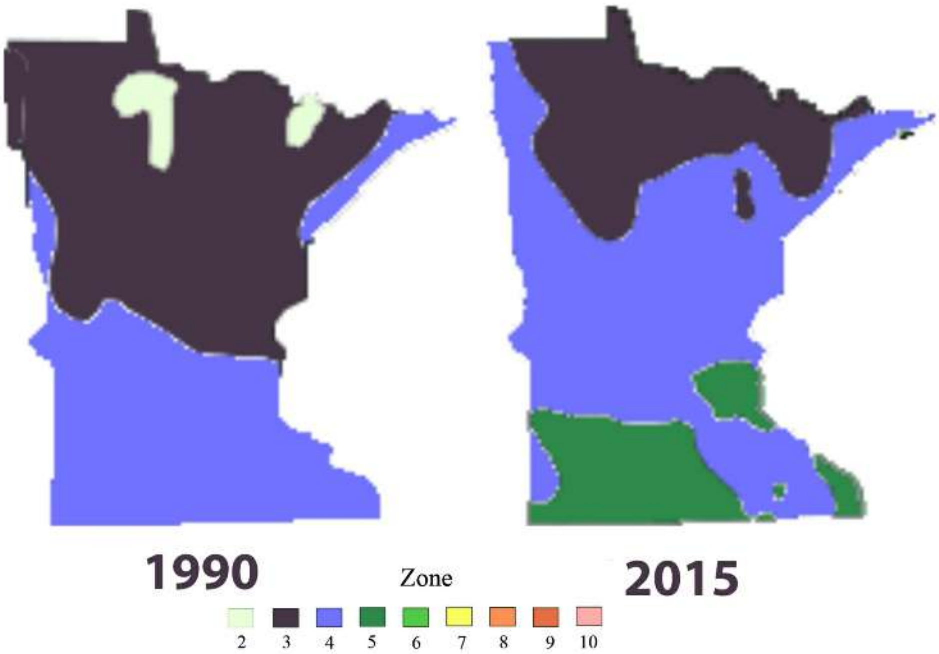
Since 1860 Minnesota has had 15 "Mega-rain" events. Seven of those storms have occurred since 2000, illustrating a increased rate of occurrence. Mega-Rain events represent a strain on storm water infrastructure as they deliver a minimum of 13.9 billion cubic feet of rainwater over a very short time.



Changing USDA Zones

In addition to warmer weather, Minnesota is experiencing less spring snow cover in April resulting in more rapidly warming soil. The cumulative effects is a shift of USDA Hardiness zones to the North. In 1990 the Cities of Chisholm, Mountain Iron, and Ranier were all Zone 3. Today Ranier remains zone 3, however Chisholm and Mountain Iron are now Zone 4. (Graphic: Arbor Day Foundation)

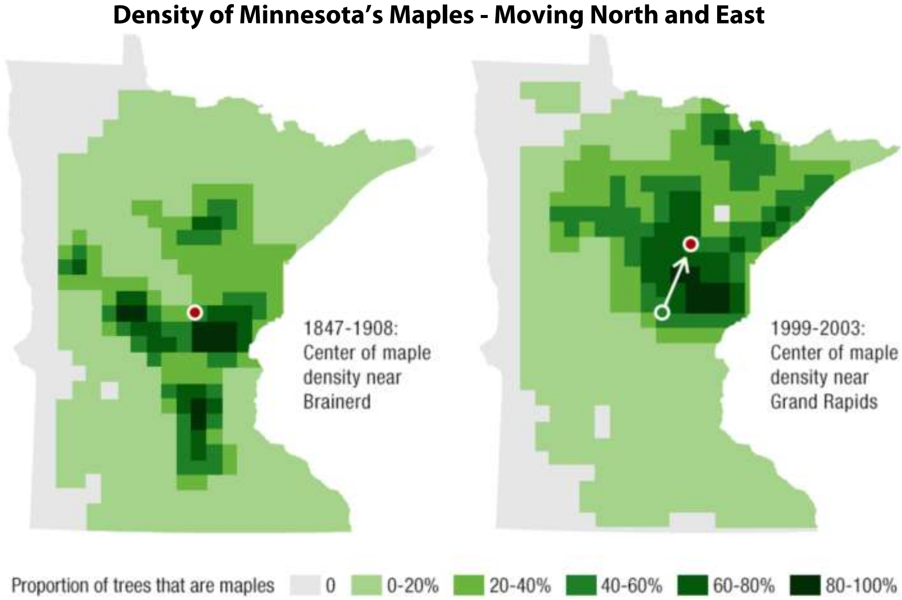
Hardiness Zone Changes in Minnesota



Trees Moving North

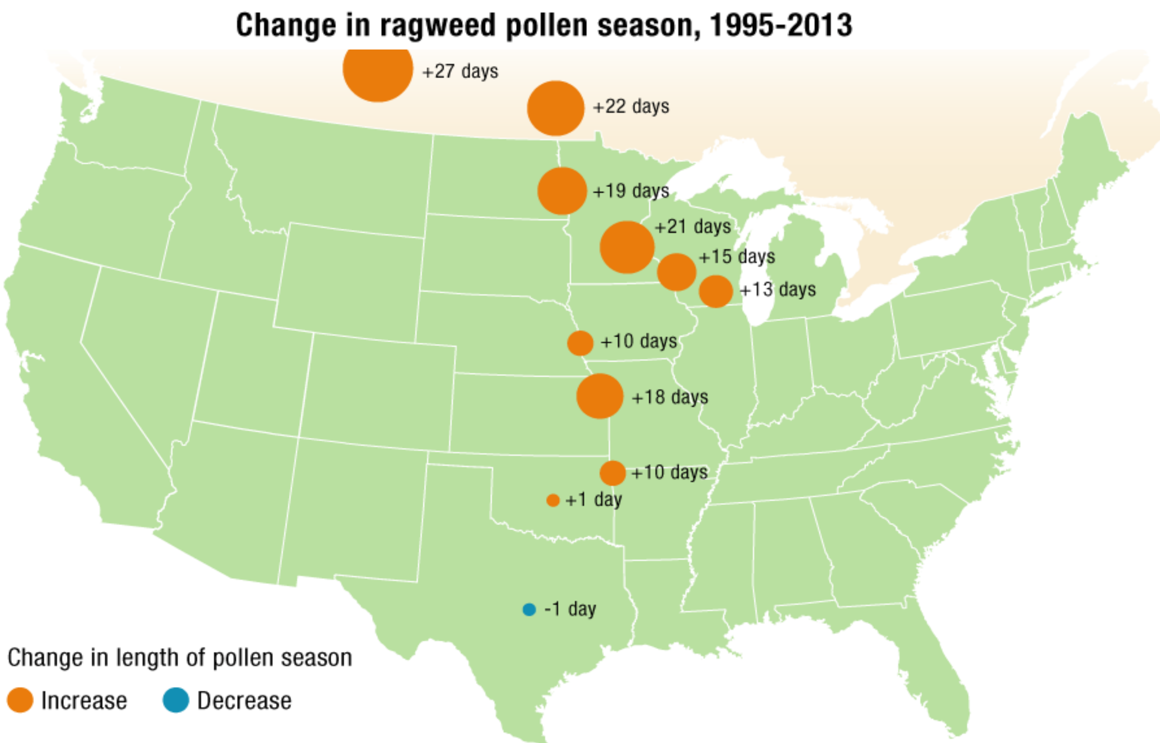
Maple forests, among other species, are moving northward, with the densest forests now occurring in the "arrowhead" section of the State rather than central region. Beyond the impacts on the ecosystem, this shift is expected to impact Minnesota's Maple syrup production in the coming years. (Graphic: Jaime Chrismar MPRnews.org)

Density of Minnesota's Maples - Moving North and East



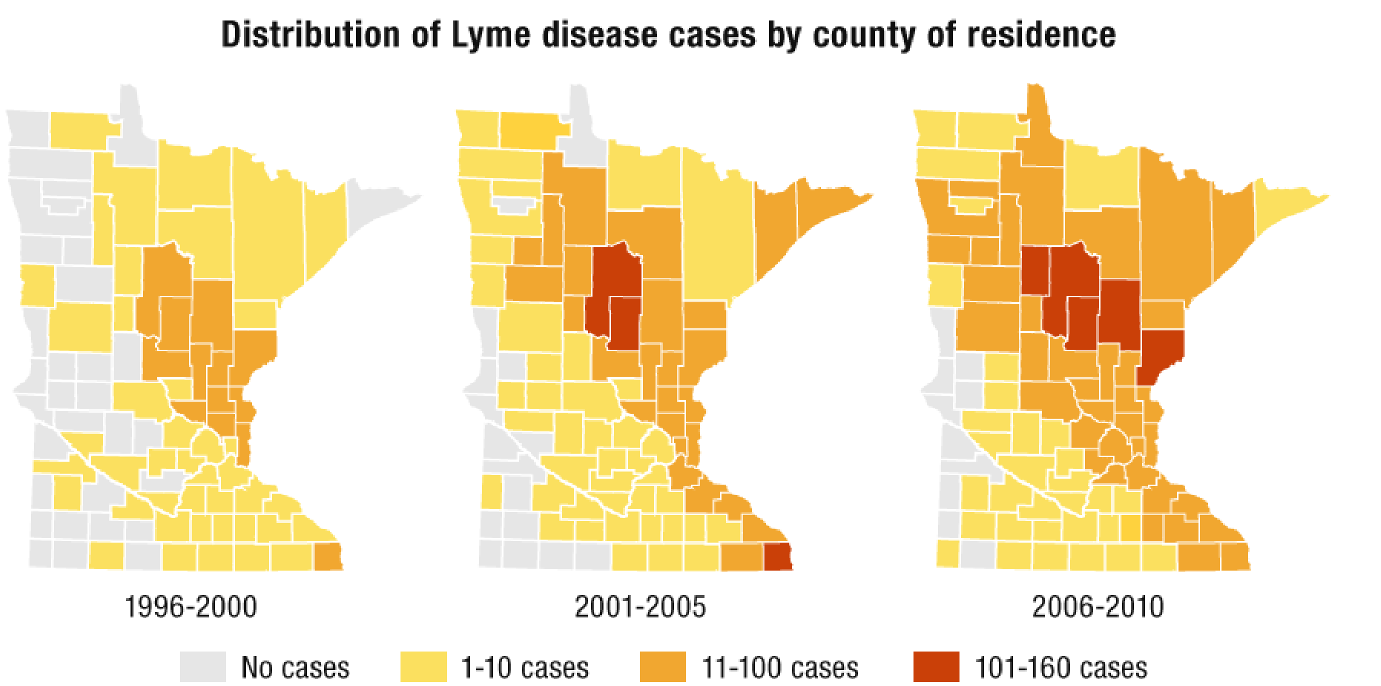
Human Allergies

With the shift in hardiness zones and increasing growing season, increases in pollen quantity and duration have been experienced and projected to continue. Beyond inflammation and irritation associated with allergic reactions, some studies indicate pollen can affect the cardiovascular and pulmonary system. (Graphic: Jaime Chrismar MPRnews.org)



Vector Borne Disease

Vector borne diseases are spread through insects and are highly sensitive to climatic factors. Warmer weather influences survival and reproduction rates of vectors, in turn influencing the intensity of vector activity throughout the year. The increase in Lyme disease cases are an illustration of the impacts of a warming Minnesota climate will have on vector borne disease intensity. (Graphic: Jaime Chrismar MPRnews.org)



Section 04

Local Climate Change

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Climate Change in the Northeast Region

The climate in the Minnesota Northeast region has already changed. From 1950 through 2015, the Region has experienced an increase in annual average temperature, an increase in the number of days above 95 degrees, an increase in the number of heavy rain events, and a decrease in the number of days below 32 degrees. Over this 60 year period, the pace of change has increased from 1980 to 2010.

Some of the most significant changes in the climate relate to variability. Climate variability can be seen in the changes in annual precipitation for the Region. Overall annual precipitation has increased slightly, however, this increase is not evenly distributed throughout the year. Winter, Spring and Summer precipitation have decreased up to 10%, while Fall precipitation has increased 13%.

(Sources: US Climate Resilience Toolkit, University of Michigan, Climate Center, Environment Minnesota Research and Policy Center, Union of Concerned Scientists)

Looking Back

From 1950 through 2015, the Minnesota Northeast Region has experienced:

Increase in annual average temperature:	1.8°
Increase in annual precipitation:	0.4%
Increase in heavy precipitation events:	37%
Increase in Days above 95:	1 day
Decrease in Days below 32:	-10 days
Increase in growing season:	9 days

Storm Weather Events

Number of Events Reported In St. Louis and Koochiching Counties:

From June 1997 to June 2007: 368 events

From June 2007 to June 2017: 562 events - an increase of 52%

Average Annual Storm Weather Economic Damage 1997-2017: $7,000,000
(source: NOAA National Centers for Environmental Information)

The Region's climate is anticipated to continue to warm through this century. Precipitation is anticipated to increase in Spring and Fall while remaining the same or decreasing in the Summer and Winter seasons. The primary changes to climate characteristics for the Region include:

- Warmer annual average temperatures with a more significant warming in winter months.
- Increase in extreme heat days.
- Increase in heavy rain fall events, with increase in flood potential.
- Increase in time between precipitation with increase in drought potential.
- Greater variability in temperature and precipitation trends.

To serve the same size population, the projected increase in air conditioning demand would require an increase in region-wide electricity consumption of : 62%

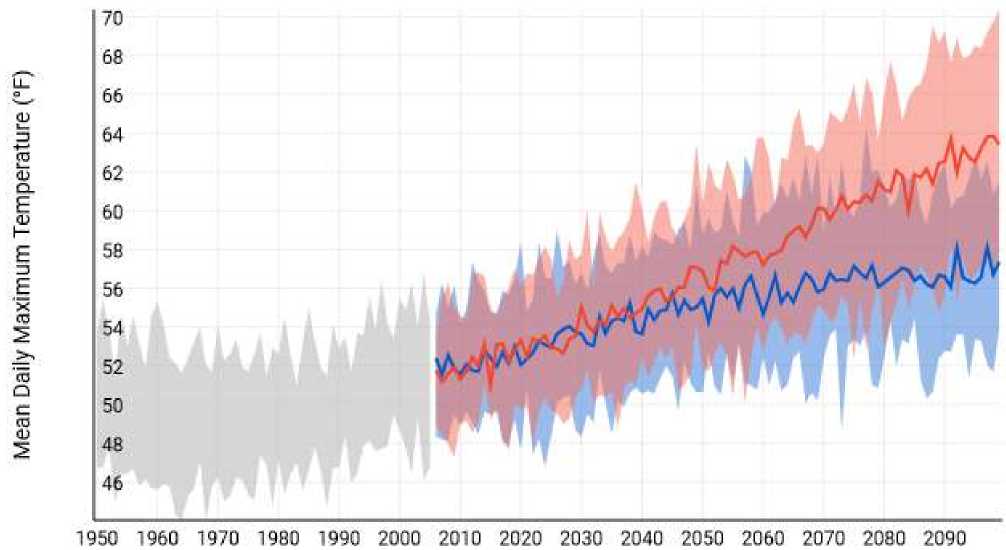
Looking Forward

By 2100, the Minnesota Northeast Region Can Expect:

Increase in annual average temperature:	3-12°F
Increase in annual precipitation:	-3 to 21% With Significant Seasonal Variation
Increase in heavy precipitation events:	30%
Increase in Days above 95:	+35 days
Decrease in Days below 32:	-50 days
Increase in growing season:	30 days
Increase in Air Conditioning Demand:	416%

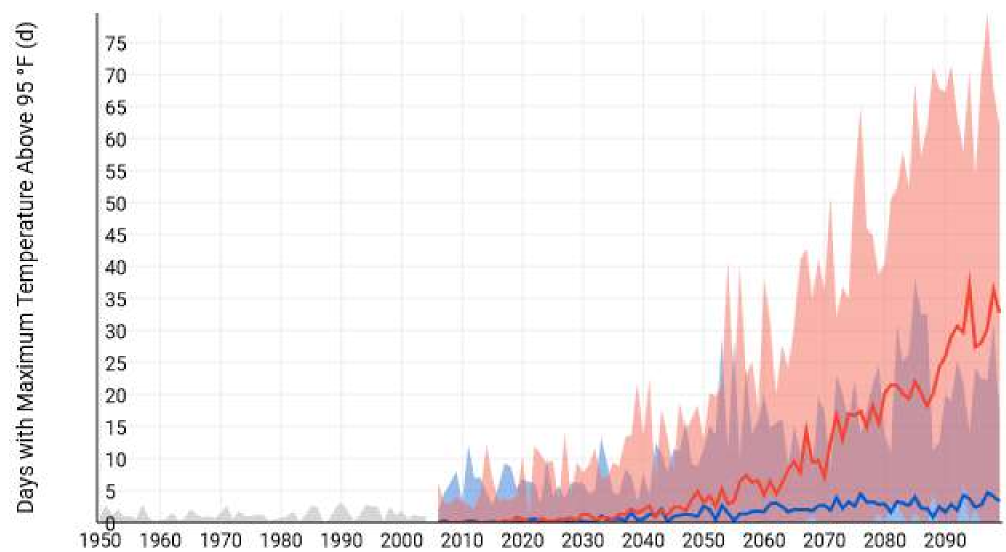
Mean Daily Maximum Temperature

This chart shows observed average daily maximum temperatures for Koochiching County and St Louis County from 1950-2010, the range of projections for the historical period, and the range of projections for two possible futures through 2100. Maximum temperature serves as one measure of comfort and safety for people and for the health of plants and animals. When maximum temperature exceeds particular thresholds, people can become ill and transportation and energy infrastructure may be stressed.



Days with Maximum Temperature Above 95°F

This chart shows observed average number of days with temperatures above 95°F for Koochiching County and St Louis County from 1950-2010, the range of projections for the historical period, and the range of projections for two possible futures through 2100. The total number of days per year with maximum temperature above 95°F is an indicator of how often very hot conditions occur. Depending upon humidity, wind, and access to air-conditioning, humans may feel very uncomfortable or experience heat stress or illness on very hot days.



(Source: US Climate Resilience Toolkit)

How To Read These Charts

Starting from the left and moving towards the right, the dark gray bars which are oriented vertically indicate observed historic values for each year. The horizontal line from which bars extend shows the county average from 1960-1989. Bars that extend above the line show years that were above average. Bars that extend below the line were below average. The lighter gray band, or area, shows the range of climate model data for the historical period – in other words, the lighter gray area shows the range of weather for the historic period.

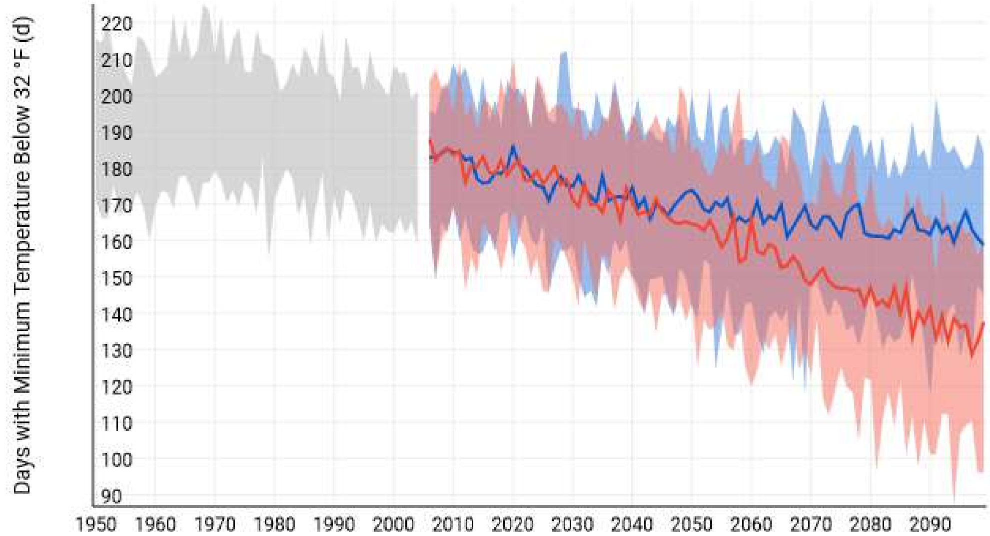
Starting from the left and moving right, the red toned band, or area, shows the range of future projections assuming global greenhouse gas emissions continue increasing at current rates. The darker red line shows the median of these projections. For planning purposes, people who have a low tolerance for risk often focus on this scenario.

The blue toned band, or area, shows the range of future projections for a scenario in which global greenhouse gas emissions stop increasing and stabilize. The darker blue line shows the median of these projections. Though the median is no more likely to predict an actual future than other projections in the range, both the red and blue lines help to highlight the projected trend in each scenario.

Days with Minimum Temperature Below 32°F

This chart shows observed average number of days with temperatures below 32°F for Koochiching County and St Louis County from 1950-2010, the range of projections for the historical period, and the range of projections for two possible futures through 2100. The total number of days per year with minimum temperature below 32°F is an indicator of how often cold days occur.

Winter recreation businesses depend on days with below-freezing temperatures to maintain snow pack. Additionally, some plants require a period of days below freezing before they can begin budding or blooming.

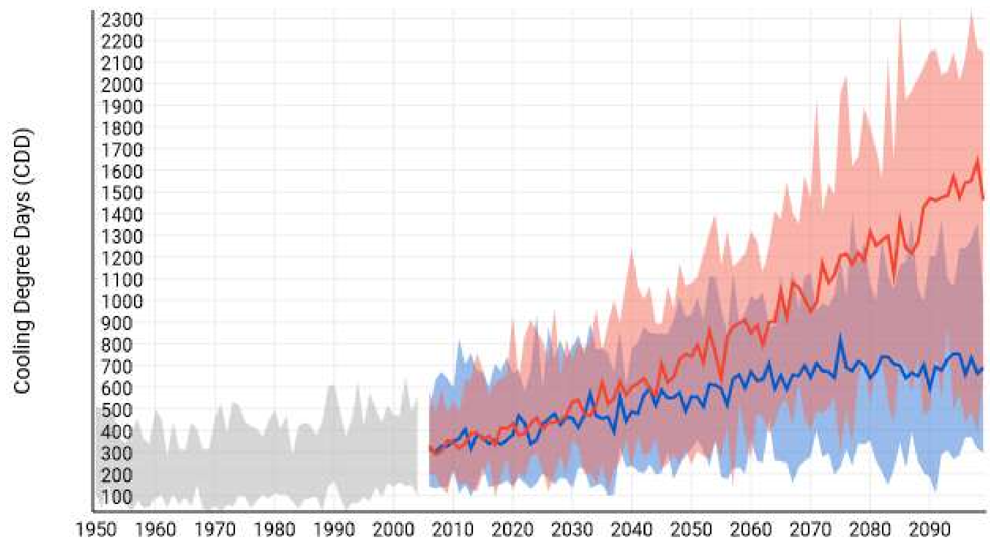


(Source: US Climate Resilience Toolkit)

Cooling Degree Days

This chart shows observed average degree cooling days for Koochiching County and St Louis County from 1950-2010, the range of projections for the historical period, and the range of projections for two possible futures through 2100. The number of cooling degree days per year reflects the amount of energy people use to cool buildings during the warm season.

Cooling degree days are calculated using 65°F degrees as the base building temperature. On a day when the average outdoor temperature is 85°F, reducing the indoor temperature by 20 degrees over 1 day requires 20 degrees of cooling multiplied by 1 day, or 20 cooling degree days.



(Source: US Climate Resilience Toolkit)

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Section 05

Region on The Move

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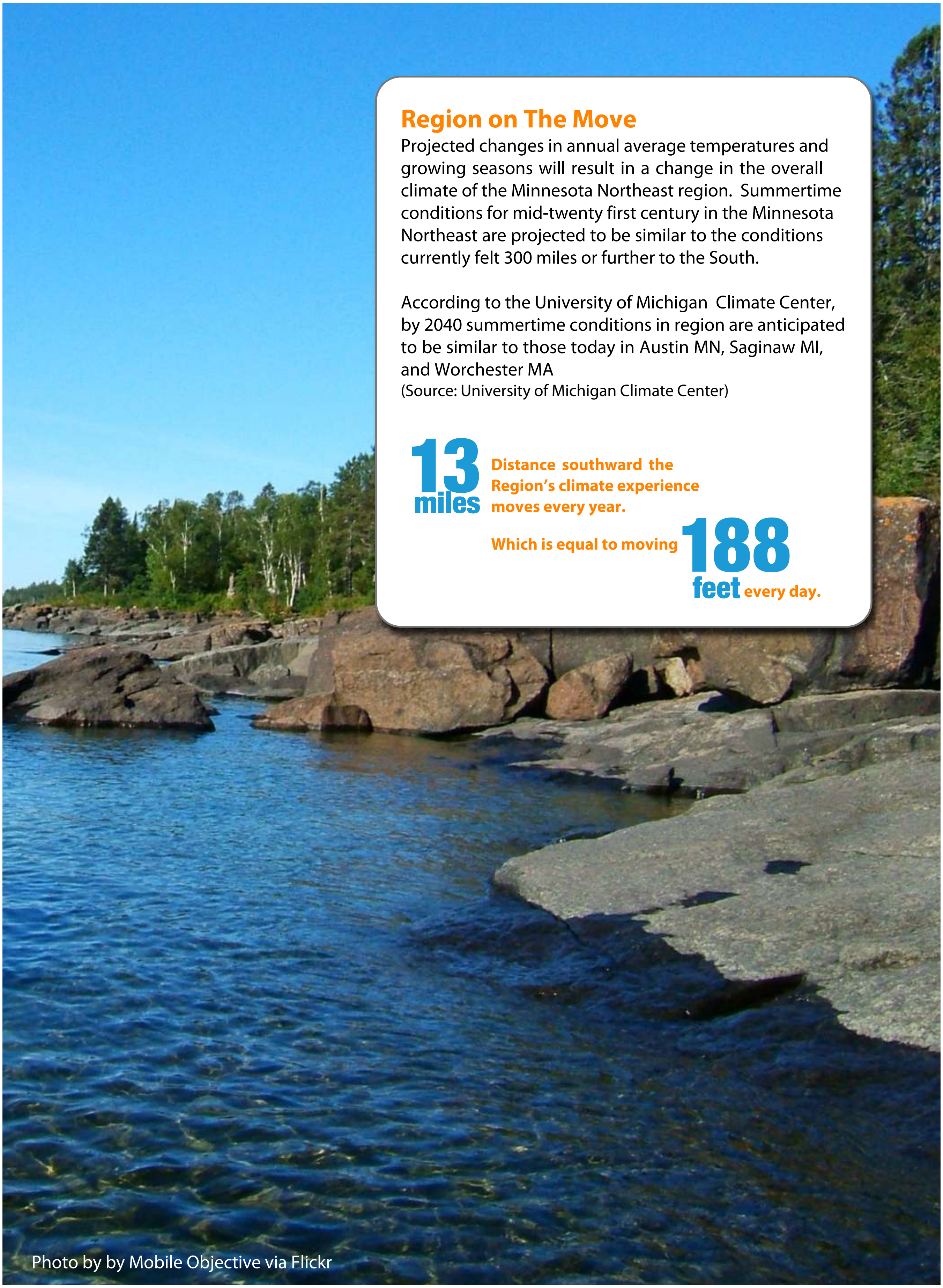


Region on The Move

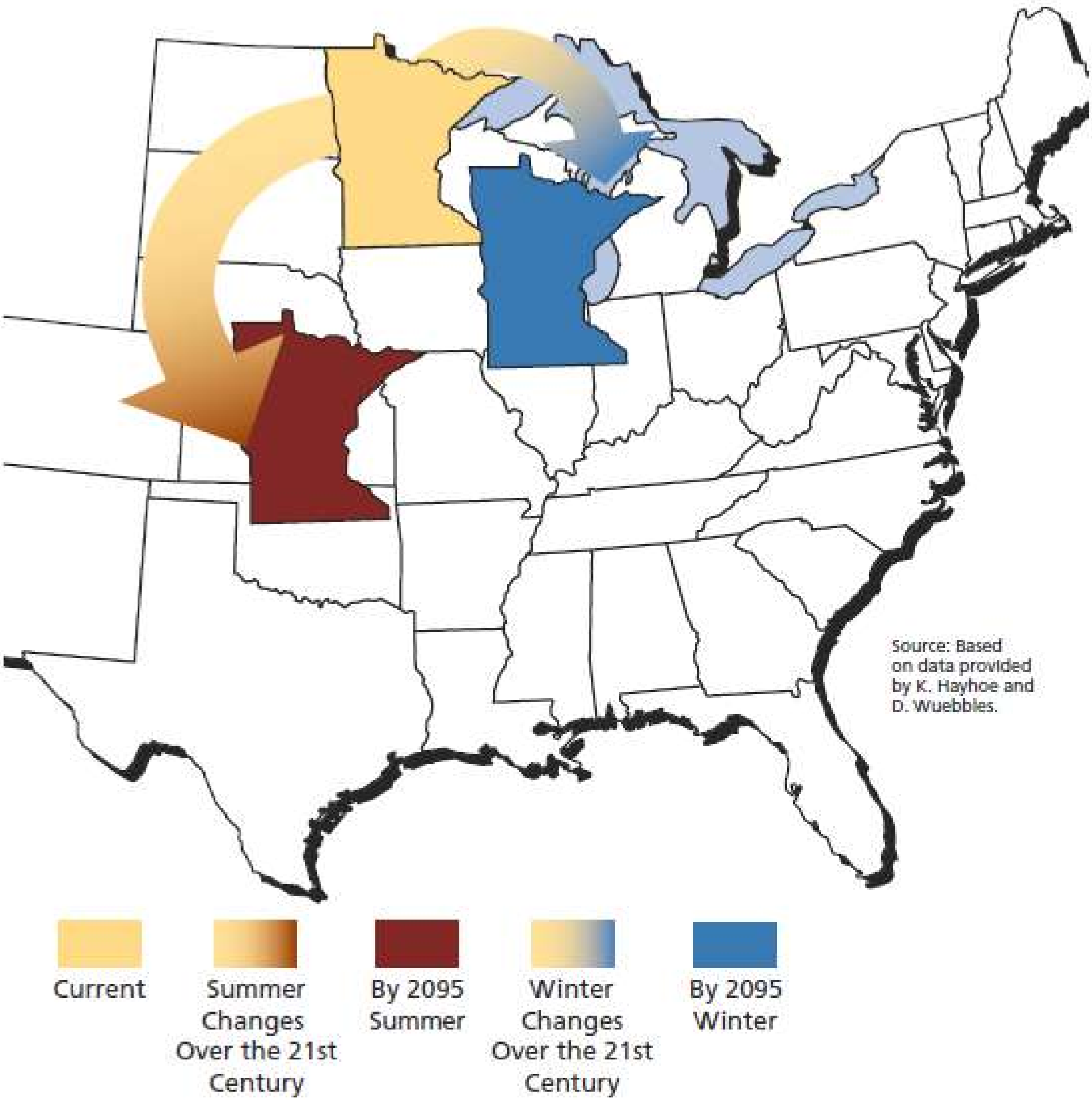
Projected changes in annual average temperatures and growing seasons will result in a change in the overall climate of the Minnesota Northeast region. Summertime conditions for mid-twenty first century in the Minnesota Northeast are projected to be similar to the conditions currently felt 300 miles or further to the South.

According to the University of Michigan Climate Center, by 2040 summertime conditions in region are anticipated to be similar to those today in Austin MN, Saginaw MI, and Worchester MA
(Source: University of Michigan Climate Center)

13 miles Distance southward the Region's climate experience moves every year.

Which is equal to moving **188 feet** every day.

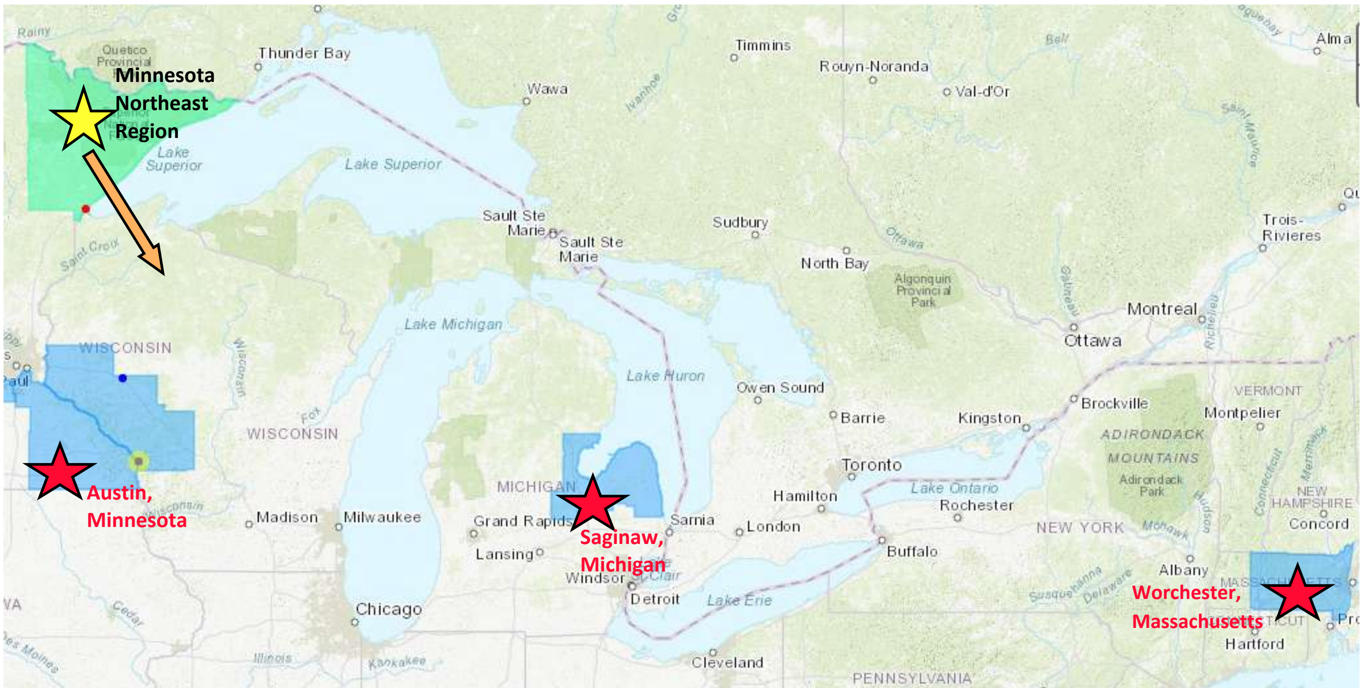
Photo by by Mobile Objective via Flickr



Climate Peers - State of Minnesota 2095

State Climate Peers experience current conditions which match the projected conditions for the State of Minnesota by 2095. As temperatures continue to rise for Minnesota into the future, the State's climate will resemble that of States to the South more and more. Climate models predict that by 2095 summers in Minnesota will be more like the current summers of Kansas, while winters will be more like current winters in Illinois.

(Source: Minnesota MPCA).



Region's Climate Peers - 2040

Region Climate Peers experience current conditions which match the projected conditions for the region in the period 2040 - 2070. On this map, all areas shaded in blue represent Climate Peers whose current summer conditions match the region's projected summer conditions by mid-century (2040-2070).

Region's Climate Peers:
Austin Minnesota
La Crosse Wisconsin
Saginaw Michigan
Worchester Massachusetts
(data from University of Michigan)

Section 06

Climate Risks to The Population

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Climate Risks to the Population

The projected changes to the Region's climate in the coming decades represent potential risks to residents. These risks are particularly acute in populations especially vulnerable to them such as children, seniors, and those with disabilities – see Vulnerable Populations section for more information. Below are some of more significant risks to the Region's population:

Extreme Weather / Temperature:

Certain groups of people are more at risk of stress, health impacts, or death related to Extreme Weather events including heat stress, tornadoes, wind storms, lightning, wildfires, winter storms, hail storms, and cold waves. The risks related to extreme weather events include traumatic personal injury (tornadoes, storms), carbon monoxide poisoning (related to power outages), asthma exacerbations (wildfires, heat stress), hypothermia/ frostbite (cold waves, winter storms), and mental health impacts.

Vulnerability to heat stress can be increased by certain variables including the presence of health conditions like diabetes and heart conditions; demographic and socioeconomic factors (e.g. aged 65 years and older living alone); and land cover (e.g. Low percentage tree canopy cover). Studies of heat waves and mortality in the United States demonstrate that increased temperatures or periods of extended high temperatures have increased heat-related deaths. During heat waves, calls to emergency medical services and hospital admissions have also increased.

According to the US National Climate and Health Assessment:

> "While it is intuitive that extremes can have health impacts such as death or injury during an event (for example, drowning during floods), health impacts can also occur before or after an extreme event as individuals may be involved in activities that put their health at risk, such as disaster preparation and post-event cleanup. Health risks may also arise long after the event, or in places outside the area where the event took place, as a result of damage to property, destruction of assets, loss of infrastructure and public services, social and economic impacts, environmental degradation, and other factors. Extreme events also pose unique health risks if multiple events occur simultaneously or in succession in a given location, but these issues of cumulative or compounding impacts are still emerging in the literature."

In addition, extreme weather can cause economic stress. Property damage, business closure, crop loss, job loss, and employment "down time" can all be caused by extreme storms, weather, and temperatures. These economic impacts can affect individuals, families, businesses, and communities at large.

Flood Vulnerability

According to the latest National Climate Assessment, the frequency of heavy precipitation events has already increased for the nation as a whole as well as for Minnesota specifically. These heavy rain events are projected to increase throughout Minnesota and are anticipated to be experienced by the City. Increases in both extreme precipitation and total precipitation have contributed to increases in severe flooding events in certain regions. Floods are the second deadliest of all weather-related hazards in the United States.

In addition to the immediate health hazards associated with extreme precipitation events when flooding occurs, other hazards can often appear once a storm has passed. Elevated waterborne disease outbreaks have been reported in the weeks following heavy rainfall, although other variables may affect these associations. Water intrusion into buildings can result in mold contamination that manifests later, leading to indoor air quality problems. Populations living in damp indoor environments experience increased prevalence of asthma and other upper respiratory tract symptoms, such as coughing and wheezing, as well as lower respiratory tract infections such as pneumonia, respiratory syncytial virus, and pneumonia.

Flooding causes economic stress. Property damage, business closure, crop loss, job loss, and employment "down time" can all be caused by extreme storms, weather, and temperatures. These economic impacts can affect individuals, families, businesses, and communities at large.

(Source: US Climate Resilience Toolkit)

Air Quality Impacts

According to the published literature, air pollution is associated with premature death, increased rates of hospitalization for respiratory and cardiovascular conditions, adverse birth outcomes, and lung cancer. Air quality is indexed (AQI) by the U.S. Environmental Protection Agency (EPA) and Minnesota Pollution Control Agency to provide a simple, uniform way to report daily air quality conditions. Minnesota AQI numbers are determined by hourly measurements of five pollutants: fine particles (PM2.5), ground-level ozone (O3), sulfur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO). The levels of all of these pollutants can be effected by climate impacts as well as the greenhouse gas emissions which are driving Minnesota's changing climate impacts.

These pollutants have a range of potential health impacts. Ozone exposure may lead to a number of adverse health effects such as shortness of breath, chest pain when inhaling deeply, wheezing and coughing, temporary decreases in lung function, and lower respiratory tract infections. Long-term exposure to fine particulate matter (also known as $PM_{2.5}$) is correlated with a number of adverse health effects. In fact, each 10 µg/m^3 elevation in $PM_{2.5}$ is associated with an 8% increase in lung cancer mortality, a 6% increase in cardiopulmonary mortality, and a 4% increase in death from general causes. The annual average of $PM_{2.5}$ provides an indication of the long-term trends in overall burden, relevant to the long-term health effects. Increased surface temperatures are known to increase ground level ozone levels. The projected Minnesota climate change impacts of extreme heat, changes in precipitation, drought and wild fires can all cause increases in fine particulate matter, which in turn, can contribute to respiratory illness particularly in populations vulnerable to them.

The US EPA designates counties with unhealthy levels of air pollution as "Non attainment" areas and areas which are on the edge of unhealthy levels "maintenance" areas. The State of Minnesota has had multiple jurisdictions designated as "non attainment" areas. However as of 2002 all of these areas have re-met federal air quality requirements and are now maintenance areas. Air quality issues currently being addressed in State of Minnesota implementation plans include Carbon Monoxide, Sulfur Dioxide, and Particulate Matter. For current and forecasted air quality throughout the state or to download the State's air quality monitoring app visit: https://www.pca.state.mn.us/air/current-air-quality

Climate change is expected to affect air quality through several pathways, including production and potency of allergens and increase regional concentrations of ozone, fine particles, and dust. Some of these pollutants can directly cause respiratory disease or exacerbate existing conditions in susceptible populations, such as children or the elderly. Other air quality issues with health considerations include allergens, pollen, and smoke from wildfires (traces sufficient to cause respiratory impacts are capable of traveling great distances). Each of these are anticipated to be increased with climate change.

Vector-Borne Diseases

Vector-Borne diseases are diseases spread by agents such as ticks and mosquitoes. The projected climate change impacts in this region are anticipated to increase the spread of vector borne diseases such as West Nile virus, and Lyme disease by altering conditions that affect the development and dynamics of the disease vectors and the pathogens they carry. Rising global temperatures can increase the geographic range of disease-carrying insects, while increased rainfall, flooding and humidity creates more viable areas for vector breeding and allows breeding to occur more quickly. In addition, Minnesota's lengthening growing season and warming winters will increase the population of vector carrying insects as well as open the region up to new species.

(Source: US Climate Resilience Toolkit)

Food Insecurity and Food-borne Diseases

According to former U.S. agriculture secretary Tom Vilsack, climate change is likely to destabilize cropping systems, interrupt transportation networks and trigger food shortages and spikes in food cost. According to the US National Climate Assessment for the Midwestern states: "In the next few decades, longer growing seasons and rising carbon dioxide levels will increase yields of some crops, though those benefits will be progressively offset by extreme weather events. Though adaptation options can reduce some of the detrimental effects, in the long term, the combined stresses associated with climate change are expected to decrease agricultural productivity."

Nutritious food is a basic necessity of life, and failure to obtain sufficient calories, macronutrients (fats, proteins, carbohydrates), and micronutrients (vitamins, minerals) can result in illness and death. While malnutrition and hunger are typically problems in the developing world, Minnesota still has significant populations affected by insufficient food resources and under-nutrition. Food can be a source of food-borne illnesses, resulting from eating spoiled food or food contaminated with microbes, chemical residues or toxic substances. The potential effects of climate change on food-borne illness, nutrition, and security are mostly indirect but represent risks, especially for vulnerable populations.

The prevalence of food insecurity can be increased by a number of direct and indirect impacts of climate change. These changes may decrease agricultural productivity, increase crop failure, and cause reductions in food supply and increases in food prices and food insecurity. Some of the climate impacts which may increase food insecurity and food-borne diseases in Minnesota include:

- Extreme weather events and changes in temperature and precipitation can damage or destroy crops and interrupt the transportation and delivery of food
- Changes in agricultural ranges, practices and changing environmental conditions can reduce the availability and nutritional content of food supplies. For example, an increase in the use of pesticides leads to a decrease in nutritional content of food.
- Spread of agricultural pests and weeds may lead to an increased use of pesticides, herbicides, and fungicides.
- Extreme weather events, such as flooding, drought, and wildfires can contaminate crops and fisheries with metals, chemicals, and toxicants released into the environment.

Water Quality/Quantity

Water risks consist of both water quality as well as water quantity issues. Water quantity issues are clearly linked to precipitation levels and timing, water variability, as well as changes in water demand. Water demand itself can be increased not only by population changes but also as a result of climate changes such as increased temperatures and time frames between rain events which increase demands on water consumption. In addition, water withdraw from ground water sources deplete aquifer capacities. Indirectly, the lack of water can cause pressure on agricultural productivity, increase crop failure, and cause reductions in food supply and increases in food prices and food insecurity. As a highly precious resource, all communities should look to increase water conservation regardless of the projected water stress levels of their immediate region, while communities in regions with a projected increase in water stress should view water conservation as a major long-term priority.

Water quality issues can be affected by climate impacts in a number of ways:

- Increased precipitation and rapid snow melt can result in flooding, which in turn increases the likelihood of water contamination from sources such as sewage as well as contaminants such as chloride, gasoline, oil, chemicals, fertilizers, and pesticides.
- Increased air and water temperatures can increase toxic algae blooms, decrease water oxygen levels, and cause changes in fish populations as well as increases in mercury concentrations in fish.
- Increased heavy rain events can result in increases in sediment, diminishing water quality.

Waterborne Illness

Waterborne diseases are caused by a variety of microorganisms, biotoxins, and toxic contaminants, which lead to devastating illnesses such as cholera, schistosomiasis and other gastrointestinal problems. Outbreaks of waterborne diseases often occur after a severe precipitation event (rainfall, snowfall). Because climate change increases the severity and frequency of some major precipitation events, communities could be faced with elevated disease burden from waterborne diseases. Increased frequency of intense extreme weather events can cause flooding of water and sewage treatment facilities, increasing the risk of waterborne diseases.

(Source: US Climate Resilience Toolkit)

Section 07

Climate Impact Multipliers

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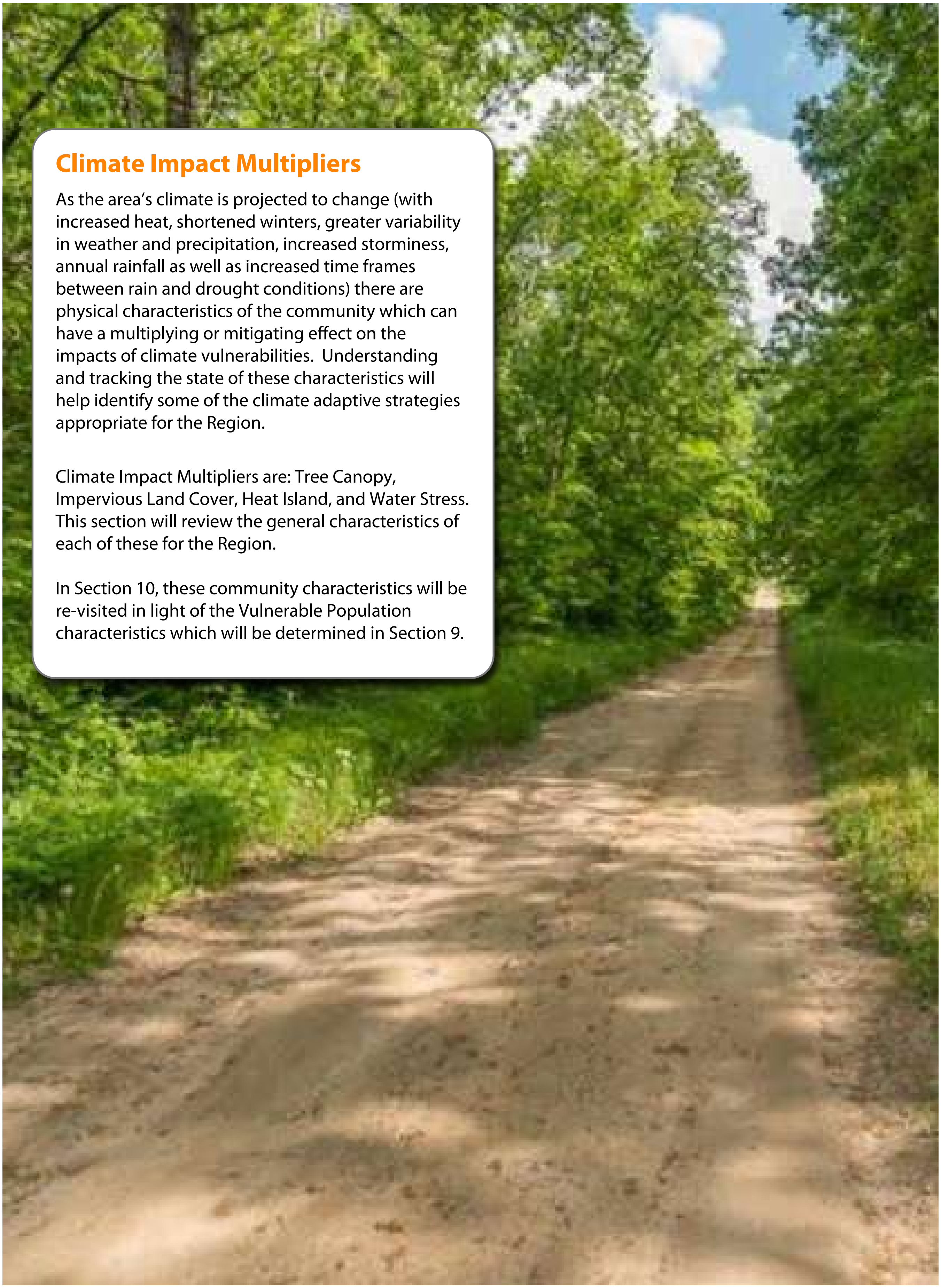


Climate Impact Multipliers

As the area's climate is projected to change (with increased heat, shortened winters, greater variability in weather and precipitation, increased storminess, annual rainfall as well as increased time frames between rain and drought conditions) there are physical characteristics of the community which can have a multiplying or mitigating effect on the impacts of climate vulnerabilities. Understanding and tracking the state of these characteristics will help identify some of the climate adaptive strategies appropriate for the Region.

Climate Impact Multipliers are: Tree Canopy, Impervious Land Cover, Heat Island, and Water Stress. This section will review the general characteristics of each of these for the Region.

In Section 10, these community characteristics will be re-visited in light of the Vulnerable Population characteristics which will be determined in Section 9.

Climate Impact Multiplier - Tree Canopy

A healthy and extensive tree canopy within developed areas can mitigate the impacts of heat stress, water impacts, increased levels of precipitation and drought, and air quality impacts. "Urban forests" deliver a range of environmental, health, and social benefits. Shaded surfaces can be anywhere from 25°F to 45°F cooler than the peak temperatures of unshaded surfaces. Trees cool communities, reduce heating and cooling costs, capture and remove air pollutants including CO_2 from the air; strengthen quality of place and local economies, improve the quality of storm water entering rivers and streams, reduce storm water infrastructure costs, improve social connections, positively contribute to property value, improve pedestrian/recreation experiences, reduce mental fatigue, improve overall quality of life for residents, and provide habitat to support biodiversity.

A healthy tree canopy mitigates heat stress in developed areas by providing direct shading on buildings and through transpiration cooling. Neighborhoods well shaded by street and yard trees can be up to 6-10 degrees cooler than neighborhoods without, reducing overall energy needs. Just three trees properly placed around a house can save up to 30% of energy use.

Region's Tree Canopy

Preliminary tree canopy coverage data is from Earth Define. Data was created with a Digital Surface Model (DSM) from first returns of the LIDAR point cloud data and bare earth elevations were removed from the DSM to derive an above ground surface model. Buildings and tree canopy were differentiated in the above ground surface model through an expert rule based classification system. Morphological filtering was used to fill small data gaps and improve the cartographic quality of the final product. For counties where the LIDAR data was not suitable as a primary data source for tree cover classification, 4 band color NAIP (National Agriculture Imagery Program) imagery was classified. The existing tree canopy proportion reported is the aggregated tree canopy area divided by the total area of each community listed.

Tree Canopy	Existing Tree Canopy
Chisholm	25.8%
Mountain Iron	40.6%
Ranier	38.5%
Duluth	38.6%
Twin City Metro:	26.9%

Planting Climate Adaptive Trees

Tree canopies in Minnesota also have some vulnerabilities associated with the current and projected impacts of climate change. Trees have a degree of vulnerability to changes in temperature ranges, precipitation patterns, soil temperature and moisture levels, and changes to winter processes and growing season length. According to the US Forest service, urban forests are very susceptible to a number of climate change factors including species invasion, and insect and pathogen attack. These stressors will make it more difficult to preserve or increase canopy cover in Minnesota communities. Conducting tree canopy studies and creating climate adaptive tree canopy policies will help Minnesota communities in adapting to these stressors.

Species projected to have negative stressors in the Minnesota Northeast region include Balsam Fir, Quaking Aspen, and Red Spruce. Extended drought conditions and warming winters may also negatively impact other species such as Birch. Finally, increased growing seasons will result in taller trees which may be more susceptible to damage in extreme weather events. Boulevard, streetscape, and parking lot trees are particularly vulnerable due to decreased snow cover, increased freeze/thaw cycles, salt exposure, and increased chemical exposure.

See Appendix 2 of this report for Climate Adaptive Tree Species by Minnesota region. Climate Adaptive Tree Species should be considered for the region's City tree planting policies and programs.

Climate Impact Multiplier - Impervious Land Cover

Impervious surfaces, including building and pavement surfaces, typically absorb solar radiation faster than pervious land coverings (grass, trees). This absorbed energy is typically retained throughout the day and then released slowly during the night. Consequently, ambient temperatures near building and paved areas are higher than grasslands and forest areas. The effects of higher levels of impervious surfaces impact not only large cities, but smaller cities and towns as well.

Increases in impervious cover can also dramatically increase the impact of so-called 100-year flood events. Typically, floods in areas of high impervious surfaces are short-lived, but extended flooding can stress trees, leading to leaf yellowing, defoliation, and crown dieback. If damage is severe, mortality can occur. In addition, flooding can lead to secondary attacks by insect pests and diseases. Some species are more tolerant of flooding than others.

Climate Impact Multiplier - Heat Island

Residents of cities and town centers are more at risk for heat-related illnesses than rural dwellers. The radiant heat trapped by impervious surfaces and buildings as well as heat generated by building mechanical systems, motorized equipment, and vehicles is known as the "Heat Island Effect" . In larger cities, heat island effects create a micro-climate throughout the metro area while occupants of smaller cities and towns can still experience higher temperatures and decreased air movement due to the effects of surrounding buildings and impervious surfaces. This heat island effect serves to increase the impact of climate change effects in developed areas of all size populations, especially those with low or intermittent tree canopy coverage. A developed area's impervious surface characteristics, and tree canopy conditions combine to exacerbate or mitigate the community's heat island impacts.

Due to the heat island effect, developed areas are usually hotter and cool off less at night than non developed areas. Heat islands can increase health risks from extreme heat by increasing the potential maximum temperatures residents are exposed to and the length of time that they are exposed to elevated temperatures. The heat island effect can make developed areas one hardiness zone warmer than the surrounding undeveloped area, allowing some more southern species to be planted. In addition to milder winters, however, heat island effects can also make summer temperatures higher, especially near dark pavements and buildings. Thus, some native plants that are becoming marginal for the area because of increased heat could experience negative effects.

The heat index is a measure of how hot weather feels. Much like wind chills combine temperature and wind to provide a figure about how cold it is in winter, heat indices measure temperature and humidity. Research indicates that in rural areas or regions with significant agriculture, crops can impact heat island effect. Unlike many plants, corn transpires, or sweats, both day and night. Keeping humidity and heat high at night means there is little chance for relief. A University of Minnesota study released in 2016 shows farm crops can increase dew points and heat indices by as much as 5 degrees, while a Northern Illinois University climatologist David Changnon released a study in 2002 showing that modern-day heat waves probably are worse than a century ago because of crops.

Minnesota Northeast Community Impervious Surface and Heat Island

The level of the urban heat island effect of a region is largely driven by the amount of impervious surface. Based on a 2006 study done by Minnesota State University and the University of Minnesota, titled "Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery", the relationship between impervious surface percentage of a community and the corresponding degree of heat island temperature increase can be understood as a ratio. The ratios vary slightly for each season. On average, a neighborhood or community's heat island effect will be 0.17 degrees F for every 1% of impervious surface area (roof tops, roadways, pavements, etc).

According to Minnesota DNR hydrology data, impervious surface in the Northeast communities likely average from less than 4% up to 10%. Portions of each community, such as business districts, are certain to be much higher.

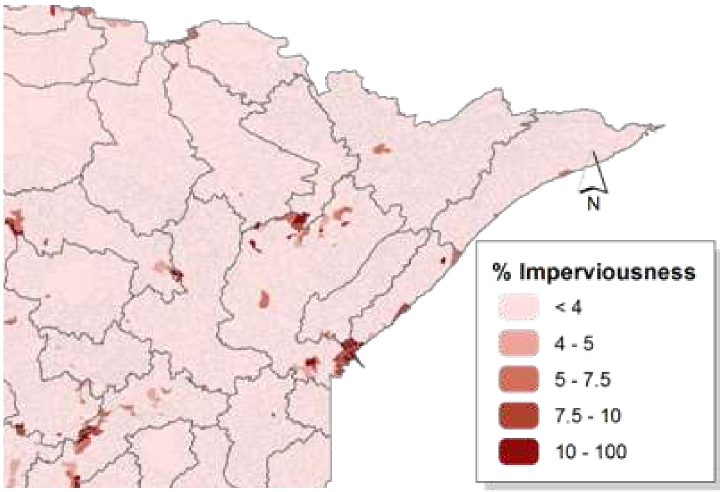
Impervious Surface Area

(University of Minnesota, 2002)

Total impervious area State Wide:	1.88%
Metro area:	13.7%
City of Chisholm:	7.5-10%
City of Mountain Iron:	4-5%
City of Ranier:	<4%

Minnesota Northeast Region Impervious Surface and Heat Island (continued)

Below is a graphic showing the impervious surface calculations by hydrology catchment within the region. Impervious coverage for the communities in the region are estimated to average from less than 4% up to 10% with certain sections like business districts likely higher. The chart to the right identifies the likely heat island effect for neighborhoods based on ranges of impervious surface land cover.



Heat Island Increase (degrees F) Based on Impervious Land Cover Percentage

4% impervious area:	0.7°F
5% impervious area:	0.9°F
7.5% impervious area:	1.3°F
10% impervious area:	1.7°F
15% impervious area:	2.6°F
20% impervious area:	3.4°F

Climate Impact Multiplier - Water Stress

Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.). Overall water risks are impacted by projected changes in precipitation levels, seasonal and annual variability, flood and drought vulnerabilities, increased air and water temperature, and water use demand and supply.

Though most of these water stress influences are direct climate impacts, we call Water Stress a climate multiplier because the existence of water stress can greatly increase the overall impact of climate conditions such as extreme heat and overall population vulnerability. It has economic ramifications for individuals as well as the community as a whole which decrease resilience. Water stress affects recreational tourism, industrial productions, jobs, and income.

Water stress in developed areas is directly affected by a community's impervious surface, tree canopy/ground cover, and heat island characteristics. Higher temperatures and impervious surface run-off lead to increases in toxic algae blooms, more rapid evaporation, reduced water retention within the water table, increased demand for irrigation, and decreased lake/river levels. A review of a community's water stress includes the overall water stress, overall water risk, and flood vulnerability.

Overall water stress measures the ratio of total annual water withdrawals to total available annual renewable supply. This number accounts for upstream consumptive use. Higher values indicate more competition among users. Increases in projected water stress into the future indicate a potential for water shortage, conflict, or management challenge.

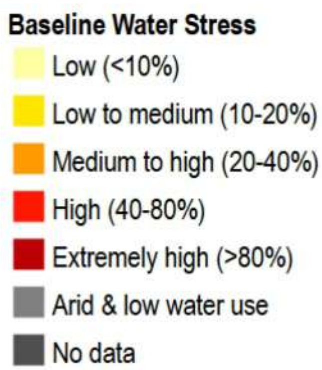
Overall water risk identifies areas with higher exposure to water-related risks and is an aggregated measure of physical risks related to quantity (flooding, drought, etc), physical risks related to water quality that may impact water availability (such as the percentage of available water that has been previously used and discharged upstream as wastewater where higher values indicate higher dependency on treatment plants and potentially poor water quality in areas that lack sufficient treatment infrastructure), and water regulatory and conflict risks.

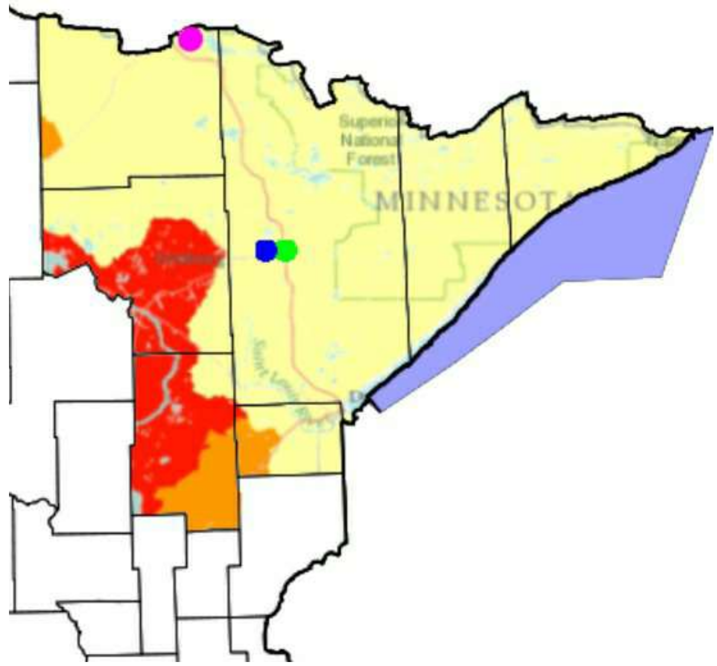
As indicated by the inclusion of upstream conditions in the overall water risk calculation, it is extremely important to note that upstream communities can impact the water risk and stress of downstream communities. Failure to implement appropriate storm water management, flood management, and water conservation policies in one community can greatly impact the water stress of communities down stream. As a highly precious resource, all communities should look to increase water conservation regardless of the projected water stress levels of their immediate region, while communities in regions with a projected increase in water stress should view water conservation as a major long-term priority.

Region's Water Stress (current)

Baseline water stress measures the ratio of total annual water withdrawals to total available annual renewable supply, accounting for upstream consumptive use. Higher values indicate more competition among users.

The current water stress in the communities of this region are:
City of Chisholm: "Low"
City of Mountain Iron: "Low"
City of Ranier: "Low"
(Source: World Resources Institute)

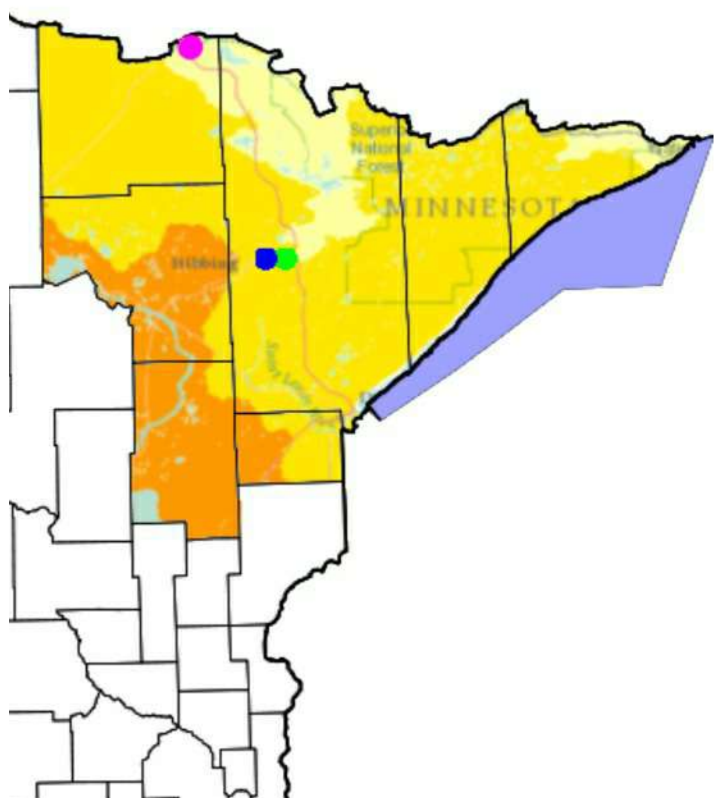


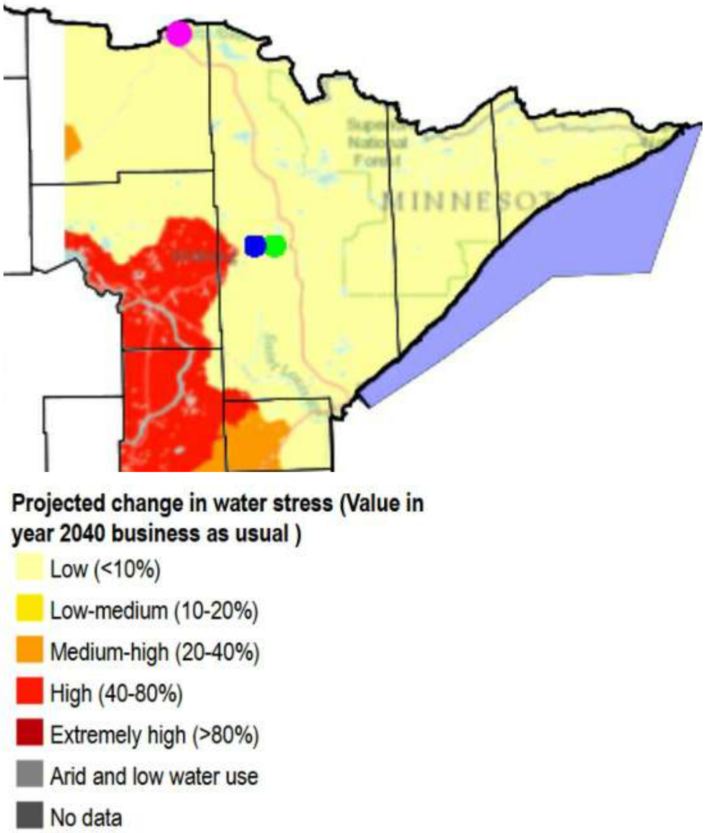


Region's Overall Water Risk (current)

Overall water risk identifies areas with higher exposure to water-related risks and is an aggregated measure of all selected indicators from the Physical Quantity, Quality and Regulatory & Reputational Risk categories.

The current water risk in the communities of this region are:
City of Chisholm: "Low to Medium"
City of Mountain Iron: "Low to Medium"
City of Ranier: "Low"
(Source: World Resources Institute)



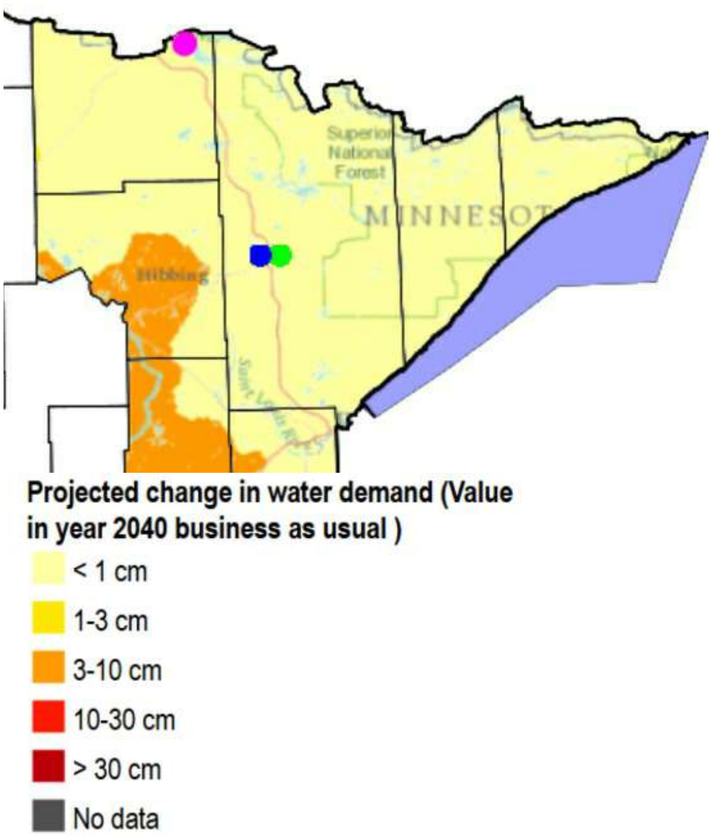


Projected Change in Region's Water Stress

(through 2040)

Projected change in water stress shows how development and/or climate change are expected to affect water stress, the ratio of water use to supply. The "business as usual" scenario (SSP2 RCP8.5) represents a world with stable economic development and steadily rising global carbon emissions.

The projected water stress in the communities of this region are:
City of Chisholm: "Low"
City of Mountain Iron: "Low"
City of Ranier: "Low"
(Source: World Resources Institute)



Projected Change in Region's Water Demand

(through 2040)

Projected change in water demand shows how development and/or climate change are expected to affect water demand. The "business as usual" scenario (SSP2 RCP8.5) represents a world with stable economic development and steadily rising global carbon emissions.

The projected change in water demand in the communities of this region are:
City of Chisholm: "Low"
City of Mountain Iron: "Low"
City of Ranier: "Low"
(Source: World Resources Institute)

Minnesota Northeast Region's Flood Vulnerability

According to the US National Climate Assessment, the ten rainiest days can contribute up to 40% of the annual precipitation in Minnesota. By 2070, the region can anticipate an increase of up to 21% in the total annual precipitation, while the amount of precipitation in summer months may actually decline. In addition, the timeframe between rains is expected to continue to increase, (source US National Climate Assessment). Under this scenario, it is likely that certain periods of the year, like Fall, may be significantly wetter with storms producing heavier rains. In anticipation of that, it is appropriate to review the communities of the region with flood risk and to review current storm water management capacity against future extreme rainfall event projections.

The maps below show the flood risk as defined by FEMA in communities of the region . Flood risks illustrated relate to water surface elevations for 1% chance annual floods ("100 year flood event"). Areas shown relate to existing bodies of water as well as potential "flash flood" zones in low-lying areas.
(Source: National Flood Services)

City of Chisholm

Chisholm Flood History*

Flood Losses
Unavailable

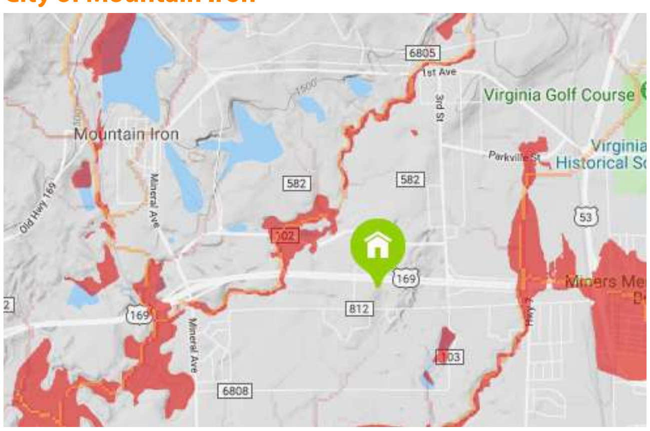
Average Flood Claim Value
Unavailable

Number of Flood Claims
Unavailable

Number of Flood Policies
Unavailable

* In last 10 years (source: FEMA)

City of Mountain Iron



Mountain Iron Flood History*

Flood Losses
Unavailable

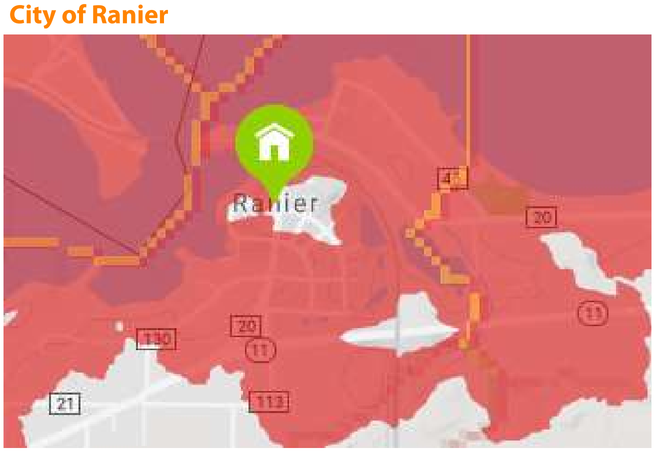
Average Flood Claim Value
Unavailable

Number of Flood Claims
Unavailable

Number of Flood Policies
Unavailable

* In last 10 years (source: FEMA)

City of Ranier



Ranier Flood History*

Flood Losses
$799,801

Average Flood Claim Value
$3,433

Number of Flood Claims
233

Number of Flood Policies
2862

* In last 10 years (source: FEMA)

Section 08

Climate Resilience Indicators

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Climate Resilience Indicators

Similar to Climate Impact Multipliers, a community's overall resilience can have a multiplying or a mitigating affect on the population's ability to adapt to climate risks and rapidly recover from extreme weather events. Understanding and tracking the state of these Resilience Indicators will help identify some of the climate adaptive strategies appropriate for the Region's communities.

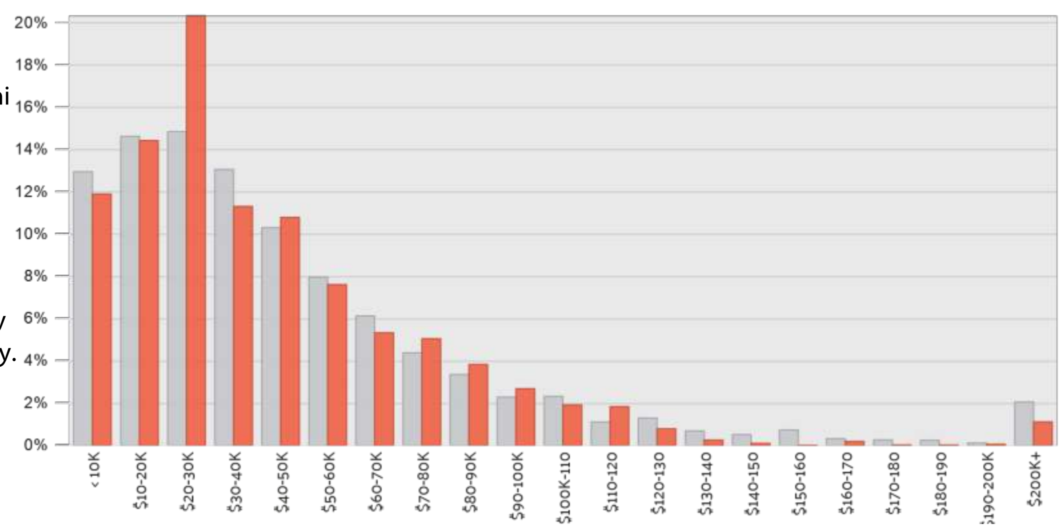
Resilience Indicators include: Economic Stress, Health Indicators, EPA Environmental Justice Screen, EPA Social Vulnerability Index, MPCA Environmental Justice Screen, Housing Burden

Minnesota Northeast Region Resilience Indicators - Economic Stress

Economic stress within communities function as an impact multiplier. The issue is not limited to individuals – communities with large lower incomes can have a lag in infrastructure planning, maintenance, and redevelopment. These stressors on a community's planning capacity or activity decrease the ability for a community to prepare for and respond to climate stresses and vulnerabilities. In addition, a report by the World Health Organization points out that disadvantaged communities are likely to shoulder a disproportionate share of the burden of climate change because of their increased exposure and vulnerability to health threats.

Wage Distribution Within City of Chisolm

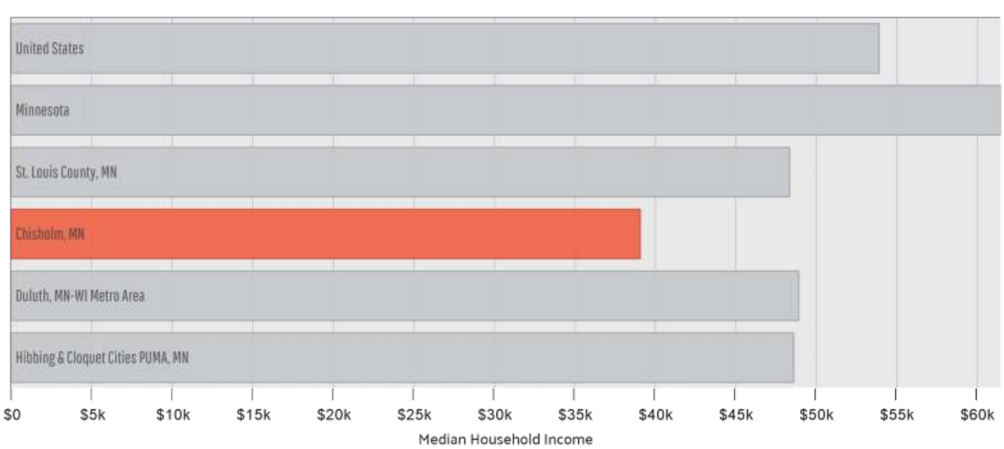
In 2015, the income inequality in the City was 0.461 according to the Gini calculation of the wage distribution. The Gini coefficient is a measure of statistical dispersion intended to represent the equality of a distribution, and is the most commonly used measure of inequality. Values range from 0 to 1, with 0 being perfect equality.



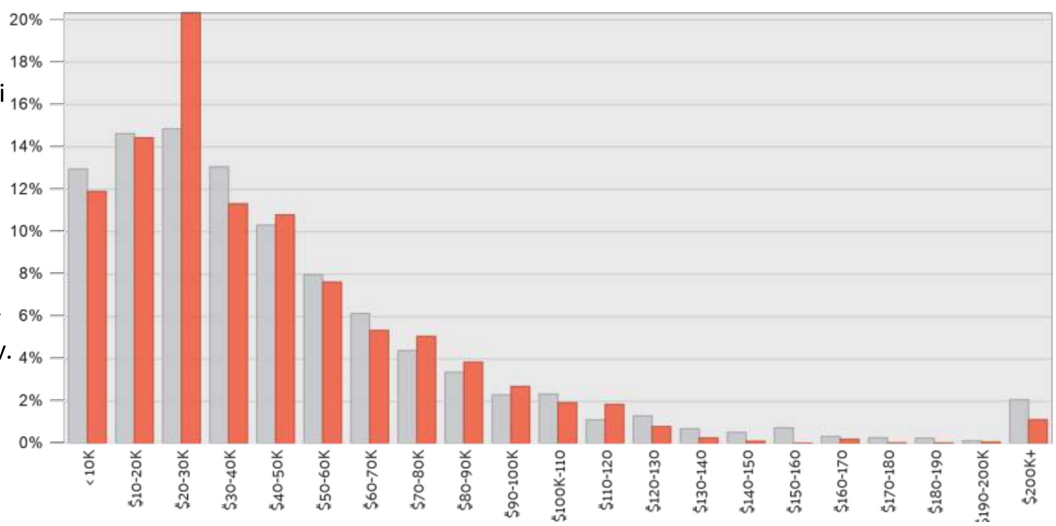
Income inequality in the City of Chisholm had a 10.4% growth from 2014 to 2015, which means that wage distribution grew somewhat less even. The 2015 GINI for the City of Chisholm is lower than the State average of 0.476. In other words, wages are distributed more evenly in the City of Chisholm in comparison to the State average.

(Source: US Census Data, DataUSA)

Median Household Income



Wage Distribution Within City of Mountain Iron

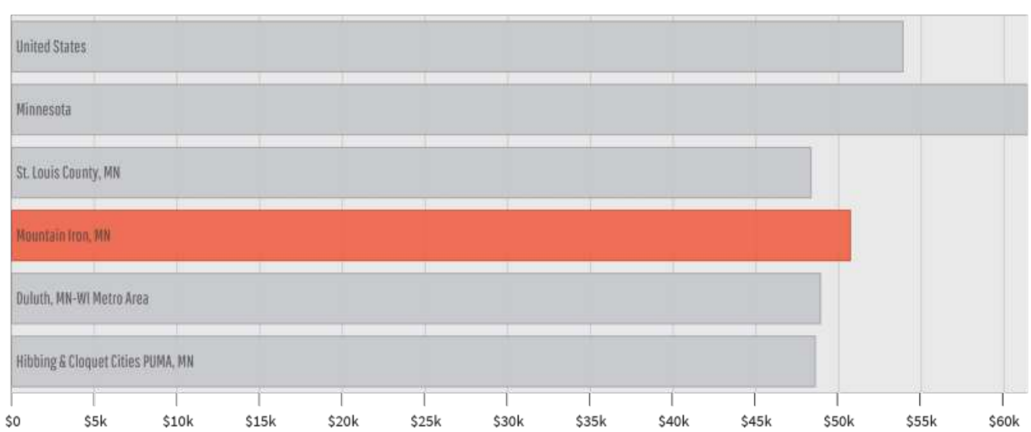


In 2015, the income inequality in the City was 0.461 according to the Gini calculation of the wage distribution. The Gini coefficient is a measure of statistical dispersion intended to represent the equality of a distribution, and is the most commonly used measure of inequality. Values range from 0 to 1, with 0 being perfect equality.

Income inequality in the City of Mountain Iron had a 10.4% growth from 2014 to 2015, which means that wage distribution grew somewhat less even. The 2015 GINI for the City of Mountain Iron is lower than the State average of 0.476. In other words, wages are distributed more evenly in the City of Mountain Iron in comparison to the State average.

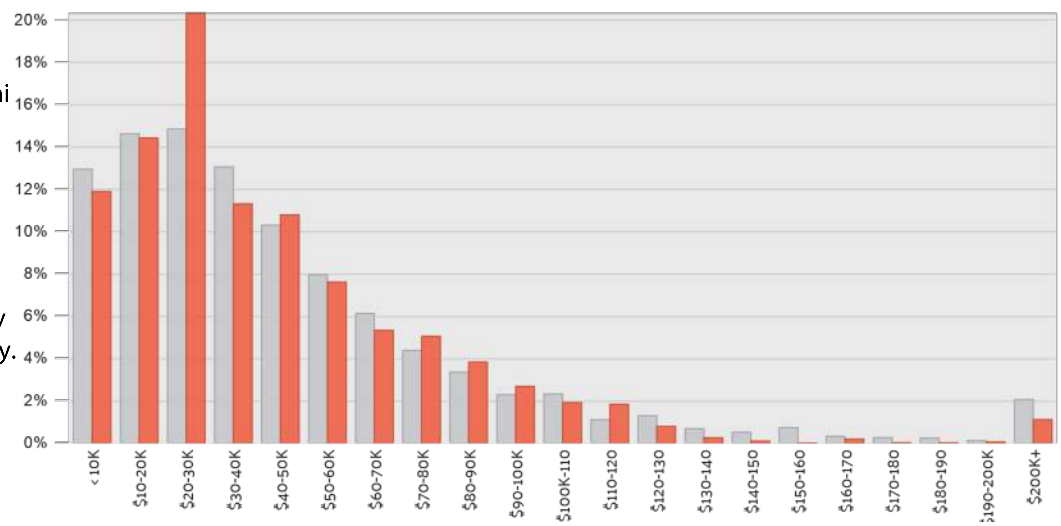
(Source: US Census Data, DataUSA)

Median Household Income



Wage Distribution Within City of Ranier

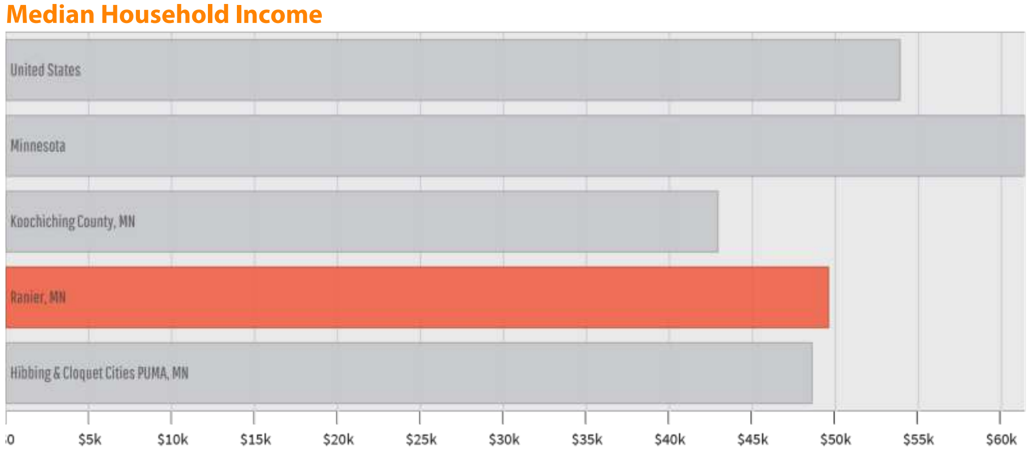
In 2015, the income inequality in the City was 0.461 according to the Gini calculation of the wage distribution. The Gini coefficient is a measure of statistical dispersion intended to represent the equality of a distribution, and is the most commonly used measure of inequality. Values range from 0 to 1, with 0 being perfect equality.



Income inequality in the City of Ranier had a 10.4% growth from 2014 to 2015, which means that wage distribution grew somewhat less even. The 2015 GINI for the City of Ranier is lower than the State average of 0.476. In other words, wages are distributed more evenly in the City of Ranier in comparison to the State average.

(Source: US Census Data, DataUSA)

Median Household Income



Minnesota Northeast Region Resilience Indicators - Health

The potential magnitude of the population climate risks outlined in section 6 “Local Climate Risks” can be anticipated by understanding current community resilience indicators. Resilience indicators which are higher locally than State or National averages may imply a potential weakness which could be exacerbated by the risks posed by projected climate change.

On the other hand, it should be understood that these community resilience indicators are usually only available at the granularity of County level. This means that each community should carefully consider potential implications for any community resilience indicator even if the local demographic appears "stronger" (lower percentage/value/percentile) than State or National levels.

	State	St Louis County	Koochiching County
Poor/Fair Health	12%	**15%**	**13%**
Uninsured	7%	**7%**	**9%**
Asthma emergency department visits (per 10,000)	40.1	**44.7**	**64.6**
Pulmonary Disease Hospitalizations (COPD per 100,000)	15.8	**17.5**	**16.7**
Heart attack hospitalizations (per 100,000)	26.7	**33.9**	**38.6**

(Source: County Health Rankings & Roadmaps program, Minnesota Department of Health)

City of Chisholm, Minnesota

Minnesota Northeast Region Resilience Indicators - EPA Environmental Justice Screen

EJSCREEN is an environmental justice mapping and screening tool that provides EPA with a nationally consistent data set and approach for environmental and demographic indicators. All of the EJSCREEN indicators are publicly-available data. EJSCREEN simply provides a way to display this information and includes a method for combining environmental and demographic indicators into EJ indexes. Below are the raw EJSCREEN Environmental Indicators which represent environmental data without adjustments for demographic data, for each of the Region's communities. All values circled in orange are values in the upper 50 percentile for the State of Minnesota.

City of Chisholm - EJScreen Environmental Indicators

Selected Variables	Value	State Avg.	%ile in State	EPA Region Avg.	%ile in EPA Region	USA Avg.	%ile in USA
Environmental Indicators							
Particulate Matter (PM 2.5 in $\mu g/m^3$)	7.54	9.27	7	10.1	3	9.14	16
Ozone (ppb)	33.1	35.8	3	37.6	0	38.4	4
NATA* Diesel PM ($\mu g/m^3$)	0.446	0.755	35	0.932	<50th	0.938	<50th
NATA* Cancer Risk (lifetime risk per million)	26	36	25	34	<50th	40	<50th
NATA* Respiratory Hazard Index	0.9	2.2	20	1.7	<50th	1.8	<50th
Traffic Proximity and Volume (daily traffic count/distance to road)	160	350	70	370	62	590	58
Lead Paint Indicator (% Pre-1960 Housing)	0.61	0.32	82	0.39	75	0.29	82
Superfund Proximity (site count/km distance)	0.011	0.18	6	0.13	1	0.13	6
RMP Proximity (facility count/km distance)	0.043	0.74	4	0.81	1	0.73	3
Hazardous Waste Proximity (facility count/km distance)	0.0053	0.12	1	0.091	0	0.093	1
Wastewater Discharge Indicator	0.00015	0.077	66	4.2	46	30	58

City of Mountain Iron - EJScreen Environmental Indicators

Selected Variables	Value	State Avg.	%ile in State	EPA Region Avg.	%ile in EPA Region	USA Avg.	%ile in USA
Environmental Indicators							
Particulate Matter (PM 2.5 in $\mu g/m^3$)	7.67	9.27	9	10.1	3	9.14	17
Ozone (ppb)	33.1	35.8	4	37.6	0	38.4	4
NATA* Diesel PM ($\mu g/m^3$)	0.158	0.755	8	0.932	<50th	0.938	<50th
NATA* Cancer Risk (lifetime risk per million)	22	36	15	34	<50th	40	<50th
NATA* Respiratory Hazard Index	0.63	2.2	10	1.7	<50th	1.8	<50th
Traffic Proximity and Volume (daily traffic count/distance to road)	75	350	56	370	50	590	46
Lead Paint Indicator (% Pre-1960 Housing)	0.33	0.32	60	0.39	51	0.29	64
Superfund Proximity (site count/km distance)	0.013	0.18	8	0.13	2	0.13	7
RMP Proximity (facility count/km distance)	0.68	0.74	60	0.81	63	0.73	67
Hazardous Waste Proximity (facility count/km distance)	0.0055	0.12	2	0.091	0	0.093	1
Wastewater Discharge Indicator	0.0014	0.077	79	4.2	59	30	70

City of Ranier - EJScreen Environmental Indicators

Selected Variables	Value	State Avg.	%ile in State	EPA Region Avg.	%ile in EPA Region	USA Avg.	%ile in USA
Environmental Indicators							
Particulate Matter (PM 2.5 in $\mu g/m^3$)	6.63	9.27	0	10.1	0	9.14	7
Ozone (ppb)	32.9	35.8	3	37.6	0	38.4	3
NATA* Diesel PM ($\mu g/m^3$)	0.174	0.755	9	0.932	<50th	0.938	<50th
NATA* Cancer Risk (lifetime risk per million)	27	36	29	34	<50th	40	<50th
NATA* Respiratory Hazard Index	1.2	2.2	28	1.7	<50th	1.8	<50th
Traffic Proximity and Volume (daily traffic count/distance to road)	120	350	66	370	58	590	54
Lead Paint Indicator (% Pre-1960 Housing)	0.46	0.32	72	0.39	63	0.29	73
Superfund Proximity (site count/km distance)	0.006	0.18	0	0.13	0	0.13	1
RMP Proximity (facility count/km distance)	0.54	0.74	55	0.81	58	0.73	62
Hazardous Waste Proximity (facility count/km distance)	0.0032	0.12	0	0.091	0	0.093	0
Wastewater Discharge Indicator	0.0002	0.077	68	4.2	48	30	59

* The National-Scale Air Toxics Assessment (NATA) is EPA's ongoing, comprehensive evaluation of air toxics in the United States. EPA developed the NATA to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that NATA provides broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. More information on the NATA analysis can be found at: https://www.epa.gov/national-air-toxics-assessment.

RMP Proximity represents the potential for chemical accident based on the number of Risk Management Plan sites in area.

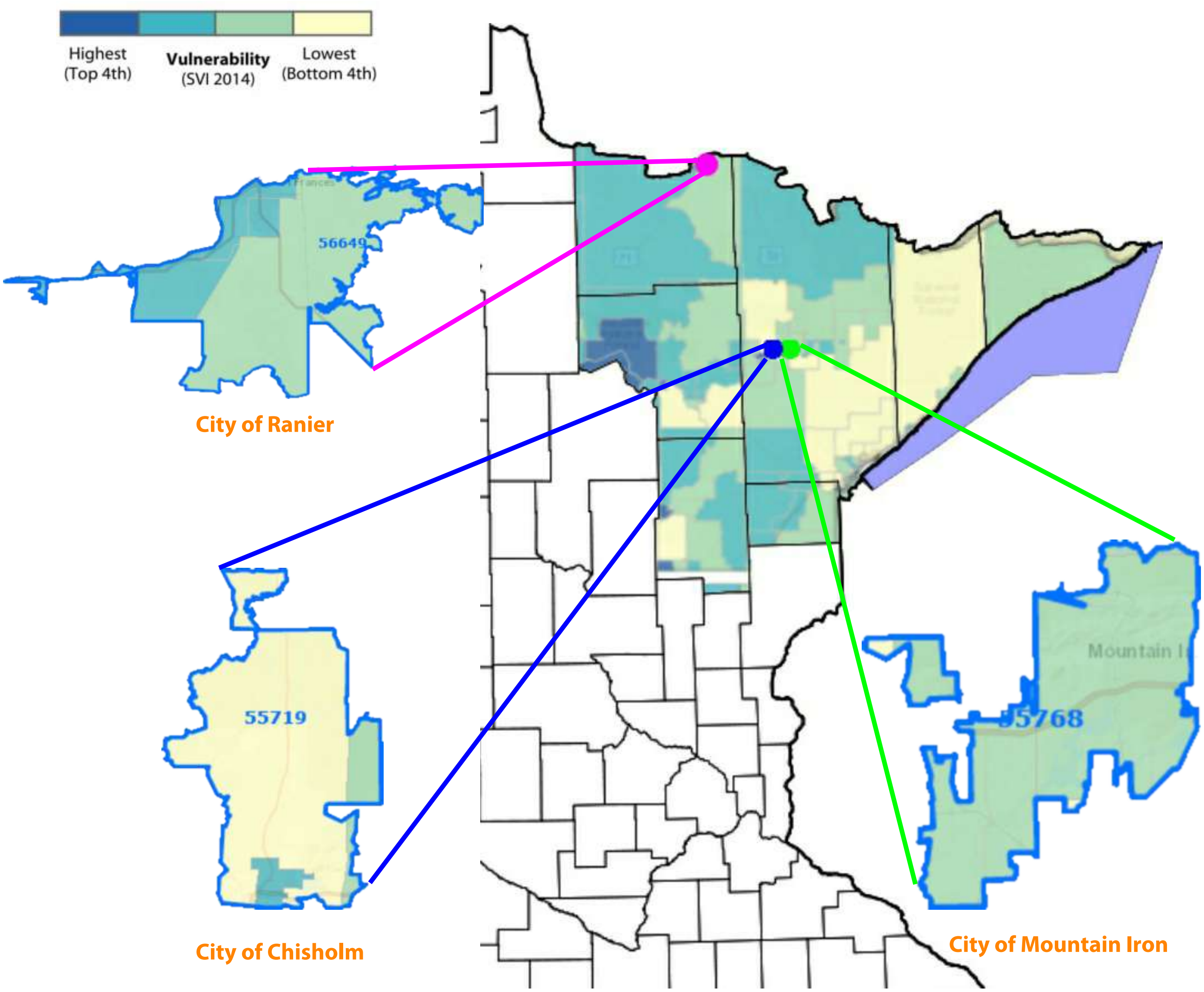
Minnesota Northeast Region Resilience Indicators - EPA Social Vulnerability Index

Social vulnerability refers to the resilience of communities when confronted by external stresses on human health, stresses such as natural or human-caused disasters, or disease outbreaks. Reducing social vulnerability can decrease both human suffering and economic loss.

The Social Vulnerability Index (SVI) compares and ranks every community in the United States at the Census Tract level. Factors include poverty, lack of car access, and crowded housing. The SVI is developed by the Centers for Disease Control. The City of Chisholm has areas in the three lowest quartiles of vulnerability; the City of Mountain Iron has areas in the second lowest quartile of vulnerability; and the City of Ranier areas in the second lowest quartile of vulnerability.

EPA Social Vulnerability Index

Legend



Minnesota Northeast Region Resilience Indicators - MPCA Environmental Justice Screen

The Minnesota Pollution Control Agency is committed to making sure that pollution does not have a disproportionate impact on any group of people — the principle of environmental justice. This means that all people — regardless of their race, color, national origin or income — benefit from equal levels of environmental protection and have opportunities to participate in decisions that may affect their environment or health.

As an initial step the MPCA considers tribal areas and census tracts with higher concentrations of low income residents and people of color as areas of increased concern for environmental justice. This screening tool allows users to identify census tracts where additional consideration or effort is warranted to ensure meaningful community engagement and to evaluate the potential for disproportionate adverse impacts using three criteria:

- At least 40% of people reported income less than 185% of the federal poverty level
- 50% or more people of color
- Federally recognized tribal areas

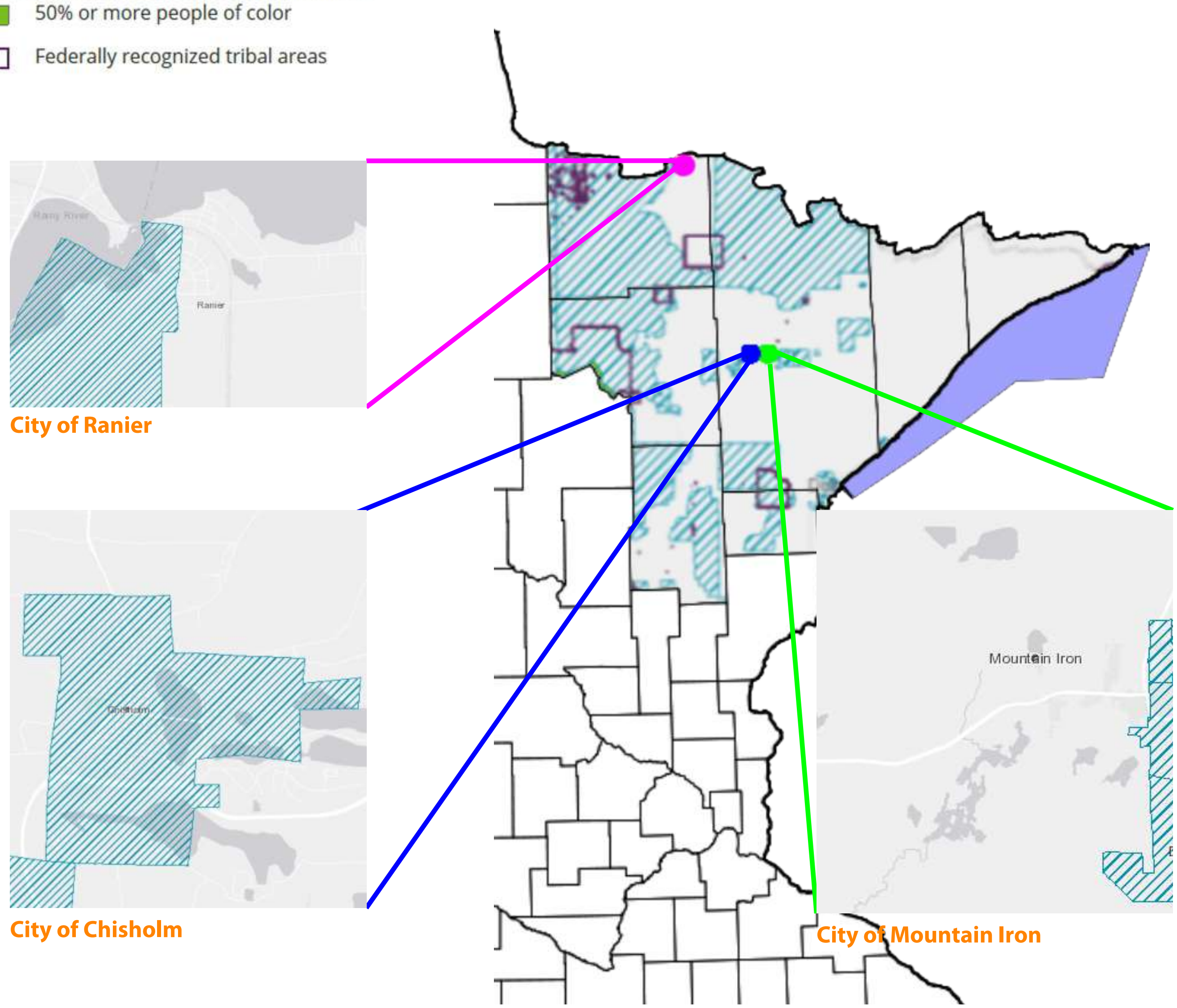
MPCA Environmental Justice Screen

Legend

At least 40% of people reported income less than 185% of the federal poverty level

50% or more people of color

Federally recognized tribal areas



Minnesota Northeast Region Resilience Indicators - Housing Burden

Housing burden can be understood as a household living with any of four housing problems: overcrowding, high housing cost, no kitchen, no plumbing. Households with housing burden can occur at any income level, though they may be more common in middle to lower income brackets. Housing burden factors, like other economic stress indicators, can challenge a household's capacity to respond to emergencies increasing that household's climate vulnerability.

These economic stressors impact a family's resilience under favorable circumstances, while the projected climate impacts can be anticipated to exacerbate the burden felt by these families. Extreme heat events will result in even higher utility costs, potential health impacts related to water and air quality issues and heat exposure require the ability to access appropriate healthcare. Additionally, the best preventative measures to make homes climate ready - such as improved insulation, air conditioning, improved energy efficiency, and well placed shade trees - require investment. Home owners living under housing cost burden are typically incapable of making these investments. Families with housing cost burden who rent, meanwhile, typically have little leverage to see to it that landlords make the investments needed to make buildings climate ready.

Housing Type Impacts on Housing Burden

The type of structure a resident lives in can impact the level of housing burden experienced by community members. According to a 2005 study by the US Housing and Urban Development Agency, renters, on average, have 10% more of their monthly income going to utility costs. Those who live in mobile home type constructions often pay even more.

The Environmental and Energy Study Institute, indicates that mobile homes built before 1980 consume an average of 84,316 BTUs per square foot, 53 percent more than other types of homes. A study by the energy consultant group Frontier Associates found that residents in older manufactured homes may pay up to $500 a month for electricity, or over 24% of average monthly income. Mobile homes are also less resilient to extreme temperatures, extreme weather, high winds, and tornado events.

The following page shows the housing type breakdown by city based on the US Census.

City of Chisholm Housing by Type and Occupancy Summary

Subject	Occupied housing units			Owner-occupied housing units			Renter-occupied housing units		
	Estimate	Percentage	Margin of Error	Estimate	Percentage	Margin of Error	Estimate	Percentage	Margin of Error
Occupied housing units	2022		+/-194	1540		+/-184	482		+/-136
UNITS IN STRUCTURE									
1, detached	174	76.80%	+/-5.5	187	95.10%	+/-3.7	6	18.50%	+/-11.7
1, attached	2	0.80%	+/-1.1	2	1.00%	+/-1.5	0	0.00%	+/-3.6
2 apartments	6	2.60%	+/-2.4	0	0.00%	+/-1.1	3	11.00%	+/-9.3
3 or 4 apartments	5	2.20%	+/-1.4	0	0.00%	+/-1.1	3	9.30%	+/-5.4
5 to 9 apartments	10	4.20%	+/-2.8	2	1.00%	+/-1.7	4	14.30%	+/-10.2
10 or more apartments	25	11.20%	+/-4.2	0	0.00%	+/-1.1	14	46.90%	+/-13.6
Mobile home or other type of housing	5	2.20%	+/-2.1	6	2.90%	+/-2.7	0	0.00%	+/-3.6

City of Mountain Iron Housing by Type and Occupancy Summary

Subject	Occupied housing units			Owner-occupied housing units			Renter-occupied housing units		
	Estimate	Percentage	Margin of Error	Estimate	Percentage	Margin of Error	Estimate	Percentage	Margin of Error
Occupied housing units	1313		+/-76	798		+/-85	515		+/-99
UNITS IN STRUCTURE									
1, detached	157	69.20%	+/-6.9	192	97.70%	+/-1.9	7	24.90%	+/-12.6
1, attached	3	1.40%	+/-1.2	3	1.40%	+/-1.9	0	1.40%	+/-2.4
2 apartments	2	0.70%	+/-1.0	0	0.00%	+/-2.2	1	1.70%	+/-2.6
3 or 4 apartments	0	0.00%	+/-1.3	0	0.00%	+/-2.2	0	0.00%	+/-3.3
5 to 9 apartments	10	4.20%	+/-2.3	0	0.00%	+/-2.2	3	10.70%	+/-6.1
10 or more apartments	55	24.10%	+/-6.5	0	0.00%	+/-2.2	18	61.40%	+/-13.3
Mobile home or other type of housing	1	0.50%	+/-1.0	2	0.90%	+/-1.6	0	0.00%	+/-3.3

City of Ranier Housing by Type and Occupancy Summary

Subject	Occupied housing units			Owner-occupied housing units			Renter-occupied housing units		
	Estimate	Percentage	Margin of Error	Estimate	Percentage	Margin of Error	Estimate	Percentage	Margin of Error
Occupied housing units	227		+/-51	197		+/-46	30		+/-22
UNITS IN STRUCTURE									
1, detached	197	86.80%	+/-7.8	174	88.30%	+/-7.4	23	76.70%	+/-32.6
1, attached	3	1.30%	+/-2.2	3	1.50%	+/-2.5	0	0.00%	+/-39.7
2 apartments	0	0.00%	+/-7.4	0	0.00%	+/-8.5	0	0.00%	+/-39.7
3 or 4 apartments	7	3.10%	+/-4.5	0	0.00%	+/-8.5	7	23.30%	+/-32.6
5 to 9 apartments	0	0.00%	+/-7.4	0	0.00%	+/-8.5	0	0.00%	+/-39.7
10 or more apartments	0	0.00%	+/-7.4	0	0.00%	+/-8.5	0	0.00%	+/-39.7
Mobile home or other type of housing	20	8.80%	+/-6.8	20	10.20%	+/-7.8	0	0.00%	+/-39.7

Section 09

Vulnerable Populations

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Vulnerable Populations in Region

Some groups face a number of stressors related to both climate and non-climate factors. For example, people living in impoverished urban or isolated rural areas, floodplains, and other at-risk locations such as areas of current or historically high levels of toxic chemical pollution are more vulnerable not only to extreme weather and persistent climate change but also to social and economic stressors. Many of these stressors can occur simultaneously or consecutively.

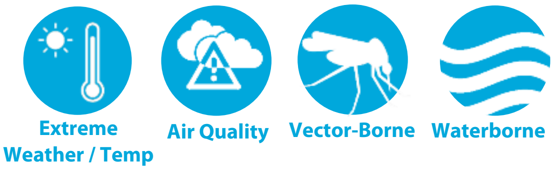
People or communities can have greater or lesser vulnerability to health risks depending on age, social, political, and economic factors that are collectively known as social determinants of health. Some groups are disproportionately disadvantaged by social determinants of health that limit resources and opportunities for health-promoting behaviors and conditions of daily life, such as living/working circumstances and access to healthcare services. Populations of concern are particularly vulnerable to climate change impacts. Heightened vulnerability to existing and projected climate impacts can be due to a sector of the population's exposure, sensitivity, or adaptive capacity to a climate impact.

The following pages identify the populations particularly vulnerable to the risks of climate change impacts within the Minnesota Northeast Region.

Children

According to the US Global Change Research Program "Children are vulnerable to adverse health effects associated with environmental exposures due to factors related to their immature physiology and metabolism, their unique exposure pathways, their biological sensitivities, and limits to their adaptive capacity. Children have a proportionately higher intake of air, food, and water relative to their body weight compared to adults. They also share unique behaviors and interactions with their environment that may increase their exposure to environmental contaminants such as dust and other contaminants, such as pesticides, mold spores, and allergens."

Children are particularly sensitive to the following Climate Risks (see Section 6 for Climate Risk information):



Vulnerability of Youth to Health Impacts of Climate Change at Different Life Stages

Source: US Global Change Research Program

Vulnerable Population Demographic Within Region's Communities

City of Chisholm
Children Under 5 Summary

Total Estimated Population:	343
Estimated Share of Total Vulnerable Population:	8-10%
Estimated Share of Total City Population:	6.9%

City of Mountain Iron
Children Under 5 Summary

Total Estimated Population:	258
Estimated Share of Total Vulnerable Population:	12-14%
Estimated Share of Total City Population:	9.0%

City of Ranier
Children Under 5 Summary

Total Estimated Population:	29
Estimated Share of Total Vulnerable Population:	4-6%
Estimated Share of Total City Population:	5.6%

Source: Census 2011-2015 American Community Survey 5-Year Estimates

Observations for Region

The estimated total child population under five for the subject cities in the Northeast region range from 29 in Ranier to 343 in Chisholm.   On average, this vulnerable population makes up 7.54% of the three Cities' total populations, with Mountain Iron having the highest share of 9% of total City population.

Children under five represent from 4-6% of the total vulnerable population in Ranier up to 12-14% of the total vulnerable population in Mountain Iron, with an average of 9-10% of the three Cities' total vulnerable populations.

Older Adults (65 and over)

Older adults are also vulnerable to the health impacts associated with climate change and weather extremes. Vulnerabilities within older adults are not uniform due to the fact that this demographic is a diverse group with distinct sub-populations that can be identified not only by age but also by race, educational attainment, socioeconomic status, social support networks, overall physical and mental health, and disability status. According to the US Global Change Research Program "the potential climate change related health impacts for older adults include rising temperatures and heat waves; increased risk of more intense floods, droughts, and wildfires; degraded air quality; exposure to infectious diseases; and other climate-related hazards."

Older Adults are particularly sensitive to the following Climate Risks (see Section 6 for Climate Risk information):

Vulnerable Population Demographic Within Region's Communities

City of Chisholm
Older Adults Summary

Total Estimated Population:	886
Estimated Share of Total Vulnerable Population:	21-23%
Estimated Share of Total City Population:	17.7%

City of Mountain Iron
Older Adults Summary

Total Estimated Population:	537
Estimated Share of Total Vulnerable Population:	26-28%
Estimated Share of Total City Population:	18.7%

City of Ranier
Older Adults Summary

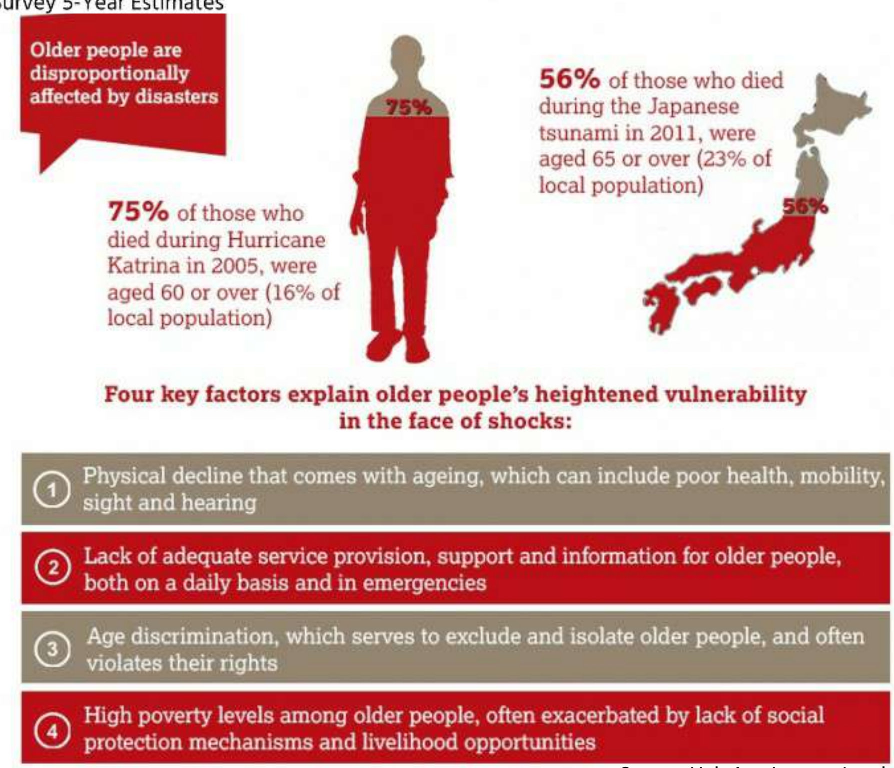
Total Estimated Population:	195
Estimated Share of Total Vulnerable Population:	28-30%
Estimated Share of Total City Population:	37.3%

Source: Census 2011-2015 American Community Survey 5-Year Estimates

Observations for Region

The estimated total older adult population for the subject cities in the Northeast region range from 195 in Ranier to 886 in Chisholm. On average, this vulnerable population makes up 19.27% of the three Cities' total populations, with Ranier having the highest share of 37.3% of total City population.

Older adults represent from 21-23% of the total population vulnerabilities in Chisholm up to 28-30% of the total population vulnerabilities in Mountain Iron, with an average of 23-25% of the three Cities' total population vulnerabilities.



Source: HelpAge International

Individuals with Disabilities

People with disabilities experience disproportionately higher rates of social risk factors, such as poverty and lower educational attainment, that contribute to poorer health outcomes during extreme events or climate-related emergencies. These factors compound the risks posed by functional impairments and disrupt planning and emergency response. Of the climate-related health risks experienced by people with disabilities, perhaps the most fundamental is their "invisibility" to decision-makers and planners. Disability refers to any condition or impairment of the body or mind that limits a person's ability to do certain activities or restricts a person's participation in normal life activities, such as school, work, or recreation.

Individuals with disabilities are particularly sensitive to the following Climate Risks (see Section 6 for Climate Risk information):

Vulnerable Population Demographic Within Region's Communities

City of Chisholm
Individuals with Disabilities Summary

Total Estimated Population:	1,111
Estimated Share of Total Vulnerable Population:	26-28%
Estimated Share of Total City Population:	22.2%

City of Mountain Iron
Individuals with Disabilities Summary

Total Estimated Population:	345
Estimated Share of Total Vulnerable Population:	16-18%
Estimated Share of Total City Population:	12.0%

City of Ranier
Individuals with Disabilities Summary

Total Estimated Population:	122
Estimated Share of Total Vulnerable Population:	18-20%
Estimated Share of Total City Population:	23.5%

Source: Census 2011-2015 American Community Survey 5-Year Estimates

Types of disabilities

Approximately 1 in 5 people in the United States has a disability. This includes about half of all American adults 65 and older and about 17% of Americans age 21-64. Disabilities can occur in one or more areas related to:

- **Communication** (seeing, hearing, or speaking), which can include people who are deaf, hard of hearing, blind, low vision (visual impairment), or have speech or language disorders
- **Cognitive functioning** (ability to plan, comprehend, and reason), which can include people with Down Syndrome, Traumatic Brain Injury (TBI), Alzheimer's disease, or dementia
- **Physical functioning** (limited or no ability to walk, climb stairs, or lift or grasp objects)

Source: US Global Change Research Program

Observations for Region

The estimated total population of individuals with disabilities for the subject cities in the Northeast region range from 122 in Ranier to 1,111 in Chisholm.   On average, this vulnerable population makes up 18.8% of the three Cities' total populations, with Ranier having the highest share of 23.5% of total City population.

Individuals with disabilities represent from 16-18% of the total population vulnerabilities in Mountain Iron up to 26-28% of the total population vulnerabilities in Chisholm, with an average of 22-24% of the three Cities' total population vulnerabilities.

Individuals Under Economic Stress

Individuals and families living under economic stress, defined here as "low income" individuals (200% poverty level), are frequently the most adaptive demographic group in our communities. Those living under economic stress exhibit on-going adaptation capabilities simply navigating day-to-day challenges with less than needed resources. This adaptive capacity, however, is overwhelmed in times of emergency as lack of sufficient economic resources greatly reduce the range of options available in response to crisis. For those in poverty, weather-related disasters or family members falling ill can facilitate crippling economic shocks.

With limited economic adaptive capacity, this portion of our population is especially vulnerable to every projected climate impact. Frequently the most effective measures in avoiding extreme heat such as efficiently functioning air conditioning or high performing building enclosures are simply not available to those in poverty while many work in outdoor or industrial jobs which are particularly vulnerable to climate conditions. Diseases which may result from exposure to vector-borne, water-borne, and air-borne pathways may go untreated due to lack of medical access or ability to pay and may increase the level of economic stress due to missed work days or even loss of employment. Those living under economic stress usually carry a heavy housing cost burden, including higher utility costs. This burden can be exacerbated from damaged sustained by their home in extreme weather or flooding events.

Those in economic stress are also frequently food insecure. In Minnesota, food insecurity affects 9.9% of all households. Many of the projected climate change impacts are likely to effect agricultural production and distribution, which in turn, may cause spikes in food costs and increase food and nutrition insecurity among those in economic stress.

Individuals experiencing economic stress, defined as those at 200% poverty level (the common definition of "Low Income") are particularly sensitive to the following Climate Risks:

Vulnerable Population Demographic Within Region's Communities

	City of Chisholm	City of Mountain Iron	City of Ranier
	Economic Stress Summary	Economic Stress Summary	Economic Stress Summary
Total Estimated Population:	949	490	230
Estimated Share of Total Vulnerable Population:	22-24%	23-25%	34-36%
Estimated Share of Total City Population:	18.9%	17.1%	44.2%

Source: Census 2011-2015 American Community Survey 5-Year Estimates

Observations for Region

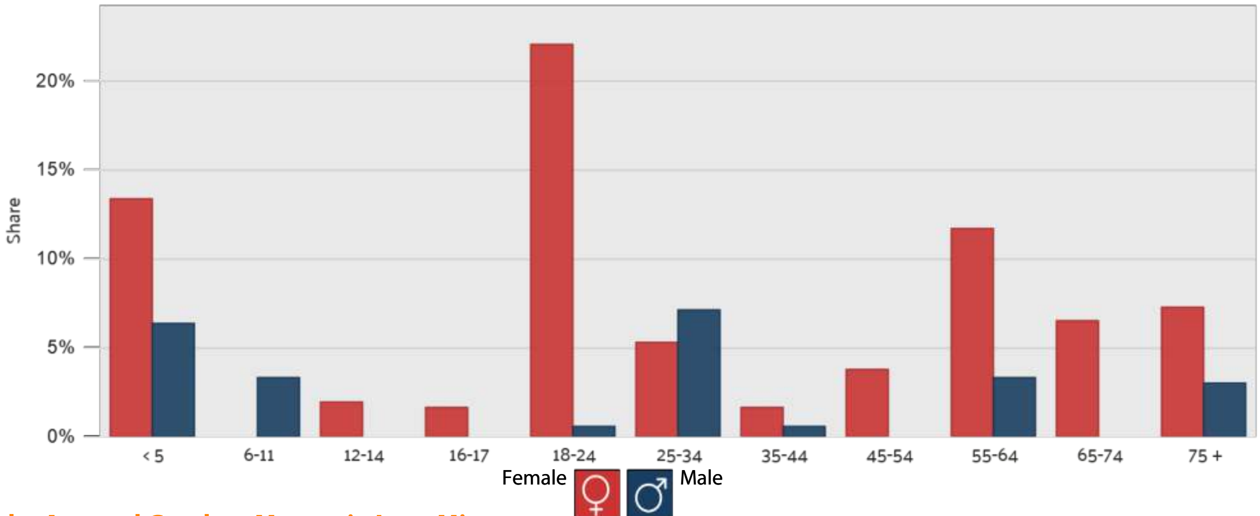
The estimated total population under economic stress for the subject cities in the Northeast region range from 230 in Ranier to 949 in Chisholm. On average, this vulnerable population makes up 19.9% of the three Cities' total populations, with Chisholm having the highest share of 18.9% of total City population.

Individuals living under economic stress represent from 22-24% of the total vulnerable population in Chisholm up to 34-36% of the total vulnerable population in Ranier, with an average of 24-26% of the three Cities' total vulnerable populations.

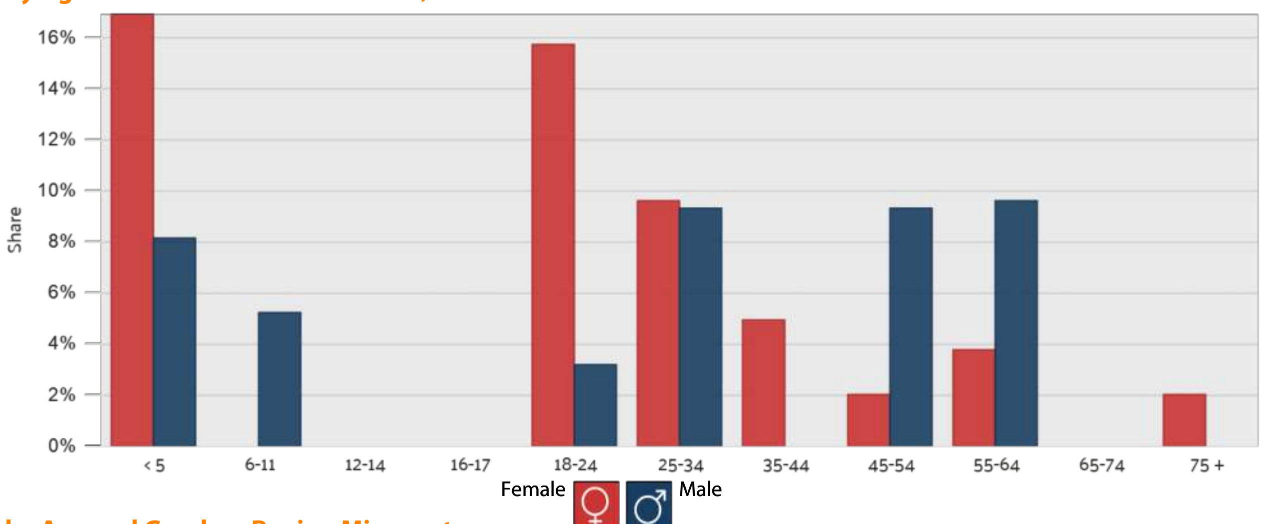
Poverty by Age and Gender

On average, 12.19% of the three Cities' total populations live below the poverty line. The largest demographic living in poverty in Chisholm is Female 18-24, in Mountain Iron it is Female under 5 and ages 18-24 (combined nearly 1/3rd of all those in poverty), and in Ranier the Male over 75 category is highest individual category, however the balance of those in poverty are females over age 25. The Census Bureau uses a set of money income thresholds that vary by family size and composition to determine who classifies is impoverished. If a family's total income is less than the family's threshold than that family and every individual in it is considered to be living in poverty.

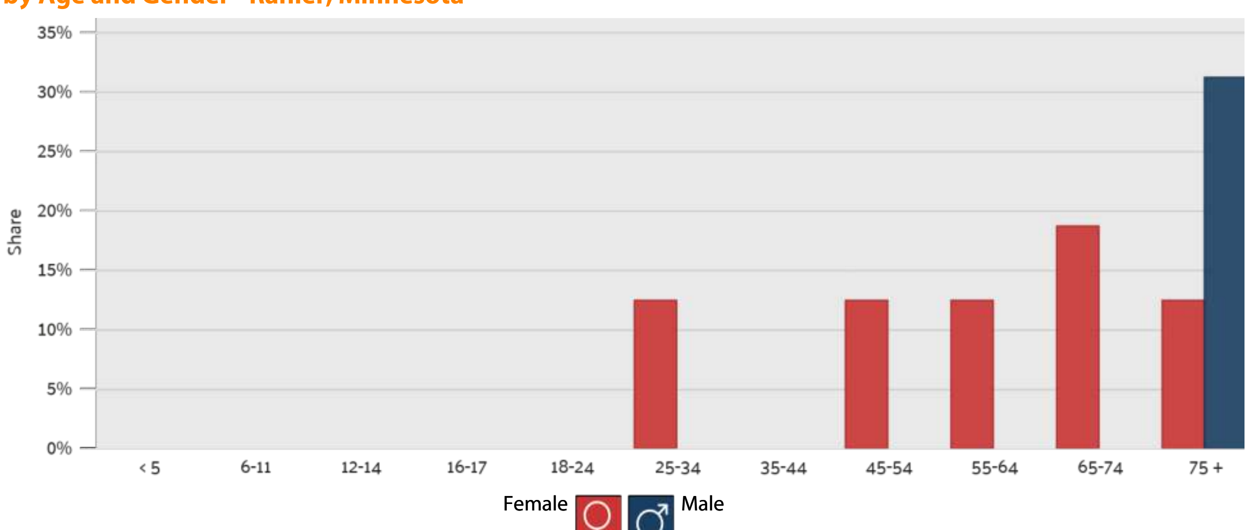
Poverty by Age and Gender - Chisholm, Minnesota



Poverty by Age and Gender - Mountain Iron, Minnesota



Poverty by Age and Gender - Ranier, Minnesota



People of Color and Limited English Populations

These populations are at increased risk of exposure given their higher likelihood of living in risk-prone areas, areas with older or poorly maintained infrastructure, or areas with an increased burden of air pollution. In addition, according to the Center for Disease Control and the National Health Interview Survey these portions of our population also experience higher incidence of chronic medical conditions which can be exacerbated by climate change impacts. These populations may also be impeded from preparing, responding, and coping with climate related health risks due to socioeconomic and education factors, limited transportation, limited access to health education, and social isolation related to language barriers.

Though not specifically a "person of color" category, individuals with limited English frequently overlap with populations of color. Individuals with limited English language skills may be more socially isolated. Their limited English also likely limits their access to public information and notifications, potentially resulting in a knowledge gap related to community resources, programs, or education which may be relevant in preparing for and recovering from climate impacts. In addition, communication barriers may create challenges for limited English speakers in understanding critical information or instructions given in public address during an extreme weather event.

People of Color may be particularly sensitive to the following Climate Risks:

Vulnerable Population Demographic Within Region's Communities

City of Chisholm
People of Color Summary

Total Estimated Population:	203
Estimated Share of Total Vulnerable Population:	4-6%
Estimated Share of Total City Population:	4.1%

City of Mountain Iron
People of Color Summary

Total Estimated Population:	95
Estimated Share of Total Vulnerable Population:	4-6%
Estimated Share of Total City Population:	3.3%

City of Ranier
People of Color Summary

Total Estimated Population:	24
Estimated Share of Total Vulnerable Population:	3-5%
Estimated Share of Total City Population:	4.7%

Source: Census 2011-2015 American Community Survey 5-Year Estimates

Observations for Region

The estimated total population of people of color for the subject cities in the Northeast region range from 24 in Ranier to 203 in Chisholm. On average, this vulnerable population makes up 3.8% of the three Cities' total populations, with Ranier having the highest share of 4.7% of total City population.

People of color represent from 3-5% of the total vulnerable population in Ranier up to 4-6% of the total vulnerable population in Mountain Iron, with an average of 4-6% of the three Cities' total vulnerable populations.

There are an estimated 352 limited English speakers combined in the Cities of Chisholm, Mountain Iron, and Ranier. Assuring key communications related to community resources, safety, emergency, and extreme weather preparedness is equally accessible to community residents with limited English is important for overall community resilience. Each city should review its current and future communications for translation opportunities targeting the city's non-English primary languages to the greatest extent feasible. The top five languages spoken in the three Cities are German, Spanish, African dialects, Serbo-Croatian, and Japanese - representing a total of more than 85% of all languages spoken by limited English speakers.

At-Risk Workers

Climate change will increase the prevalence and severity of occupational hazards related to environmental exposure. As our climate changes, we may also experience the emergence of new work related risks. Climate change can be expected to affect the health of outdoor workers through increases in ambient temperature, more prevalent and longer-lasting heat waves, degraded air quality, extreme weather, vector-borne diseases, and industrial exposures. Workers affected by climate change include farmers, ranchers, and other agricultural workers; laborers exposed to hot indoor work environments; outdoor construction, landscaping, and maintenance workers; paramedics, firefighters and other first responders; transportation workers; retail/service workers stationed outdoors. Not all of these positions are able to be identified and counted using the available data.

For individuals employed in climate vulnerable jobs who also fall within other vulnerable population categories, the health effects of climate change can be cumulative. For these individuals, the risks experienced in their work can be exacerbated by exposures associated with poorly insulated housing and lack of air conditioning. Workers may also be exposed to adverse occupational and climate-related conditions that the general public may be more able to avoid, such as direct exposure to extreme heat, extreme weather events, low air quality, or wildfires.

Individuals employed in at-risk occupations may be particularly sensitive to the following Climate Risks:

Extreme Weather / Temp | Flood | Air Quality | Vector-Borne | Waterborne

Total Employment by Occupation - City of Chisholm

From 2014 to 2015, employment in Chisholm, MN declined at a rate of -1.7%, from 2,057 employees to 2,022 employees.

The most common job groups, by number of people living in Chisholm, MN, are Production & Transportation, Service, and Management, Business, Science, & Arts. This chart illustrates the share breakdown of the primary jobs held by residents of Chisholm, MN.

(Source: USAData, US Census Bureau)

Total Employment by Occupation - City of Mountain Iron

From 2014 to 2015, employment in Mountain Iron, MN declined at a rate of -3.69%, from 1,411 employees to 1,359 employees.

The most common job groups, by number of people living in Mountain Iron, MN, are Management, Business, Science, & Arts, Sales & Office, and Production & Transportation. This chart illustrates the share breakdown of the primary jobs held by residents of Mountain Iron, MN.

(Source: USAData, US Census Bureau)

Total Employment by Occupation - City of Ranier

From 2014 to 2015, employment in Ranier, MN declined at a rate of -7.08%, from 226 employees to 210 employees.

The most common job groups, by number of people living in Ranier, MN, are Management, Business, Science, & Arts, Service, and Natural Resources, Construction, & Maintenance. This chart illustrates the share breakdown of the primary jobs held by residents of Ranier, MN

(Source: USAData, US Census Bureau)

Image: Cliffs Natural Resources Inc.

Im

Vulnerable Population Demographic Within Region's Communities

City of Chisholm

Climate Vulnerable Workers Summary

Total Estimated Population: **750**

Civilian employed population 16 years and over	2022
Protective service occupations:	11
Building and grounds maintenance:	54
Natural resources, construction, and maintenance:	323
Production, transportation, and material moving:	362
Total	750

Estimated Share of Total Workers: **37%**

Estimated Share of Total Vulnerable Population: **18-20%**

Estimated Share of Total City Population: **14.9%**

City of Mountain Iron

Climate Vulnerable Workers Summary

Total Estimated Population: **404**

Civilian employed population 16 years and over	1359
Protective service occupations:	8
Building and grounds maintenance:	58
Natural resources, construction, and maintenance:	224
Production, transportation, and material moving:	114
Total	404

Estimated Share of Total Workers: **29.7%**

Estimated Share of Total Vulnerable Population: **17-19%**

Estimated Share of Total City Population: **14.1%**

City of Ranier

Climate Vulnerable Workers Summary

Total Estimated Population: **80**

Civilian employed population 16 years and over	210
Protective service occupations:	6
Building and grounds maintenance:	2
Natural resources, construction, and maintenance:	40
Production, transportation, and material moving:	32
Total	80

Estimated Share of Total Workers: **38%**

Estimated Share of Total Vulnerable Population: **20-22%**

Estimated Share of Total City Population: **15.4%**

Source: Census 2011-2015 American Community Survey 5-Year Estimates

Observations for Region

The estimated total population of workers employed in climate vulnerable jobs for the subject cities in the Northeast region range from 80 in Ranier to 750 in Chisholm. On average, this vulnerable population makes up 14.8% of the three Cities' total populations, with Ranier having the highest share of 15.4% of total City population.

Workers in climate vulnerable jobs represent from 17-19% of the total vulnerable population in Mountain Iron up to 20-22% of the total vulnerable population in Ranier, with an average of 18-20% of the three Cities' total vulnerable populations.

Individuals with Possible Food Insecurity

Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, and extreme weather events and heat; changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations. These effects can be anticipated regionally as well as worldwide to become more pronounced by mid-century. As the food distribution system becomes more stressed, individuals with less readily available access are more likely to be negatively impacted by the resulting cycles of food shortages and food price increases.

Individuals experiencing food insecurity may be particularly sensitive to the following Climate Risks:

Extreme Weather / Temp | Flood | Air Quality | Water Quality | Waterborne

Food Access

On the maps below highlighted sections represent low-income census tracts (tracts where 20% or more of the population is at or below poverty, or where family median incomes are 80% or less of State median) where a significant number (at least 500 people) or share (at least 33 percent) of residents are distant from the nearest supermarket. In sections which are green, residents are more than 1 mile (urban) or 10 miles (rural) from nearest supermarket.

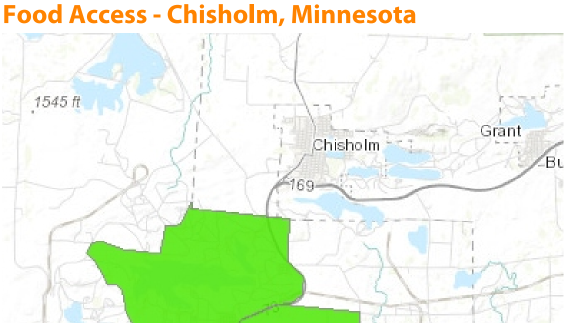
(Source: USDA Economic Research Service Food Atlas)

Vehicle Access

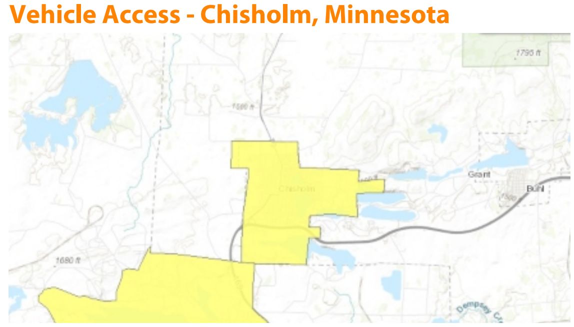
On the maps below, highlighted sections represent Low-income census tract where more than 100 housing units do not have a vehicle and are more than ½ mile from the nearest supermarket in urban/suburban areas, or a significant number (at least 500 people) or share (at least 33 percent) of residents are more than 20 miles from the nearest supermarket in rural areas.

(Source: USDA Economic Research Service Food Atlas)

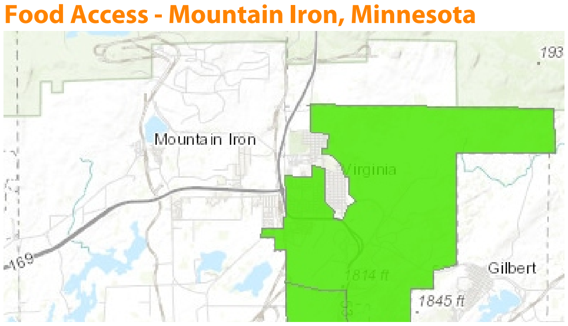
Food Access - Chisholm, Minnesota



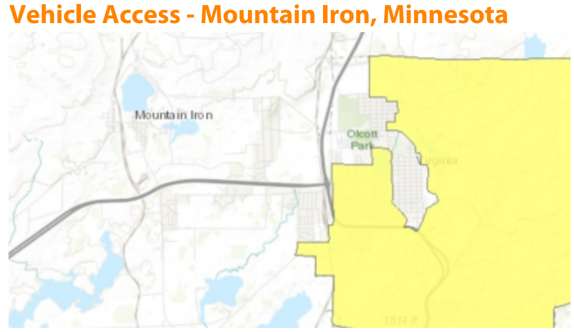
Vehicle Access - Chisholm, Minnesota



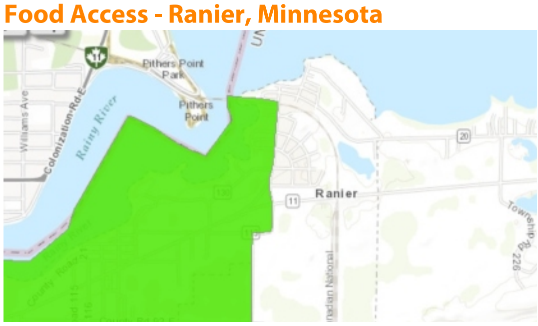
Food Access - Mountain Iron, Minnesota



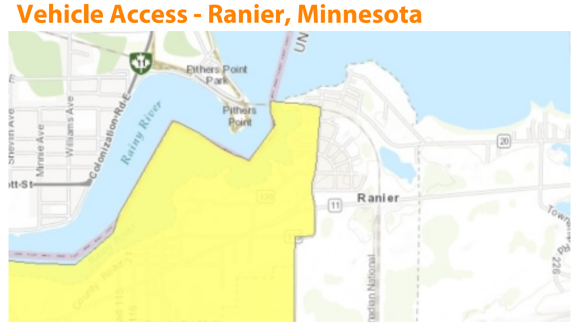
Vehicle Access - Mountain Iron, Minnesota



Food Access - Ranier, Minnesota



Vehicle Access - Ranier, Minnesota



Composite Vulnerabilities

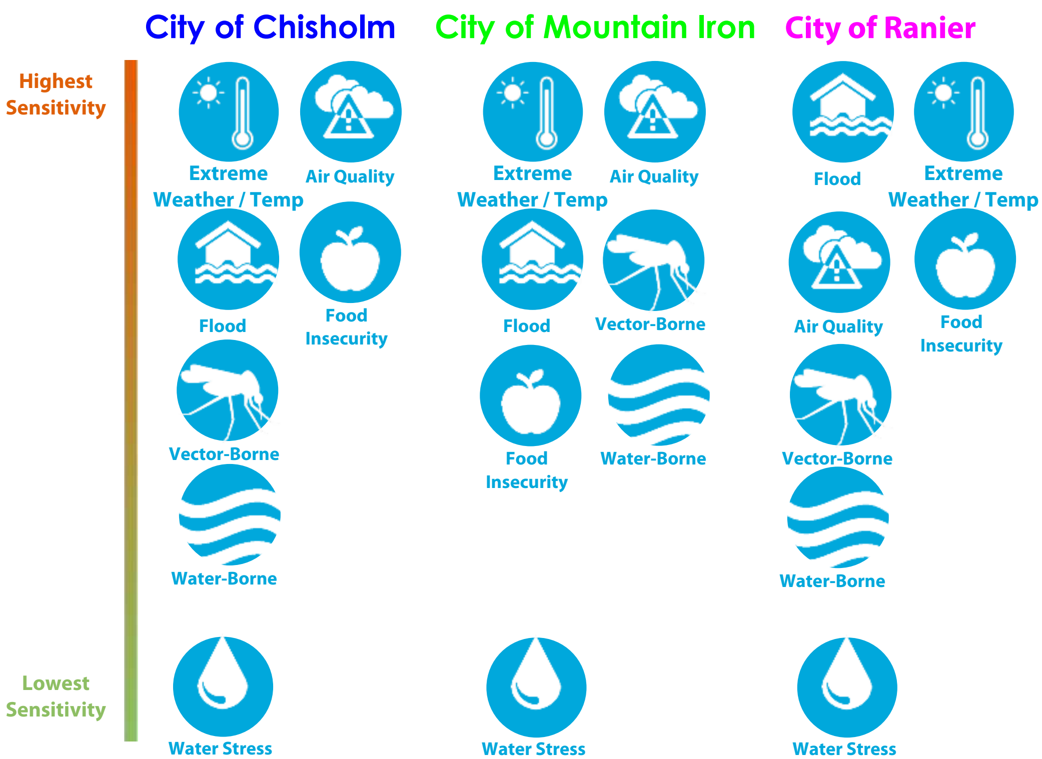
The map below provides a composite mapping of all vulnerable populations illustrated in this section. It should be noted that it is possible for individuals to be members of more than one vulnerable population. For example, an individual may be both an adult over age 65 as well as an individual living below 200% of poverty level. Consequently, the "Estimated Population" counts provided on this composite vulnerabilities review may not be accurate, but the numbers represented here provide a reasonable estimate of the magnitude of total vulnerable populations in each community. This composite view of vulnerable populations is also useful in identifying those climate risks which may be most impactful to the most vulnerable individuals.

As indicated in the review below, the communities can be viewed based on the instances of population vulnerability using a Vulnerability Coefficient. The Vulnerability Coefficient represents the ratio of total instances of population vulnerabilities to the total population within the community where higher numbers represent a higher prevalence of vulnerabilities within the community population.

Composite Population Vulnerabilities Within Region's Communities
(Vulnerability Coefficient)

Community	Total Population Vulnerabilities	Vulnerability Coefficient
City of Chisholm	4,522	0.90
City of Mountain Iron	2,201	0.77
City of Ranier	684	1.31

Northeast Region Risk Sensitivity



Vulnerability Risk Sensitivity

Based on the total estimated population count for each vulnerable population and considering the risks each demographic is most sensitive to, the population vulnerabilities can be considered from highest sensitivity (more vulnerable individuals) to lowest (fewer vulnerable individuals) sensitivity.

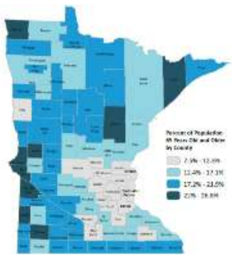
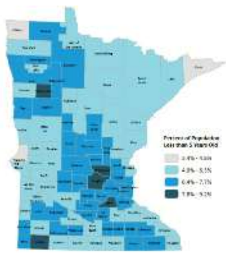
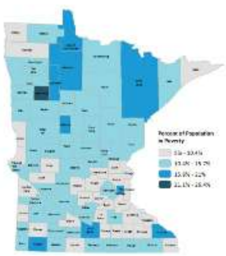
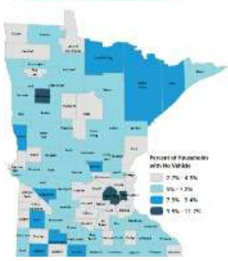
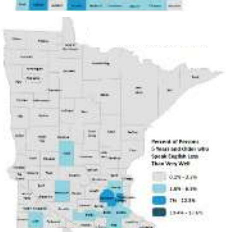
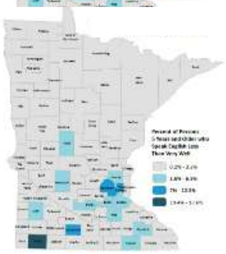
It should be noted that risks which appear to have lower sensitivity levels should not be considered irrelevant for the community. The graphic to the left is a possible ordering of risk sensitivity for the communities within the Northeast Minnesota Region.

Comparison of Vulnerable Populations of Region's Communities

The graphics below compare the percentage of population for some of the most vulnerable groups in the State of Minnesota, and each of the Region's subject cities. This comparison is one of three primary ways in which this report analyzes the vulnerable population data. For more information see the "Findings" section of this report.

(Source: State of Minnesota Department of Health and US Census Data)

Vulnerable Population Comparisons:

		Minnesota	Chisholm	Mountain Iron	Ranier	Region Average
	65 Years and Older	15.1%	17.7%	18.7%	37.5%	19.3%
	Under 5 Years	6.7%	6.9%	9.0%	5.6%	7.5%
	<100% Poverty	9.9%	13.3%	11.9%	3.2%	12.2%
	No Vehicle	2.6%	3.3%	1.6%	1.5%	2.6%
	Limited English	4.4%	5.5%	2.4%	0.4%	4.2%
	Disabilities	11.1%	22.2%	12.0%	23.5%	18.8%

Section 10

Findings

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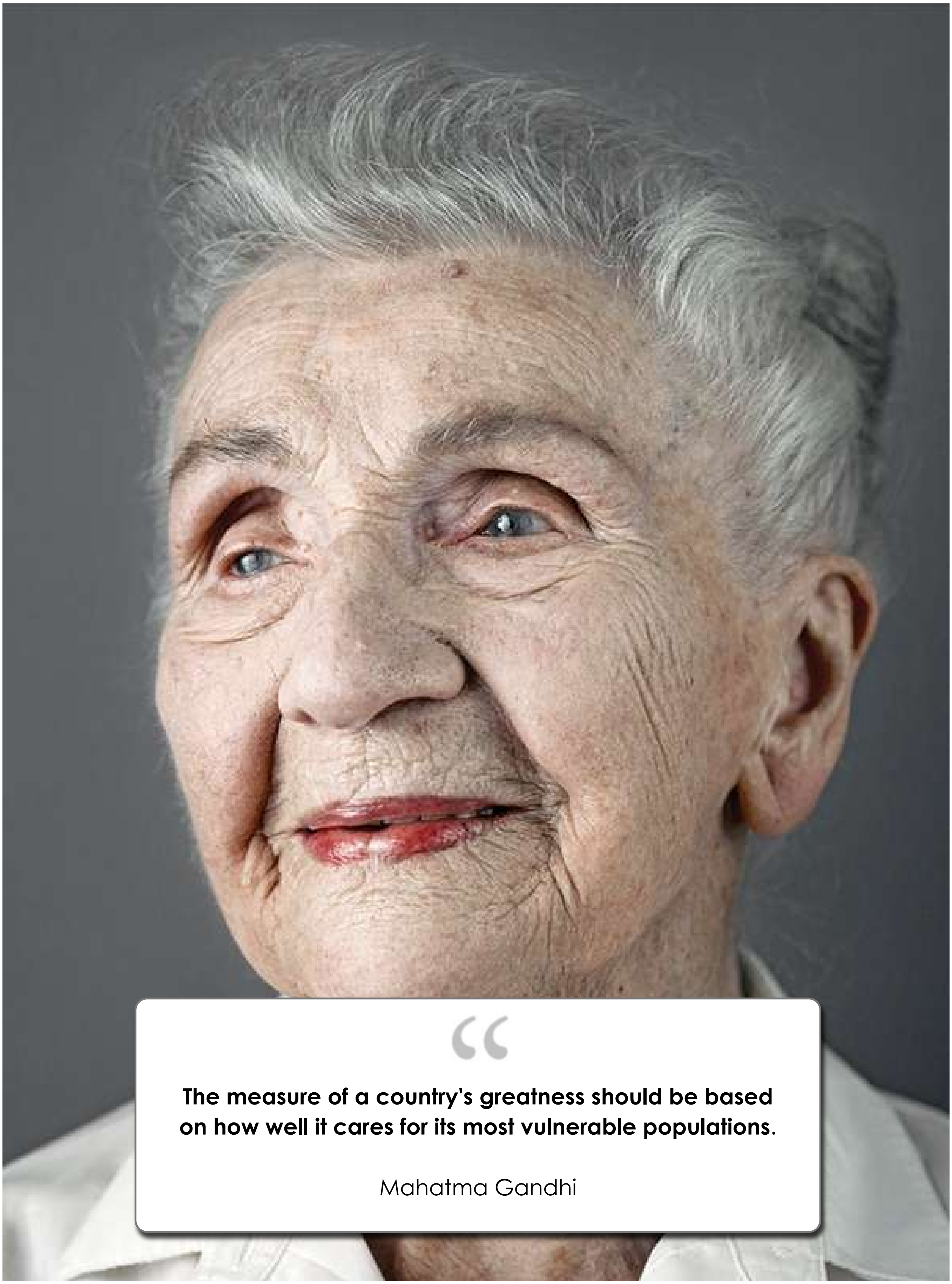

"
The measure of a country's greatness should be based on how well it cares for its most vulnerable populations.
Mahatma Gandhi

Findings

Findings - Vulnerable Populations

Climate change impacts will affect everyone and City policies and actions should consider climate adaptive needs of the entire community. As with all planning efforts climate adaptation benefits from analysis in order to assist in establishing priorities for initial efforts. An effort to structure a prioritization should not be seen as an attempt to discard the need to address climate impacts for any population within the City - whether or not it is defined as one of the "vulnerable" populations . Prioritization, however, is necessary to ensure the greatest impact and effectiveness of limited City resources.

To assist in prioritization, this report reviews the community Vulnerable Populations data through a number of "filters" or criteria. The first is to compare the vulnerable demographic categories against each other within a community, the second is a recap of the comparison of vulnerable populations against state and regional averages, and the third is to compare the risk sensitivity categories represented by the various vulnerable populations within a community.

A review for prioritization within each of the Region's subject cities follows on the next pages.

Review and Comparison of Population Vulnerabilities - City of Chisholm

Comparing Vulnerable Populations Within The City

Population	Est Total	Share
Children	345	7-9%
Older Adults	886	20-22%
Disabled	1,111	25-27%
Economic Stress	949	22-24%
People of Color	203	4-6%
At Risk Workers	633	14-16%

Based on this view of the population vulnerabilities of the City, Disabled individuals, Older Adults, and those living in Economic Stress, represent those with the most significant vulnerabilities.

Regional Comparison of Vulnerable Populations

As detailed at the end of Section 9, a comparison of the Region's Average vulnerable populations can be made against the same population groupings State-wide.

Based on this comparison to the State, groups of comparative concern for the City are:

Economic Stress
Limited English
Limited Vehicle Access
Individuals with Disabilities

Comparing Risk Sensitivities Within City

This comparison is based on the total estimated count for each vulnerable population and considers the particular risks each demographic is most sensitive to. The result is an accounting of the risks with the greatest number of sensitive individuals (see Section 9 for more info)

The risks with the highest sensitivities are:

Extreme Temp / Weather
Air Quality Impacts
Flood
Food Access

Review and Comparison of Population Vulnerabilities - City of Mountain Iron

Comparing Vulnerable Populations Within The City

Population	Est Total	Share
Children	258	12-14%
Older Adults	537	25-27%
Disabled	345	16-18%
Economic Stress	217	23-25%
People of Color	95	4-6%
At Risk Workers	323	15-17%

Based on this view of the population vulnerabilities of the City, Older Adults, Disabled individuals, and those living in Economic Stress, represent those with the most significant vulnerabilities.

Regional Comparison of Vulnerable Populations

As detailed at the end of Section 9, a comparison of the Region's Average vulnerable populations can be made against the same population groupings State-wide.

Based on this comparison to the State, groups of comparative concern for the City are:

Children Under 5
Older Adults
Economic Stress
Individuals with Disabilities

Comparing Risk Sensitivities Within City

This comparison is based on the total estimated count for each vulnerable population and considers the particular risks each demographic is most sensitive to. The result is an accounting of the risks with the greatest number of sensitive individuals (see Section 9 for more info)

The risks with the highest sensitivities are:

Extreme Temp / Weather
Air Quality Impacts
Flood
Vector Borne Diseases

Review and Comparison of Population Vulnerabilities - City of Ranier

Comparing Vulnerable Populations Within The City

Population	Est Total	Share
Children	29	4-6%
Older Adults	195	28-30%
Disabled	122	18-20%
Economic Stress	230	34-36%
People of Color	24	3-5%
At Risk Workers	74	10-12%

Based on this view of the population vulnerabilities of the City, those living in Economic Stress, Older Adults, and Disabled individuals represent those with the most significant vulnerabilities.

Regional Comparison of Vulnerable Populations

As detailed at the end of Section 9, a comparison of the Region's Average vulnerable populations can be made against the same population groupings State-wide.

Based on this comparison to the State, groups of comparative concern for the City are:

Older Adults
Individuals with Disabilities

Comparing Risk Sensitivities Within City

This comparison is based on the total estimated count for each vulnerable population and considers the particular risks each demographic is most sensitive to. The result is an accounting of the risks with the greatest number of sensitive individuals (see Section 9 for more info)

The risks with the highest sensitivities are:

Flood
Extreme Temp / Weather
Air Quality Impacts
Food

Summary of Vulnerable Population Findings -

City of Chisholm

As noted , Climate Change impacts will affect everyone. Prioritizing the City's efforts to address the most vulnerable populations within the City will help ensure the greatest impact with limited resources. Based on the previous review the City's adaptive efforts may be most effective by prioritizing strategies which address the climate risks of Extreme Temp/Weather, Air Quality Impacts, Vector Borne Diseases, and Food Insecurity. Particular attention should be paid to strategies which are most effective for individuals with Disabilities, Older Adults, and those in Economic Stress.

Summary of Vulnerable Population Findings -

City of Mountain Iron

As noted , Climate Change impacts will affect everyone. Prioritizing the City's efforts to address the most vulnerable populations within the City will help ensure the greatest impact with limited resources. Based on the previous review the City's adaptive efforts may be most effective by prioritizing strategies which address the climate risks of Extreme Temp/Weather, Air Quality Impacts, Vector Borne Diseases, and Flood. Particular attention should be paid to strategies which are most effective for Older Adults, individuals with Disabilities, Children, and those in Economic Stress.

Summary of Vulnerable Population Findings -

City of Ranier

As noted , Climate Change impacts will affect everyone. Prioritizing the City's efforts to address the most vulnerable populations within the City will help ensure the greatest impact with limited resources. Based on the previous review the City's adaptive efforts may be most effective by prioritizing strategies which address the climate risks of Flood, Extreme Temp/Weather, Air Quality Impacts, and Food Insecurity. Particular attention should be paid to strategies which are most effective for those in Economic Stress, Older Adults, and individuals with Disabilities.

Findings - City's Climate Impact Multipliers

Based on the summary of vulnerable population findings from the previous pages, it is appropriate to re-visit some of the Community's Climate Impact Multiplier characteristics defined in Section 7 to determine which, if any, of those characteristics should be addressed in the prioritized Adaptation and Resilience Goals and Strategies.

Findings - Impervious Surface, Tree Canopy, and Heat Island

The graphics below illustrates an aerial image of some of the primary communities within the Region. Lighter colors represent increased impervious surfaces and sun exposures. Areas which have both higher density, and increased impervious surfaces and sun exposures (lighter color) are areas likely to experience micro climate heat island effects and would benefit from anti-heat island strategies particularly those in the tracts with the highest impact sensitivities.

Impervious Surface, Tree Canopy, and Heat Island - City of Chisholm

Based on the aerial view of the City of Chisholm to the left, it appears that the downtown area and core of the City of Chisholm may benefit from increased tree canopy development. We recommend that the City of Chisholm conduct a detailed tree canopy and land cover assessment city-wide to determine ideal strategies and priorities for addressing impervious surface impacts. Study should also identify tree species within community to determine if they are resilient or vulnerable species.

Impervious Surface, Tree Canopy, and Heat Island - City of Mountain Iron

Based on the aerial view of the City of Mountain Iron to the left, it appears that much of the City has a quality tree canopy, however, the downtown area may benefit from increased tree canopy development. We recommend that the City of Mountain Iron conduct a detailed tree canopy and land cover assessment of the downtown area to determine ideal strategies and priorities for addressing impervious surface impacts. Study should also identify tree species within community to determine if they are resilient or vulnerable species.

Impervious Surface, Tree Canopy, and Heat Island - City of Ranier

Based on the aerial view of the City of Ranier to the left, it appears that much of the City has a quality tree canopy. We recommend that the City of Ranier may benefit from a community tree canopy study, and identification of tree species to determine if they are resilient or vulnerable species, and development of strategies to retain and improve the tree canopy health in the community.

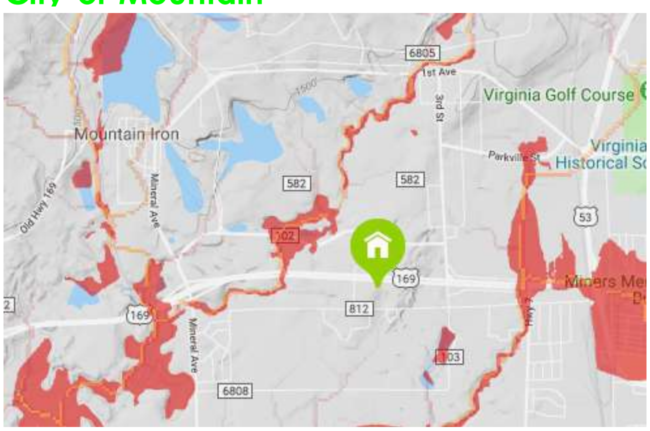
Findings - Flood Vulnerability

The graphics below illustrates FEMA flood vulnerable areas with darker shades representing higher flood risk levels. Each Community should carefully review the locations of the vulnerable populations outlined in this report to determine which populations with higher climate impact sensitivities may reside in areas which would benefit from flood mitigation strategies. Those which overlap with the higher exposure areas illustrated in the Impervious Surface, Tree Canopy, and Heat Island graphics would likely also benefit from strategies which increase tree canopy and pervious land cover.

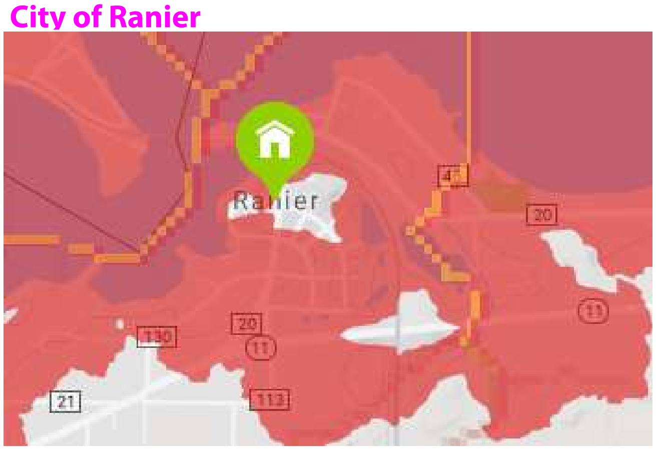
Additionally, each community should review their susceptibility to flash flooding which can occur in a variety of geographic areas beyond FEMA designated flood zones. Flash flood vulnerabilities can be identified by using the Blue Spot mapping method.

City of Chisholm

City of Mountain



City of Ranier



Findings - Climate Resilience Indicators

Based on the Region's increased risk sensitivity of Air Quality the EPA Environmental Indicators of particular concern are:

Indicator	Chisholm	Mountain Iron	Ranier
Particulate Matter (PM 2.5)	16th percentile	17th percentile	7th percentile
Ozone	4th percentile	4th percentile	3rd percentile
Diesel Particulate Matter	<50th percentile	<50th percentile	<50th percentile

Potential health effects of PM exposure, increased risk of:
impaired respiratory function
chronic cough
bronchitis
chest illness
chronic obstructive pulmonary disease (COPD)
pneumonia
cardiovascular diseases
allergic disease and asthma
cardiopulmonary diseases
cancer

Breathing in particles causes inflammation in our respiratory and circulatory system. These pollutants can make it harder to breathe; it can cause asthma-like symptoms - of particular concern with St Louis and Koochiching County's high instance of asthma emergency department visits. High rates of particulate matter pollution have been linked to higher rates of cancer, heart disease, stroke, and early on-set dementia.

The primary source for particulate matter pollution is vehicle emissions and incomplete fossil fuel combustion for heating, cooling, and energy generation. The Clean Diesel Program provides support for projects that protect human health and improve air quality by reducing harmful emissions from diesel engines. This program includes grants and rebates funded under the Diesel Emissions Reduction Act (DERA). Each City's proximity to high traffic volumes are in the following State of Minnesota percentiles:

	Chisholm	Mountain Iron	Ranier
Traffic Proximity	70th percentile	56th percentile	66th percentile

Summary of Climate Impact Multiplier and Climate Resilience Findings

In addition to the strategy priorities outlined in the Summary of Vulnerable Population Findings, each City should look to prioritize strategies which address the City's Climate Impact Multiplier characteristics and opportunities. These community characteristics will benefit from strategies which: increase pervious surfaces, tree canopy cover, and greenscaping; mitigate flood hazards; and increase Air Quality, particularly from stationary and mobile fossil fuel use.

Photo: SVR Design

Section 11

Recommendations

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Recommendations

Recommended Adaptation and Resilience Goals

On the following pages are recommended overall goals for increasing the climate resilience for each City. These goals are based on the anticipated climate impacts for the Region as well as the vulnerable populations present in each City. Some of the goals and strategies identified in this report will require new City policies or program development. Many others have some existing City, County, and State policies already underway which relate to them. A detailed review of all existing policies against the goals and the strategies recommended in this report should be conducted and policy modifications integrated.

Following the Climate Adaptation and Resilience Goals provided for each City is a Recommended Menu of Adaptation and Resilience Strategies. The menu of strategies provided relate to all goals identified for all Cities within this region. Each City may wish to focus only on those strategies listed for the Goals recommended for that City

In prioritizing the implementation of the goals and strategies which follow, each of the Cities should:

- Consider available resources and opportunities to leverage new resources.
- When budget, staff, or schedule restrictions limit strategy implementation capacity, apply strategies with a priority towards vulnerable populations and tracts/areas with higher vulnerable populations (see Section 10, page 10-3 for further information)
- Consider the associated carbon emission reduction opportunities and other co-benefits of strategies.
- Study the anticipated equity impacts of strategies.
- Consider the urgency and window of opportunity.
- Conduct appropriate outreach and engagement efforts with community residents and businesses for community feedback and buy-in.
- Identify departments / staff capable of taking the lead for strategy implementation. Integrate implementation plans into a routine working plan that is reviewed and revised regularly (every 2 to 5 years recommended).
- Whenever possible select strategies that provide everyday benefits in addition to climate risk reduction. These forms of strategies are known as "no regrets strategies" and they can be justified from economic, social, and environmental perspectives whether natural hazard events or climate change hazards take place or not.

Climate Adaptation and Resilience Goals - City of Chisholm

Goals are organized based on the primary anticipated climate change impacts they address. Detailed strategies for each goal are identified in the next section.

C Goals To Build Capacity For Preparing For And Responding To Population Risks Of Climate Change Impacts

Goal C1 - Incorporate climate change preparedness activities into existing local government plans and programs as a means to increase resilience while minimizing costs.

Goal C2 - Improve effectiveness of on-going adaptation measures.

Goal C3 - Strengthen emergency management capacity to respond to weather-related emergencies.

Goal C4 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to climate impacts.

Goal C5 - Enhance resilience of critical city operations.

Goal C6 - Enhance city's capacity for adaptation implementation.

Goal C7 - Secure funding to support City's adaptation efforts.

H Goals Responding to Heat Stress And Extreme Weather

Goal H1 - Strengthen emergency management capacity to respond to heat stress and extreme weather.

Goal H2 - Minimize health issues caused by extreme heat days, especially for populations most vulnerable to heat.

Goal H3 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to high heat and extreme weather.

Goal H4 - Decrease the urban heat island effect, especially in areas with populations most vulnerable to heat.

Goal H5 - Enhance resilience of community tree canopy and park/forest land

Goal H6 - Enhance the resilience of buildings within the community to extreme heat, weather, and energy and fuel disruptions.

Goal H7 - Improve the energy efficiency and weatherization of homes and businesses to reduce energy costs and carbon pollution.

Goal H8 - Expand access to distributed solar energy in low-income communities in order to lower energy bills, increase access to air conditioning, and decrease carbon pollution levels.

Goal H9 - Enhance resilience of local businesses to extreme weather.

Goal H10 - Strengthen social cohesion and networks to increase support during extreme weather events.

Goal H11 - Increase the resilience of natural and built systems to adapt to increased timeframes between precipitation and increased drought conditions.

Goal H12 - Enhance the reliability of the grid during high heat events to minimize fires, brownouts and blackouts.

Goals Responding to Air Quality Impacts

Goal A1 - Reduce auto-generated particulate matter, tailpipe pollutants, waste heat, and ozone formation.

Goal A2 - Increase and maintain air quality for residents and businesses.

Goals Responding To Vector-Borne Disease Risks

Goal V1 - Manage the increased risk of disease due to changes in vector populations.

Goals Responding To Food Insecurity And Food-borne Disease Risks

Goal FI-1 - Increase food security for residents, especially those most vulnerable to food environment.

Goals Enhancing Economic Resilience In Support of Climate Resilience

Goal E1 - Leverage the economic development opportunities of the Green Economy

Goal E2 - Enhance community resilience through economic resilience

Goal E3 - Including Economic Resilience in Emergency Response Planning

Climate Adaptation and Resilience Goals - City of Mountain Iron

Goals are organized based on the primary anticipated climate change impacts they address. Detailed strategies for each goal are identified in the next section.

C Goals To Build Capacity For Preparing For And Responding To Population Risks Of Climate Change Impacts

Goal C1 - Incorporate climate change preparedness activities into existing local government plans and programs as a means to increase resilience while minimizing costs.

Goal C2 - Improve effectiveness of on-going adaptation measures.

Goal C3 - Strengthen emergency management capacity to respond to weather-related emergencies.

Goal C4 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to climate impacts.

Goal C5 - Enhance resilience of critical city operations.

Goal C6 - Enhance city's capacity for adaptation implementation.

Goal C7 - Secure funding to support City's adaptation efforts.

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Goal H3 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to high heat and extreme weather.

Goal H4 - Decrease the urban heat island effect, especially in areas with populations most vulnerable to heat.

Goal H5 - Enhance resilience of community tree canopy and park/forest land

Goal H6 - Enhance the resilience of buildings within the community to extreme heat, weather, and energy and fuel disruptions.

Goal H7 - Improve the energy efficiency and weatherization of homes and businesses to reduce energy costs and carbon pollution.

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Goal H10 - Strengthen social cohesion and networks to increase support during extreme weather events.

Goal H11 - Increase the resilience of natural and built systems to adapt to increased timeframes between precipitation and increased drought conditions.

Goal H12 - Enhance the reliability of the grid during high heat events to minimize fires, brownouts and blackouts.

Goals Responding to Air Quality Impacts

Goal A1 - Reduce auto-generated particulate matter, tailpipe pollutants, waste heat, and ozone formation.

Goal A2 - Increase and maintain air quality for residents and businesses.

Goals Responding To Vector-Borne Disease Risks

Goal V1 - Manage the increased risk of disease due to changes in vector populations.

Goals Responding To Flood Vulnerability

Goal F1 - Strengthen emergency management capacity to respond to flood-related emergencies.

Goal F2 - Increase the resilience of the natural and built environment to more intense rain events and associated flooding.

Goal F3 - Enhance resilience to fuel disruptions in transportation and mobility.

Goals Enhancing Economic Resilience In Support of Climate Resilience

Goal E1 - Leverage the economic development opportunities of the Green Economy

Goal E2 - Enhance community resilience through economic resilience

Goal E3 - Including Economic Resilience in Emergency Response Planning

Climate Adaptation and Resilience Goals - City of Ranier

Goals are organized based on the primary anticipated climate change impacts they address. Detailed strategies for each goal are identified in the next section.

C Goals To Build Capacity For Preparing For And Responding To Population Risks Of Climate Change Impacts

Goal C1 - Incorporate climate change preparedness activities into existing local government plans and programs as a means to increase resilience while minimizing costs.

Goal C2 - Improve effectiveness of on-going adaptation measures.

Goal C3 - Strengthen emergency management capacity to respond to weather-related emergencies.

Goal C4 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to climate impacts.

Goal C5 - Enhance resilience of critical city operations.

Goal C6 - Enhance city's capacity for adaptation implementation.

Goal C7 - Secure funding to support City's adaptation efforts.

H Goals Responding to Heat Stress And Extreme Weather

Goal H1 - Strengthen emergency management capacity to respond to heat stress and extreme weather.

Goal H2 - Minimize health issues caused by extreme heat days, especially for populations most vulnerable to heat.

Goal H3 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to high heat and extreme weather.

Goal H4 - Decrease the urban heat island effect, especially in areas with populations most vulnerable to heat.

Goal H5 - Enhance resilience of community tree canopy and park/forest land

Goal H6 - Enhance the resilience of buildings within the community to extreme heat, weather, and energy and fuel disruptions.

Goal H7 - Improve the energy efficiency and weatherization of homes and businesses to reduce energy costs and carbon pollution.

Goal H8 - Expand access to distributed solar energy in low-income communities in order to lower energy bills, increase access to air conditioning, and decrease carbon pollution levels.

Goal H9 - Enhance resilience of local businesses to extreme weather.

Goal H10 - Strengthen social cohesion and networks to increase support during extreme weather events.

Goal H11 - Increase the resilience of natural and built systems to adapt to increased timeframes between precipitation and increased drought conditions.

Goal H12 - Enhance the reliability of the grid during high heat events to minimize fires, brownouts and blackouts.

A Goals Responding to Air Quality Impacts

Goal A1 - Reduce auto-generated particulate matter, tailpipe pollutants, waste heat, and ozone formation.

Goal A2 - Increase and maintain air quality for residents and businesses.

F Goals Responding To Flood Vulnerability

Goal F1 - Strengthen emergency management capacity to respond to flood-related emergencies.
Goal F2 - Increase the resilience of the natural and built environment to more intense rain events and associated flooding.
Goal F3 - Enhance resilience to fuel disruptions in transportation and mobility.

FI Goals Responding To Food Insecurity And Food-borne Disease Risks

Goal FI-1 - Increase food security for residents, especially those most vulnerable to food environment.

E Goals Enhancing Economic Resilience In Support of Climate Resilience

Goal E1 - Leverage the economic development opportunities of the Green Economy
Goal E2 - Enhance community resilience through economic resilience
Goal E3 - Including Economic Resilience in Emergency Response Planning

Recommended Menu of Adaptation and Resilience Strategies

Adaptive capacity can be broadly defined as the ability of a system to adjust, limit, and cope with potential hazards due to climate change. Potential measures of adaptive capacity include access to financial resources, health infrastructure, and technology. Adaptive capacity also refers to the ability of a system to reduce hazardous exposures, which can be measured by the implementation of government programs, initiatives, or policies.

To meet the recommended Adaptation goals outlined in the previous section, this report provides a range of potential adaptation strategies. This Menu of Adaptation and Resilience Strategies should form the basis for a Climate Adaptation Implementation planning effort. The planning effort should include a detailed review of the City's existing policies and community resources. The Climate Adaptation Implementation planning effort should include appropriate community engagement to share information about population vulnerabilities to the changing climate and to solicit feedback on the final adaptation strategies. The final Climate Adaptation Implementation Plan should include a detailed implementation schedule and should identify responsible parties for each strategy to be implemented.

C Strategies To Build Capacity For Preparing For And Responding To Population Risks Of Climate Change Impacts

Goal C1 - Incorporate climate change preparedness activities into existing local government plans and programs as a means to increase resilience while minimizing costs.

C1-1

Adopt climate change adaptation actions which fulfill other societal goals, such as sustainable development, disaster risk reduction, or improvements in quality of life, and can therefore be incorporated into existing decision-making processes. These are called "no regrets" actions.

C1-2

Address climate change adaptation and mitigation (to help reduce the need to adapt more and possibly beyond human capacity in the future) in locally meaningful ways in the local comprehensive plan.

C1-3

Consider populations most vulnerable to heat and living in urban heat islands when making decisions about tree planting, protection and maintenance, green infrastructure placement, and access to vegetated open spaces and natural areas of City owned land.

C1-4

Establish a multi-jurisdiction/multi-department adaptive management coordination team to: review emerging climate research, trends and regulations at least once a year.

C1-5

Utilize an equity framework or lens to ensure preparation actions are implemented in ways that deliver more equitable outcomes and prioritize populations most vulnerable to climate change impacts.

C1-6

As appropriate, coordinate with or require health and safety service providers to support recommendations of this Population Vulnerability Assessment (e.g., provide education and resources about climate risks to populations most vulnerable to climate change impacts and development of continuity of operations plans).

C1-7

Continue to pursue energy efficiency opportunities to minimize impacts from rising energy costs and increased cooling demands in City and County owned and operated facilities.

C1-8

Train public health officials, urban planners and emergency responders about the specific community risks from climate change (priority).

C1-9

Complete a Climate Adaptation and Action Plan identifying finalized climate adaptation strategies as well as climate mitigation (greenhouse gas emission and energy reduction) strategies. Include community engagement process and detailed implementation plan.

Goal C2 - Improve effectiveness of on-going adaptation measures.

C2-1

Establish a community engagement effort to develop a detailed climate adaptation implementation plan.

C2-2

Involve all vulnerable populations in the community to develop relevant parts of the plan, specifically taking into account the need to engage trusted leaders, meet in locations perceived as safe and convenient and at available times for those demographics, and providing transportation, childcare, and wage support as needed.

Goal C3 - Strengthen emergency management capacity to respond to weather-related emergencies.

C3-1

Train emergency responders on the risks from climate change and engage them in the process of adaptation planning and resiliency.

C3-2

Coordinate with city, county, and state emergency managers by sharing this report and engage them for response and communication planning coordination.

C3-3

Develop, test, train, and update emergency response plans that address hazards likely to become more frequent or intense as the climate changes, including flood and extreme heat. Plan for projected increases in weather-related emergencies, especially high-heat days, and the resulting potential for increased violence, mental illness, chemical dependency and addiction.

C3-4

Promote equity in hazard mitigation, and emergency response and recovery activities, and consider populations most vulnerable to weather-related emergencies in all plans and exercises, including evacuation routes, transportation for vulnerable population groups, shelter in place locations, back-up power operations, extended access to fuel/power sources and drinking water, etc.

C3-5

After weather-related emergency events, assess response to identify effectiveness, deficiencies and resources needed to build future resilience.

C3-6

Through training, educational materials and other resources, strengthen capabilities of individuals and organizations that assist in disaster response as well as community/cultural groups to prepare for potential climate change impacts, including disproportionate impacts on populations most vulnerable to climate change risks.

C3-7

Create map of key infrastructure vulnerabilities and level of risk.

C3-8

During Hazard Mitigation Plan Update process include climate change risk assessment and incorporate climate adaptation strategies into planning process.

Goal C4 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to climate impacts.

C4-1

Create and make available an Emergency Response Toolkit offering tips and suggestions for residents to increase their emergency preparedness.

C4-2

Outreach to local community groups representing vulnerable populations outlined in this document (churches, minority representatives, senior center and supportive groups, etc.) and develop a coordinated communication plan to reach vulnerable populations.

C4-3

Link low-income populations, communities of color, older adults and people with disabilities to services that help reduce safety, health and financial risks associated with climate change impacts.

C4-4

Build capacity and leadership within communities most vulnerable to climate change impacts by promoting, supporting and leveraging community-specific strategies, projects and events.

C4-5

Invest in research projects that identify local vulnerabilities and the most appropriate region-specific strategies.

Goal C5 - Enhance resilience of critical city operations.

C5-1

Establish mutual aid agreements with neighboring law enforcement, fire, first responders and utilities.

C5-2

Conduct climate change impacts and adaptation training for law enforcement, fire, first responders, and utilities.

C5-3

Develop emergency response plans that include information on increased risks and vulnerabilities from climate change.

C5-4
Explore feasibility of establishing a solar micro-grid serving community facilities and supporting critical operations power backup.
C5-5
Decrease impervious areas and increase the total eco-roof acreage of public buildings (green roof, cool roof, etc.).

Goal C6 - Enhance city's capacity for adaptation implementation.

C6-1
Engage in available support for local leaders to establish or enhance emergency shelters: https://www.disasterassistance.gov/get-assistance/community-leaders?queryString=shelter%20housing
C6-2
Participate in programs that evaluate and share city practices and provide technical support, such as the GreenStep Cities program (https://greenstep.pca.state.mn.us/) and the Regional Indicators Initiative.
C6-3
Identify funding and financing opportunities to pay for adaptation and resiliency planning and project implementation
C6-4
Create cross jurisdictional partnerships that pool resources to protect vulnerable assets and increase capacity to respond to emergencies.
C6-5
Identify staff responsible for City preparedness, emergency response, and recovery efforts for each type of event and risk identified in this report.

Goal C7 - Secure funding to support City's adaptation efforts.

C7-1
Explore development of sustainability / carbon / or climate fund.
C7-2
Develop a list of projects and a list of potential grant or other funding opportunities.
C7-3
Examine how existing funding sources can be leveraged to enhance resilience and climate adaptation.
C7-4
Leverage Community Development Block Grants from the Department of Housing and Urban Development (HUD) to invest in resilient and equitable communities: https://www.hud.gov/program_offices/comm_planning/communitydevelopment ; https://www.hudexchange.info/programs/cdbg-state/state-cdbg-program-eligibility-requirements/ https://www.hudexchange.info/grantees/minnesota/?program=2

H Strategies Responding to Heat Stress And Extreme Weather

Goal H1 - Strengthen emergency management capacity to respond to heat stress and extreme weather.

H1-1
Plan and establish alternative or on-site power supply.
H1-2
Develop energy management plans for key facilities and cooling centers.
H1-3
Identify key risk areas and infrastructure that is at risk from high heat or extreme weather. Train and educate emergency responders about this risk.
H1-4
Develop, test, train, and update emergency response plans that address hazards likely to become more frequent or intense as the climate changes, including heat stress and extreme weather.
H1-5
Create map of key infrastructure vulnerabilities and level of risk.

H1-6

Make emergency communications available in multiple languages and platforms. The City's top non-English languages should be addressed in the multiple-language communication plan. Platforms used should focus specifically on reaching the City's top vulnerable populations identified in this report.

H1-7

Develop communication plan, methods, and pathways for when community power and communication systems are non-functional.

Goal H2 - Minimize health issues caused by extreme heat days, especially for populations most vulnerable to heat.

H2-1

Create a Heat Response Plan, in coordination with the County if appropriate, based on Minnesota Department of Health Extreme Heat Toolkit - mid-cost
http://www.health.state.mn.us/divs/climatechange/extremeheat.html

H2-2

Partner with community-based organizations and local service providers to seniors and people with disabilities to assess the need for and coordinate the operation of cooling environments, including extended hours of Senior Center Operations, which are culturally appropriate and readily accessible (low-mid cost).

H2-3

Improve the energy efficiency of homes, apartments and commercial buildings to keep interiors cool, improving the comfort and safety of occupants and reducing the need for summer air conditioning. Encourage the planting of trees and vegetation on the south and west sides of homes and buildings to reduce summer heat gain (mid-cost). Job creation opportunity.

H2-4

Ensure public safety staff is properly trained to recognize and respond to physical and behavioral signs of heat related illness (mid-low cost).

H2-5

Create a reverse 911 call system where public health officials call vulnerable individuals during extreme heat events (mid-low cost).

H2-6

Create an interactive and easy to use website that maps all area cooling centers and provides advice and information on how to stay safe during high heat events (mid-cost).

H2-7

Provide travel vouchers to vulnerable individuals to use during high heat emergencies since lack of transportation is highly correlated to heat vulnerability (mid cost).

H2-8

Provide indoor cooling centers and outdoor cooling stations (mid-cost).

H2-9

Implement a heat alert and response program to prevent heat-related illness and death (mid-cost).

H2-10

Increase in heat education at community centers, parks, pools, and City facilities (low-cost).

H2-11

Make air conditioned public facilities available during poor air quality days and high heat days

Goal H3 - Improve the capacity of the community, especially populations most vulnerable to climate change risks, to understand, prepare for and respond to high heat and extreme weather.

H3-1

Expand the capacity to educate health care providers to recognize and report patterns of heat-related illnesses and injuries, and to inform the public about preventive actions.

H3-2

Provide education and resources about climate risks to the public, especially those most vulnerable to potential impacts of high-heat and extreme weather, via communication platforms typically relied upon for information by those populations.

H3-3
Develop and distribute culturally appropriate and accessible materials about extreme heat and related respiratory-illness, especially to populations most vulnerable to those impacts, via communication platforms typically relied upon for information by those populations.

Goal H4 - Decrease the urban heat island effect, especially in areas with populations most vulnerable to heat.

H4-1
Develop an outreach campaign coordinated with local social non-profits and community groups to help build awareness of heat island risks and establish a foundation for action.

H4-2
Identify vulnerable urban tree canopy and street tree sections and develop policies to incentivize, encourage, or require strategic tree planting for heat island mitigation (mid-cost).

H4-3
Develop policies and programs which decrease impervious surfaces, especially in neighborhoods of increased vulnerable populations (high-cost).

H4-4
Research, evaluate and pilot porous paving, de-paving, vegetation and/or more reflective surfaces in parking areas to reduce and cool impervious surfaces, particularly in urban heat island areas with populations most vulnerable to heat (high-cost).

H4-5
Add or modify park plantings in under-served areas, and increase maintenance to sustain mature tree canopy, decrease tree hazards and delay tree replacement needs (mid-cost).

H4-6
Reduce generation of waste heat from buildings by promoting and incentivizing building energy efficiency measures (low-cost).

H4-7
Consider building and development standards/policies/ordinances (applicable to public buildings, to PUDs, and to private-sector buildings which receive public funding/resources) to increase vegetative cover and increase the solar reflective quality of surfaces (mid-cost).

H4-8
Explore creation of a Heat Island Reduction Incentive / Award program. Incentives and awards from governments, utilities, and other organizations can be an effective way to spur individual heat island reduction actions. Incentives might include below-market loans, tax breaks, product rebates, grants, and giveaways. (Determine the optimum balance for achieving climate adaptation goals of incentives vs. potential loss of tax base needed to accomplish those goals.) Awards can reward exemplary work, highlight innovation, and promote solutions across the public and private sectors.

H4-9
Create incentive programs for cool roofs and green roofs. Develop policies/ordinances (for public buildings, PUDs, and private-sector buildings which receive public funding/resources) that require all new roofs meet cool roof standards if applicable. Utilize reach code if adopted as option for State Building Code. (See CA Title 24 Cool Roof Requirement as an example:
http://www.energy.ca.gov/title24/coolroofs/documents/COOLROOF-REQUIREMENTS.PDF) (mid-cost)

H4-10
In areas where increased tree canopy is not feasible or appropriate, design and build shading structures (high-cost).

Goal H5 - Enhance resilience of community tree canopy and park/forest land

H5-1
Conduct a City Tree Canopy and Land Cover Survey to determine the extent, quality, and opportunities for the City's tree canopy (low-cost).

H5-2
Evaluate the impact of the City's tree codes and modify to enhance protection of city's tree canopy (mid-cost).

H5-3
Develop a tree planting incentive program for residents, include a maintenance plan as part of the program (low-mid).
H5-4
Apply the latest climate and forestry science to develop a climate adaptive ready tree species list for use in City plantings/replacements as well as for communication to residents, building owners, and developers (low-cost). https://www.extension.umn.edu/garden/yard-garden/trees-shrubs/recommended-trees-for-minnesota/index.html
H5-5
Apply the latest climate science in revision of urban tree canopy goals for the City and address tree canopy disparities in neighborhoods where populations most vulnerable to heat live (low-cost).
H5-6
Participate in State and Federal urban forestry assistance programs as available (funding opportunity)
H5-7
Build community gravel beds to raise bare root tree stock with more fibrous root systems that have greater resilience at lower cost for transplantation to parks and boulevards: http://www.mntreesource.com/gravel-beds.html
H5-8
Create a Citizen Pruner program that assists city staff focused on large tree removals and mature trees by having residents help young trees grow properly and not become public safety hazards: http://www.mntreesource.com/citizen-pruner.html

Goal H6 - Enhance the resilience of buildings within the community to extreme heat, weather, and energy and fuel disruptions.

H6-1
Make a property-assessed clean energy (PACE) program available for conservation and renewable energy (low).
H6-2
Promote businesses and residents exploring making their building sites solar resilient: http://solarresilient.org/
H6-3
Adopt policies to incentivize building owners to increase the resilience of existing and new buildings with resilience strategies such as elevated HVAC and electrical off basement floor, installation of backflow preventers, tree maintenance, permeable pavements, energy conservation and on-site renewable energy generation, and safe rooms.

Goal H7 - Improve the energy efficiency and weatherization of homes and businesses to reduce energy costs and carbon pollution.

H7 - 1
Explore development of a Living Buildings or Living Community district: https://living-future.org/lcc/
H7-2
Create a building weatherization program that includes a job training component: https://risingsunenergy.org/
H7-3
Promote the Weatherization Assistance Program to lower income families and homeowners: https://mn.gov/commerce/consumers/consumer-assistance/weatherization/

Goal H8 - Expand access to distributed solar energy in low-income communities in order to lower energy bills, increase access to air conditioning, and decrease carbon pollution levels.

H8 -1
Participate in federal, state, and local utility programs that incentivize the implementation of wind and solar power generation (low-cost).

H8 -2

Consider promoting the development or use of community solar gardens (CSGs) by public and private entities to enable fuller and more economic use of the community's solar resource, including participating as subscribers, assisting in marketing CSG opportunities for economic development, or providing sites for gardens (high-cost?).

H8 -3

Establish NET Metering and/or a Solar Feed-in-Tariff as part of the local utility to expand local rooftop solar (mid-cost).

H8 -4

Fight energy poverty by bringing no-cost solar energy systems to low-income families on public energy assistance: https://www.rreal.org/solar-assistance

H8 -5

Explore Solar+Storage for low- and moderate-income communities: https://www.cesa.org/projects/energy-storage-technology-advancement-partnership/

Goal H9 - Enhance resilience of local businesses to extreme weather.

H9-1

Identify local measures to address impacts to local economies, local resources, and infrastructure systems as a result of more frequent or severe weather events.

H9-2

Identify local initiatives as cost-saving measures that may, as a result, lower energy consumption, reduce the generation of greenhouse gas emissions, preserve water supply, reduce municipal waste, or increase participation in recycling programs.

H9-3

Identify the unique challenges faced by local businesses during extreme weather events.

Goal H10 - Strengthen social cohesion and networks to increase support during extreme weather events.

H10-1

Strengthen City's Heat Response Plan through collaboration with community stakeholders and populations most vulnerable to heat.

H10-2

Work with health care and social services providers to ensure their ability to provide appropriate services during extreme heat events.

H10-3

Work with community groups, churches, synagogues, and mosques that serve vulnerable populations to develop targeted support and outreach about the dangers of heat (mid-low cost)

H10-4

Set up call trees and block networks to check on neighbors during/after extreme weather events especially involving grid disruption.

H10-5

Improve the safety and walkability of neighborhood sidewalks to increase foot traffic and opportunities for community interaction and easy access to neighborhood businesses.

H10-6

Increase affordability and accessibility of transit options to improve ridership and strengthen facial recognition among residents in the neighborhood.

Goal H11 - Increase the resilience of natural and built systems to adapt to increased timeframes between precipitation and increased drought conditions.

H11-1

Determine stormwater volume requirements meeting anticipated future storm levels and identify stormwater management systems and infrastructure not capable of meeting projected needs. Prioritize upgrades required and implement. (mid-cost) (should be top priority)

H11-2

Adopt innovative techniques such as vegetated streets to provide habitat diversity and connectivity co-benefits while improving stormwater management. (mid-high cost)

Goal H12 - Enhance the reliability of the grid during high heat events to minimize fires, brownouts and blackouts.

H12-1

Work with local electric utilities to conduct a grid capacity and conditions assessment. Assessment recommendations should also identify renewable energy capacities and potentials including renewable energy back up.

Strategies Responding to Air Quality Impacts

Goal A1 - Reduce auto-generated particulate matter, tailpipe pollutants, waste heat, and ozone formation.

A1-1

Add bike racks around neighborhood businesses and community gathering places to reduce vehicle exhaust from driving and idling. (medium)

A1-2

Install roadside vegetation that creates effective barriers to prevent drifting of air pollutants to adjacent schools and residences. (medium)

A1-3

Conduct a Public Transit and bike infrastructure study and establish appropriate community wide bike infrastructure (low).

A1-4

Measure City transportation connectivity using Center for Neighborhood Technology's AllTransit index. Other indices also exist for walkable neighborhoods, commuting by bicycle, and commuting by walking (low).

A1-5

Develop and implement an Electric Vehicle "EV Ready" strategy plan (low).

A1-6

Reduce generation of waste heat from mobile sources by promoting and incentivizing public transit, biking and walking. (low-mid cost)

A1-7

Plan, design and maintain infrastructure to accommodate emerging autonomous vehicle technology and shared-ride economy strategies.

Goal A2 - Increase and maintain air quality for residents and businesses.

A2-1

Improve the weatherization and ventilation of homes, apartments and commercial buildings. Weatherization or retrofitting may include: installing storm windows, weather stripping, caulking, insulation. Methods of ventilating buildings and maintaining acceptable thermal conditions using resilient or passive design strategies should be a priority.

A2-2

Promote public awareness of air quality considerations and improvement strategies.

A2-3

Create a building weatherization program that includes a job training component (https://risingsunenergy.org/)

A2-4

Promote the Weatherization Assistance Program to lower income families and homeowners: https://mn.gov/commerce/consumers/consumer-assistance/weatherization/

A2-5

Establish a Green Roof policy to promote and advance the development of green roofs on existing buildings and new construction. Encourage rooftop garden / farm installations which advance food security. For a review of existing greenroof policies throughout the US review: http://www.traversecitymi.gov/downloads/green_roof_policies_incentieves_programs_case_studies_32014.pdf)

A2-6
Enhance street scape plantings and tree canopies, especially in areas of high traffic volumes.

A2-7
Explore use of the EPA Midwest Clean Diesel Program resources to create enhanced City policies and ordinances. The Clean Diesel Program provides support for projects that protect human health and improve air quality by reducing harmful emissions from diesel engines. This program includes grants and rebates funded under the Diesel Emissions Reduction Act (DERA).
https://www.epa.gov/cleandiesel/midwest-clean-diesel-initiative

A2-8
Explore use of the EPA Midwest Clean Diesel Program Funding to create incentives and support for City Operations and community businesses in the transition of fleets to Clean Diesel fleets. The Clean Diesel Program provides support for projects that protect human health and improve air quality by reducing harmful emissions from diesel engines. This program includes grants and rebates funded under the Diesel Emissions Reduction Act (DERA). https://www.epa.gov/cleandiesel/midwest-clean-diesel-initiative

A2-9
Conduct education and outreach on the health impacts of air pollution, longer allergy seasons, and extreme heat events.

F Strategies Responding To Flood Vulnerability

Goal F1 - Strengthen emergency management capacity to respond to flood-related emergencies.

F1-1
Plan and establish alternative or on-site power supply, especially those from renewable resources such as Solar.

F1-2
Develop energy management plans for water supply and wastewater treatment facilities and infrastructure.

F1-3
Build flood barriers to protect infrastructure, especially water and waste water infrastructure.

F1-4
Identify key risk areas and the infrastructure that is at risk from flooding. Train and educate emergency responders about this risk.

F1-5
Develop, test, train, and update emergency response plans that address hazards likely to become more frequent or intense as the climate changes, including flash flooding and unseasonal riverine flooding.

F1-6
Create map of key infrastructure vulnerabilities and level of risk.

F1-7
Incorporate trees and vegetation into complete street design.

Goal F2 - Increase the resilience of the natural and built environment to more intense rain events and associated flooding.

F2-1
Identify and address vulnerabilities in local infrastructure as a result of increased frequency and severity of storms and rainfall. (Mid cost).

F2-2
Determine storm water volume requirements meeting anticipated future storm levels and identify storm water management systems and infrastructure not capable of meeting projected needs. Prioritize upgrades required and implement. Integrate upgrades into already scheduled maintenance programs and budgets. (Mid cost)

F2-3
Review city codes, drainage rules, and surface waterways to evaluate their ability to protect and improve stream flows, seeps, springs, wetland function, water quality including temperature, vegetation and habitat, and storm water management during periods of extreme heavy rain. Use the Natural Resource Inventory and other data to track gains and losses, and propose revisions as necessary.

F2-4
Explore new and support expansion of voluntary programs promoting increased on-site storm water management such as rain gardens and impervious surfaces (low-cost).
F2-5
Adopt a storm water credit system to incentivize on-site management.
F2-6
Provide education and resources about climate risks to the public, especially those most vulnerable to potential impacts of flooding.
F2-7
Provide education to residents on what actions they can take to reduce their risk to extreme precipitation events and flash flooding.

Goal F3 - Enhance resilience to fuel disruptions in transportation and mobility.

F3-1
Develop and implement an Electric Vehicle “EV Ready” strategy plan that includes solar powered EV charging and EVs for city fleets.

[Need new sub-goals related to fuel disruption from flooding.]

V Strategies Responding To Vector-Borne Disease Risks

Goal V1 - Manage the increased risk of disease due to changes in vector populations.

V1-1
Identify and prioritize risks from current and projected extreme precipitation that threaten local infrastructure, environmental quality, health, ecosystems, public safety, and economic development (low-cost). (Part of first priorities)
V1-2
Develop and distribute culturally appropriate and accessible materials about vector-borne disease prevention.
V1-3
Expand the capacity to educate health care providers to recognize and report patterns of vector-borne disease illnesses and injuries, and to inform the public about preventive actions.
V1-4
Create and maintain a Response Plan for emerging vector-borne diseases, including increased capacity for health services that are triggered by certain case thresholds.
V1-5
Adopt/enforce codes/ordinances requiring window screens, especially for rental housing facilities.
V1-6
Strengthen insect-control efforts in areas of the city with more vulnerable populations and/or increased standing water, including water collected in abandoned refuse/tires/furnishings/etc
V1-7
Conduct education and outreach on the health impacts of vector-borne disease and strategies for avoidance.
V1-8
Strengthen insect-control efforts in areas of the city with more vulnerable populations and/or increased standing water, including water collected in abandoned refuse/tires/furnishings/etc.

FI Strategies Responding To Food Insecurity And Food-borne Disease Risks

Goal FI-1 - Increase food security for residents, especially those most vulnerable to food environment.

FI1-1
Conduct a detailed Food Security Assessment to determine food insecurity conditions within the City, target areas within the City for improvement, and identify detailed strategies to increase food security within City.

FI1-2
Expand the prevalence of community gardens and family gardens through the continued development, improvement, and communication of the City's urban agriculture policies and ordinances (low-cost).
FI1-3
Promote local food production, sales, and consumption and review City Codes to remove barriers for urban farming including innovative solutions such as aquaponics, hydroponics, indoor agriculture, vertical farms, etc.
FI1-4
Develop policies and ordinances which promote, encourage, or require permaculture landscaping in lieu of "traditional" lawn oriented landscaping.
FI1-5
Develop edible landscape zones for city-controlled properties and street boulevard zones where practicable (low-mid cost). (Could be similar or lower cost than existing landscaping)
FI1-6
Continue to support, collaborate on, and implement invasive species control programs (low-cost).
FI1-7
Develop pollinator friendly policies including promotion of pollinator habitats on public and private land as well as policies which restrict and eliminate neonicotinoid pesticides (low-cost).
FI1-8
Attract and promote grocery store and food market investment in food desert sections of the City. Collaborate with neighboring communities to maximize coverage. (Major priority)
FI1-9
Identify, map and prioritize food insecure areas and populations.

E Strategies Enhancing Economic Resilience In Support of Climate Resilience

Goal E1 - Leverage the economic development opportunities of the Green Economy

E1-1
Leverage Community Development Block Grants from the Department of Housing and Urban Development, or HUD, to invest in resilient and equitable communities.
E1-2
Conduct a Climate Economy Economic Development Assessment to identify economic development potential of climate adaptation, climate mitigation, and energy action planning.
E1-3
Develop job training programs focused on building resiliency- solar construction, weatherization, etc.
E1-4
Conduct a Community-Wide Renewable Energy Potentials Study for the City. Study should identify economic development opportunities as well as economic savings/impacts of expansion of renewable energy infrastructure within the City.
E1-5
Foster small business and green business development, particularly those which increase renewable energy, climate mitigation and adaptation resources within the community.

Goal E2 - Enhance community resilience through economic resilience

E2-1
Conduct a planning effort focused on identifying economic vulnerabilities and opportunities, especially those affecting the city's vulnerable populations. Identify economic resilience strategies and strengthen public-private economic communications, especially with targeted group businesses (minority-owned, veteran owned, economically disadvantaged, etc). Possible example process: https://www.eda.gov/ceds/
E2-2
Explore opportunities to broaden the City's economic base with diversification initiatives, such as targeting the development of emerging clusters or industries that (a) build on the region's unique assets and competitive strengths; and (b) provide stability during downturns that disproportionately impact any single cluster or industry

E2-3

Work with community businesses to explore the creation of an incentivized "buy local" campaign to enhance resilience of small local businesses.

E2-4

Explore development of one or more Green Zones, a place-based policy initiative aimed at improving health and supporting economic development using environmentally conscious efforts in communities that face the cumulative effects of environmental pollution, as well as social, political and economic vulnerability. http://www.ci.minneapolis.mn.us/sustainability/policies/green-zones

Goal E3 - Including Economic Resilience in Emergency Response Planning

E3-1

Make sure key business infrastructure is recognized in the City and County's general hazard mitigation plan and emergency response plan.

E3-2

Analyze how risks and hazards identified in this report and the City / County's emergency response plan may impact the economic community. Conduct outreach to industry groups and public-private partnerships to promote private sector investment addressing them.

E3-3

Explore use of geographic information systems (GIS) to link with municipal business licenses, tax information, and other business establishment data bases to track local and regional "churn" and available development sites as well as integrated hazard information to make rapid post-incident impact assessments.

E3-4

Ensure redundancy in telecommunications and broadband networks to protect commerce and public safety in the event of natural or man-made disasters.

E3-5

Facilitate in-person discussions with community businesses to build relationships and prepare City's business community for risks and hazards identified in this report and the City / County's emergency response plan, and identify the businesses and infrastructure that are most vulnerable to disaster.

Section 12

Possible Funding

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Possible Funding

Many of the strategies for increasing climate resilience can be done for little to no costs. Some strategies, however, come with a cost which may be more than the City can cover within the desired implementation timeframe. Increasingly, funding for local climate adaptation and resilience projects must draw on a range of public and private financing. For instance, groups may apply for federal grant funding, work through public/private partnerships, and/or fund projects through local taxes.

In the United States, a range of government entities and private foundations offer financial and technical resources to advance local adaptation and mitigation efforts. For your convenience, we've listed some of them here.

EPA Smart Growth Grants and Other Funding
The U.S. Environmental Protection Agency's Office of Sustainable Communities occasionally offers grants to support activities that improve the quality of development and protect human health and the environment.
https://www.epa.gov/smartgrowth/epa-smart-growth-grants-and-other-funding

Partnership for Sustainable Communities
The U.S. Department of Housing and Urban Development (HUD), U.S. Department of Transportation (DOT), and the U.S. Environmental Protection Agency (EPA) work together to help communities nationwide improve access to affordable housing, increase transportation options, and lower transportation costs while protecting the environment. The site's map of grants shows information on awards already made through Partnership programs.
https://www.sustainablecommunities.gov/partnership-resources
https://www.sustainablecommunities.gov/content/grants-your-community

FEMA (Federal Emergency Management Agency) Preparedness (Non-Disaster) Grants
FEMA provides state and local governments with preparedness program funding to enhance the capacity of their emergency responders to prevent, respond to, and recover from a range of hazards.
https://www.fema.gov/preparedness-non-disaster-grants

FEMA Hazard Mitigation Assistance
FEMA's Hazard Mitigation Assistance grant programs provide funding to protect life and property from future natural disasters. https://www.fema.gov/hazard-mitigation-assistance

- Hazard Mitigation Grant Program (HMGP) assists in implementing long-term hazard mitigation measures following a major disaster. https://www.fema.gov/hazard-mitigation-grant-program
- Pre-Disaster Mitigation (PDM) provides funds for hazard mitigation planning and projects on an annual basis. https://www.fema.gov/pre-disaster-mitigation-grant-program https://www.fema.gov/pre-disaster-mitigation-grant-program
- **Flood Mitigation Assistance (FMA)** provides funds for projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis. https://www.fema.gov/flood-mitigation-assistance-grant-program

Drought Recovery Information
This page from the National Integrated Drought Information System describes support that may be available through federal agencies for both short- and long-term impacts of drought. Links lead to information regarding financial and technical assistance, disaster assistance programs, economic injury loans, and assistance in implementing conservation practices. https://www.drought.gov/drought/search/site/resources%20OR%20recovery

Clean Diesel Program
The Clean Diesel Program provides support for projects that protect human health and improve air quality by reducing harmful emissions from diesel engines. This program includes grants and rebates funded under the Diesel Emissions Reduction Act (DERA). https://www.epa.gov/cleandiesel

USDA Natural Resources Conservation Service
NRCS offers voluntary programs to eligible landowners and agricultural producers to provide financial and technical assistance to help manage natural resources in a sustainable manner.
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/
Programs include:

- The **Agricultural Management Assistance Program** helps agricultural producers use conservation to manage risk and address natural resource issues through natural resources conservation. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/ama/?cid=stelprdb1242818
- **Conservation Innovation Grants** offer funding opportunities at the state level to stimulate the development and adoption of innovative conservation approaches and technologies that leverage federal investment in environmental enhancement and protection. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/
- The **Conservation Stewardship Program** helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/csp/?cid=stelprdb1242683
- The **Environmental Quality Incentives Program** provides financial and technical assistance to agricultural producers in order to address natural resource concerns and deliver environmental benefits, such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation, or improved or created wildlife habitat. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelprdb1242633

Federal Funding Compendium for Urban Heat Adaptation
The Georgetown Climate Center produced an in-depth document that collected and analyzed information relating to 44 separate federal programs that could support cities and states in reducing the impacts of urban heat. While federal funding sources are often dependent on appropriations, this list may be useful for finding federal funding opportunities for climate-related work.
http://www.georgetownclimate.org/files/report/Federal%20Funding%20Compendium%20for%20Urban%20Heat%20Adaptation.pdf

Tribal Climate Change Guide to Funding, Science, Programs and Adaptation Plans
This sortable spreadsheet can help tribes find potential funding sources and other resources. Maintained by University of Oregon. http://tribalclimateguide.uoregon.edu/

Kresge Environment Program
The Kresge Foundation Environment Program seeks to help communities build resilience in the face of climate change. They invest in climate resilience through two primary strategies:

1. Accelerating place-based innovation through support to efforts that are anchored in cities and have a strong potential to serve as models.
2. Building the climate-resilience field by supporting activities to disseminate and bring to scale promising climate-resilience approaches. http://kresge.org/programs/environment

Quadratec Cares 'Energize The Environment' Grant Program

This program offers two $3,500 grants per year, one each in the spring and fall, to an individual or group implementing a program designed to benefit the environment. Examples of projects the program may fund include trail building or restoration, community environmental educational projects, and youth educational engagement events. Proposers write and submit a 1000-1600 word essay to apply for the grants. Entries for the fall grant are due on June 30th; entries for the spring grant are due October 30th. https://www.quadratec.com/page/quadratec-cares-grant-program

Wildlife Conservation Society's Climate Adaptation Fund

This fund supports projects that demonstrate effective interventions for wildlife adaptation to climate change.
http://wcsclimateadaptationfund.org/

Climate Solutions University

The Climate Solutions University aids rural communities by offering training, expertise, and support in climate adaptation planning through a peer-learning network. In the past, the organization has offered two distance-learning programs: the Climate Adaptation Plan Development Program focuses on forest and water resource resilience, and the Climate Adaptation Plan Implementation Program supports participants in moving the plan into action.
http://www.mfpp.org/csu/

Open Space Institute Resilient Landscape Initiative

The Resilient Landscapes Initiative, supported by the Doris Duke Charitable Foundation, offers two types of grants for specified locations in the eastern United States. The group's Capital Grants help land trusts and public agencies increase the conservation of resilient landscapes in areas that represent critical climate priorities. The group's Catalyst Grants help land trusts and public agencies build the knowledge base of key audiences and advance the practical application of climate science. https://www.openspaceinstitute.org/funds/resilient-landscapes-funds

Section 13

Conclusions and Next Steps

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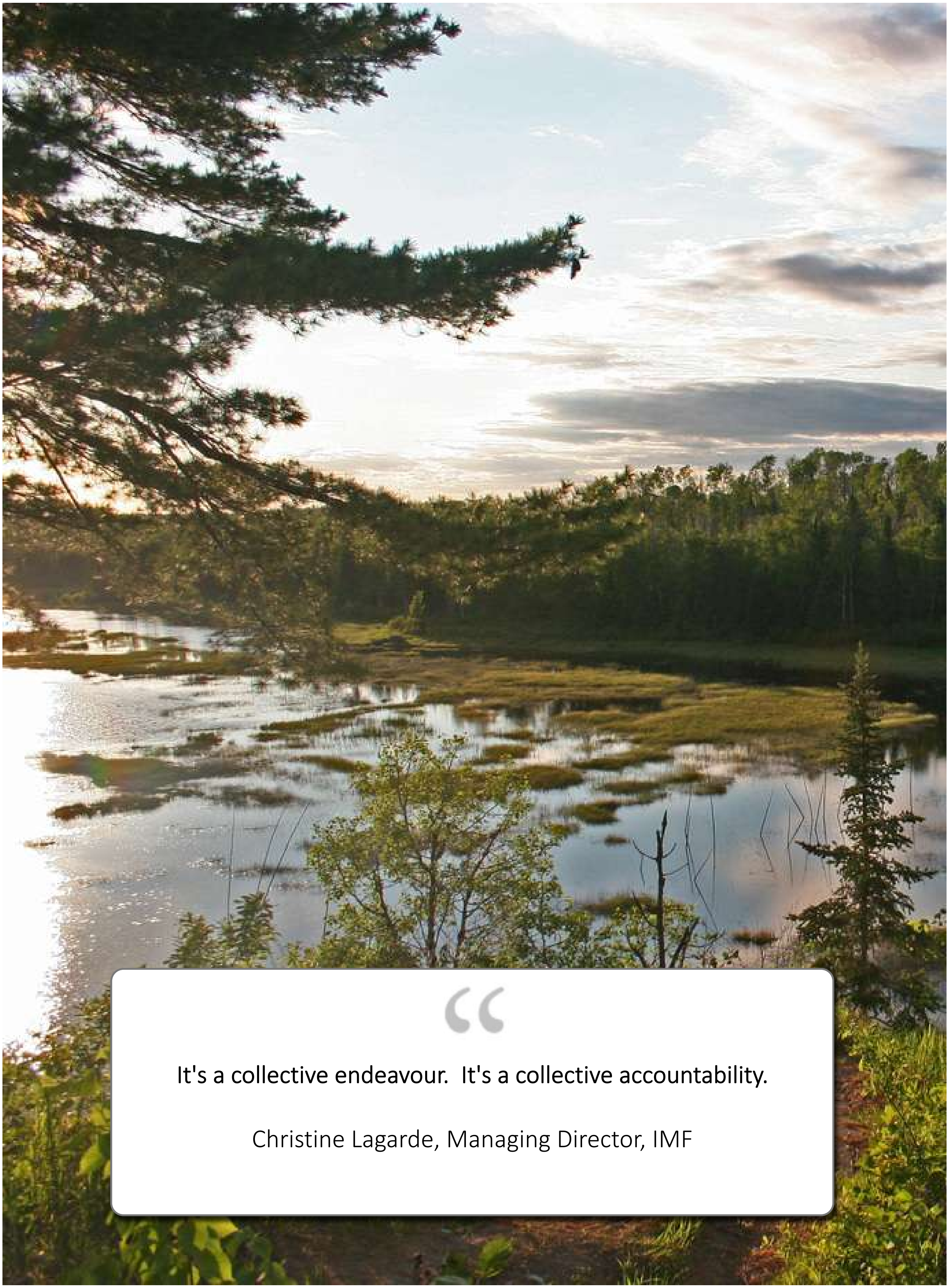

"

It's a collective endeavour. It's a collective accountability.

Christine Lagarde, Managing Director, IMF

The Minnesota Northeast Region has already seen climate changes. The changes to Minnesota's climate are occurring already: shorter winters with fewer cold extremes, and more heavy and extreme precipitation. In the future, there is relatively high confidence that those two changes will continue to increase in frequency and intensity, and also that Minnesota will begin to experience heat extremes beyond the historical variability of the climate. There is somewhat lower confidence that drought, and also tornadoes, hail and straight-line wind will increase in frequency and/or intensity as a result of climate change in the future.

The projected changes to the Region's climate represent stressors for both the environment and people. Urban tree canopies as well as urban populations have unique vulnerabilities associated with the projected climate changes for the Region.

Next Steps

We recommend that the City of Chisholm, City of Mountain Iron, and City of Ranier conduct and develop a Adaptation Implementation Plan. We recommend the City's explore developing this plan collaboratively. This effort should focus on refining and applying the adaptation strategies included in this report to the specific geographic features, habitats, city infrastructure, and city neighborhoods with higher concentrations of the demographic sectors most vulnerable to the projected climate change risks. An implementation planning effort should focus on a community outreach process to develop support for the finalized strategies as well as to begin the process of developing public awareness and engagement in implementing the adaptation strategies.

Specific recommended next steps are:

1) Integrate appropriate content, findings, and recommendations from this Population Vulnerability and Climate Adaptation Framework into the each City's Comprehensive Plan.
2) Identify resources within the community which serve, or can serve, as emergency shelters and cooling centers. Evaluate each resource.
3) Conduct a "Blue spot" flash flood mapping, or Flood Index assessment of community to identify potential flash flood prone zones within community based on mid-century projected rainfall volumes.
4) Conduct a City-wide tree canopy, ground cover study and master plan addressing heat island, impervious surface, and water runoff aspects, reflecting vulnerable population/economic considerations by neighborhood
5) Assess community's water system for flood resilience and water borne disease risk and preparedness.
6) Engage City Staff in reviewing the data and findings of this report for feedback.
7) Engage the public for review of key concepts and data of this report and for feedback on adaptation goals and strategies. The City could include a review of Climate Mitigation strategies in this effort as well (energy efficiency, renewable energy, and greenhouse gas emission reduction strategies).
8) Develop a Climate Adaptation Implementation Plan. The Implementation Plan should include:
    - A) Refinement and finalization of City Adaptation Goals and Strategies.
    - B) Delineation of the individuals and departments responsible for the implementation of each strategy.
    - C) Identification of how the implementation of each strategy will be monitored / reported, and appropriate metrics for measurement of effectiveness of strategy.
    - D) Development of a Climate Vulnerability Communication Strategy for English as well as limited English speakers. The Communication Strategy should target the primary languages identified in Section 9, Page 9-9 of this report. Strategies should include development of translated messages as well as the development/expansion of trusted and effective communication pathways to reach all key English and non-English speaking demographic groups in the City.

Section A1

Appendix 1
Local Climate Risks to the Environment

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Climate change projections for the City represent potential risks. The types of risks can be organized into risks to the environment and ecosystems and risks to the population. The following is an overview of the potential risks posed by climate change for the region:

Climate Risks to the Environment

Warmer summers

Pollution control risks:
Wildfires may lead to soil erosion

Habitat risks:
Greater evaporation
Lower groundwater tables
Switching public water supply between surface and groundwater sources may affect the integrity of water bodies

Fish Wildlife and Plant risks:
Species that won't tolerate warmer summers may die/migrate
Biota at the southern limit of their range may disappear from ecosystems
Species may be weakened by heat and become out-competed
Essential food sources may die off or disappear, affecting the food web
Species may need to consume more water as temperature rises

Recreation and Public Water Supply Risks:
More people using water for recreation may raise the potential for pathogen exposure
Warmer temperatures may drive greater water demand
Evaporation losses from reservoirs and groundwater may increase

Warmer winters

Pollution Control risks:
Increased fertilizer and pesticide use due to longer growing season.
Warmer winters result in more ice and freeze thaw resulting in greater chloride application and more permanent damage to local water bodies due to increased salt concentrations.

Habitat risks:
Less snow, more rain may change the runoff/infiltration balance; base flow in streams may change
Changing spring runoff with varying snow.

Fish Wildlife and Plant risks:
Species that used to migrate away may stay all winter and species that once migrated through may stop and stay
Pests may survive winters that used to kill them and invasive species may move into places that used to be too cold
Some plants need a "setting" cold temperature and may not receive it consistently
A longer growing season may lead to an extra reproductive cycle
Food supplies and bird migrations may be mistimed

Recreation and Public Water Supply Risks:
Summer water supplies that depend on winter snow pack may be reduced or disappear
Cold places may see more freeze/thaw cycles that can affect infrastructure

Warmer water

Pollution Control risks:
Temperature criteria for discharges may be exceeded (thermal pollution)
Warmer temperatures may increase toxicity of pollutants
Higher solubility may lead to higher concentration of pollutants
Water may hold less dissolved oxygen
Higher surface temperatures may lead to stratification
Greater algae growth may occur
Parasites, bacteria may have greater survival or transmission

Habitat risks:
Warmer water may lead to greater likelihood of stratification
Desired fish may no longer be present
Warmer water may promote invasive species or disease

Fish Wildlife and Plant risks:
Newly invasive species may appear
Habitat may become unsuitably warm, for a species or its food
Heat may stress immobile biota
Oxygen capacity of water may drop

Climate Risks to the Environment

Some fish reproduction may require cold temperatures; other reproductive cycles are tied to water temperature
Parasites and diseases are enhanced by warmer water

Fish resource food harvesting, Recreation, and Public Water Supply Risks:
Harmful algal blooms may be more likely
Fishing seasons and fish may become misaligned
Desired recreational fish may no longer be present
Invasive plants may clog creeks and waterways
Changes in treatment processes may be required
Increased growth of algae and microbes may affect drinking water quality

Increased drought

Pollution Control risks:
Critical-low-flow criteria for discharging may not be met
Pollutant concentrations may increase if sources stay the same and flow diminishes
Pollution sources may build up on land, followed by high-intensity flushes

Habitat risks:
Groundwater tables may drop
Base flow in streams may decrease
Stream water may become warmer
Increased human use of groundwater during drought may reduce stream baseflow
New water supply reservoirs may affect the integrity of freshwater streams

Fish Wildlife and Plant risks:
Species may not tolerate a new drought regime (birch family)
Native habitat may be affected if freshwater flow in streams is diminished or eliminated

Recreation and Public Water Supply Risks:
Freshwater flows in streams may not support recreational uses
Groundwater tables may drop
Maintaining passing flows at diversions may be difficult

Increased storminess

Pollution Control risks:
Combined sewer overflows may increase
Treatment plants may go offline during intense floods
Streams may see greater erosion and scour
Urban areas may be subject to more floods
Flood control facilities (e.g., detention basins, manure management) may be inadequate
High rainfall may cause septic systems to fail

Habitat risks:
The number of storms reaching an intensity that causes significant problems may increase
Stronger storms may cause more intense flooding and runoff
Turbidity of surface waters may increase
Increased intensity of precipitation may yield less infiltration
Stream erosion may lead to high turbidity and greater sedimentation
Lower pH from NPS pollution may affect target species

Fish Wildlife and Plant risks:
Greater soil erosion may increase turbidity and decrease water clarity
Greater soil erosion may increase sediment deposition in estuaries, with consequences for benthic species

Recreation and Public Water Supply Risks:
More frequent or more intense storms may decrease recreational opportunities
Greater nonpoint source pollution may impair recreation
Water infrastructure may be vulnerable to flooding
Flood waters may raise downstream turbidity and affect water quality

(Source: USEPA “Being Prepared for Climate Change A Workbook for Developing Risk-Based Adaptation Plans”)

Section A2

Appendix 2
Climate Adaptive Tree Species

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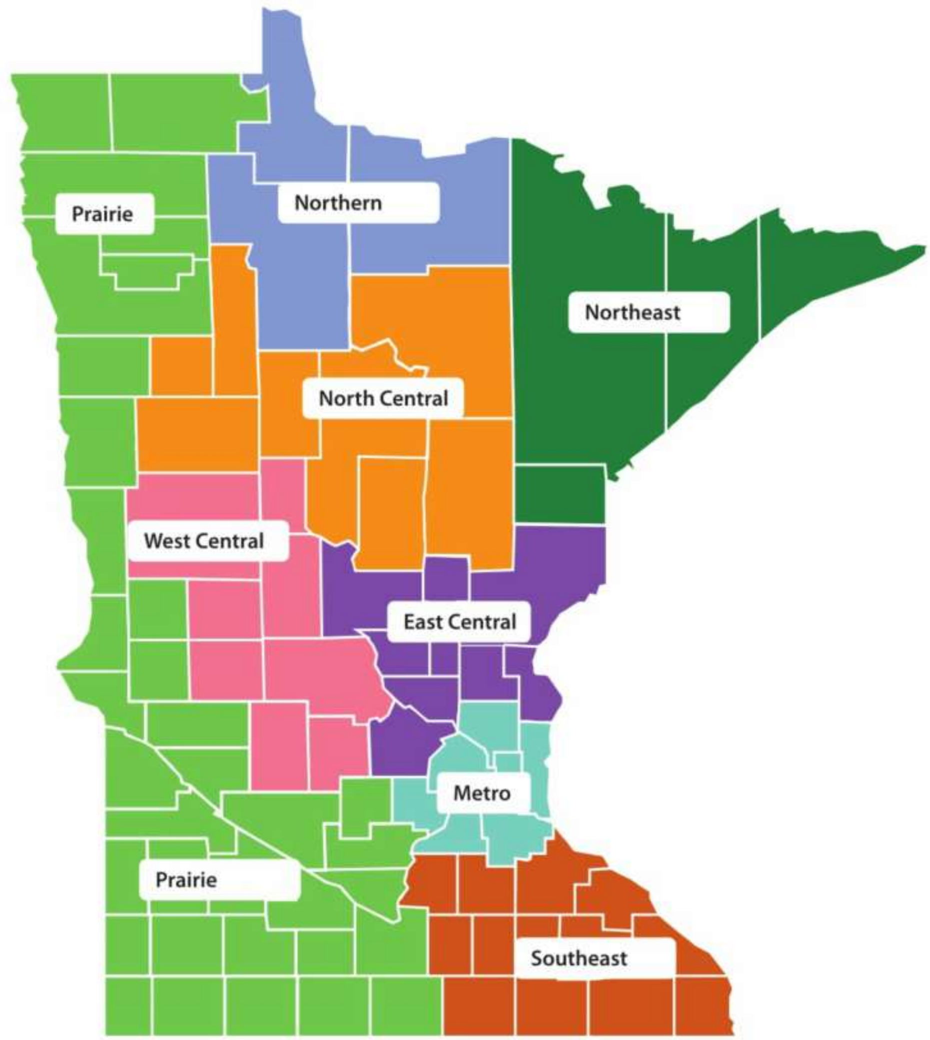
Trees Likely to Thrive in Minnesota's Changing Climate

The trees listed on the following page are native tree species most likely to have the greatest increase of abundance from today through 2099. These species are anticipated to have appropriate habitat requirements based on the US Forest Service Climate Change models. The map below defines regions of Minnesota in color code. To see which trees are anticipated to be climate adaptive for your region look for trees shown on the following page with a matching color square.



Information and Graphics by:

Minnesota Pollution Control Agency

Minnesota Department of Natural Resources

American Elm

Basswood

Black Cherry

Black Oak

Black Walnut

Boxelder

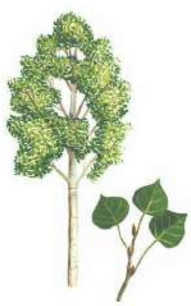
Bur Oak

Eastern Cottonwood

Hackberry

Jack Pine

Northern Red Oak



Quaking Aspen

Red Maple

Silver Maple

Sugar Maple

White Oak

White Pine

Check local tree ordinance before planting your tree.

Invasive trees and trees with low disease or insect tolerance were eliminated from the list.

Section A3

Appendix 3

Excerpt from *Adapting to Climate Change in Minnesota*

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Adapting to Climate Change in Minnesota

2017 Report of the Interagency Climate Adaptation Team

Report Excerpt

May 2017

Confidence that climate change has *already* impacted common Minnesota weather/climate hazards

Confidence	Hazard	Recent & Current Observations
Highest	**Extreme cold**	Rapid decline in severity, frequency
	Extreme rainfall	Becoming larger and more frequent
Moderately High	**Heavy snowfall**	Large events more frequent
Low	**Severe thunderstorms & tornadoes**	Historical comparisons difficult; Few major tornadoes in MN since late 2010
Lowest	**Heat waves**	No recent increases or worsening
	Drought	

Source: MN DNR State Climatology Office

Confidence that climate change will impact common Minnesota weather/climate hazards beyond 2025

Confidence	Hazard	Expectations beyond 2025
Highest	**Extreme cold**	Continued rapid decline
Highest	**Extreme rainfall**	Unprecedented events expected
High	**Heat waves**	Increases in severity, coverage, and duration expected
Moderately High	**Drought**	Increases in severity, coverage, and duration possible
Moderately Low	**Heavy snowfall**	Large events less frequent as winter warms
Moderately Low	**Severe thunderstorms & tornadoes**	More "super events" possible, even if frequency decreases

Source: MN DNR State Climatology Office

Projected climate changes in Minnesota

Continued rapid loss of cold weather extremes and enhancement of extreme precipitation

In the years and decades ahead, winter warming and increased extreme rainfall will continue to be Minnesota's two leading symptoms of climate change (see Figure 7).

Figure 7

Hazard	Projections through century	Confidence in projected changes
Extreme cold	Continued loss of cold extremes and dramatic warming of coldest conditions	Highest
Extreme rainfall	Continued increase in frequency and magnitude; unprecedented flash-floods	
Heat waves	More hot days with increases in severity, coverage, and duration of heat waves	High
Drought	More days between precipitation events, leading to increased drought severity, coverage, and duration	Moderately High
Heavy snowfall	Large events less frequent as winter warms, but occasional very large snowfalls	Moderately low
Severe thunderstorms & tornadoes	More "super events" possible, even if frequency decreases	

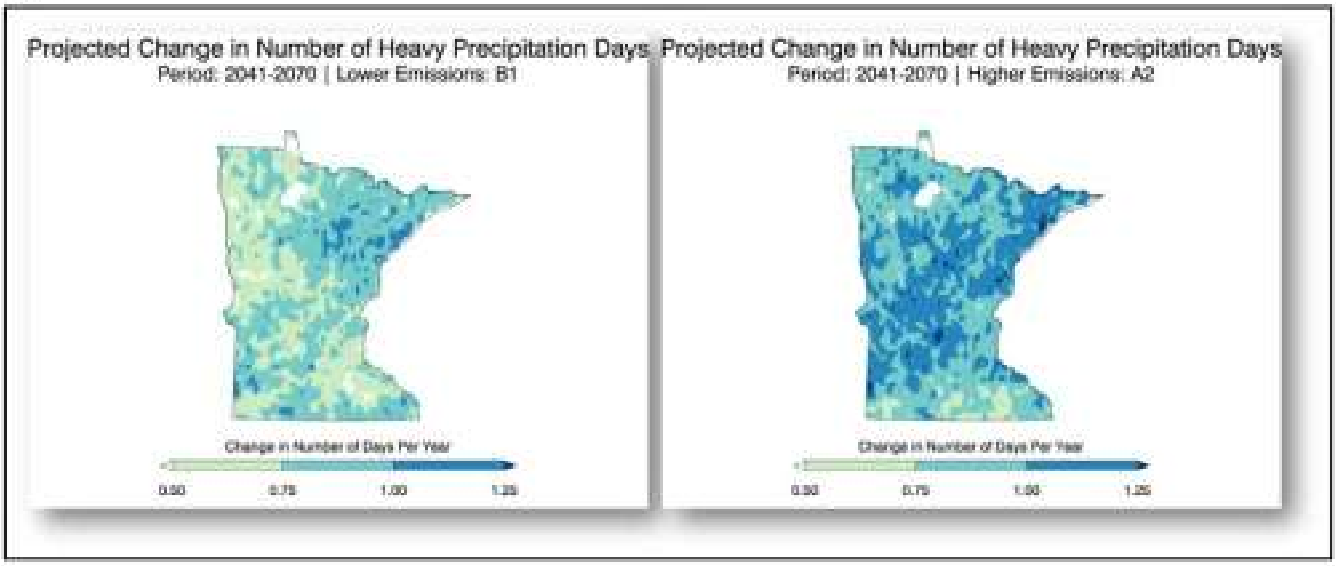
Lowest	Low	Moderately Low	Moderately High	High	Highest

Confidence Scale

Snapshot of projected and expected trends among common weather hazards in Minnesota, and confidence that those hazards will change (further) through the year 2099 in response to climate change. Graphic based on information from 2014 National Climate Assessment, and data analyzed by the Minnesota DNR State Climatology Office.

Greenhouse gas concentrations will continue rising through the century, and the air's ability to trap heat from the earth's surface will increase accordingly. As a result, winters, and cold conditions in particular, will continue warming well beyond historical bounds. Continued warming of the atmosphere will evaporate even more water into the air, further limiting the amount of cooling Minnesota will be able to achieve at night and during the winter. This increased water vapor will also enhance precipitating weather systems, continuing the trend toward more — and larger — heavy rainfall events (see Figure 8). Minnesota can expect unprecedented rainfall events during the remainder of the 21st century.

Figure 8



Projected changes by mid-century in number of days annually with heavy rainfall, defined as the upper 2% of daily precipitation for the 1971-2000 climate period. Left image is the "ensemble" or model average for a lower emissions scenario. The right image is the same, but for a higher emissions scenario. Images derived from output used for the 2014 National Climate Assessment, courtesy of GLISA (Great Lakes Integrated Science + Assessments).

More hot days likely and more drought possible

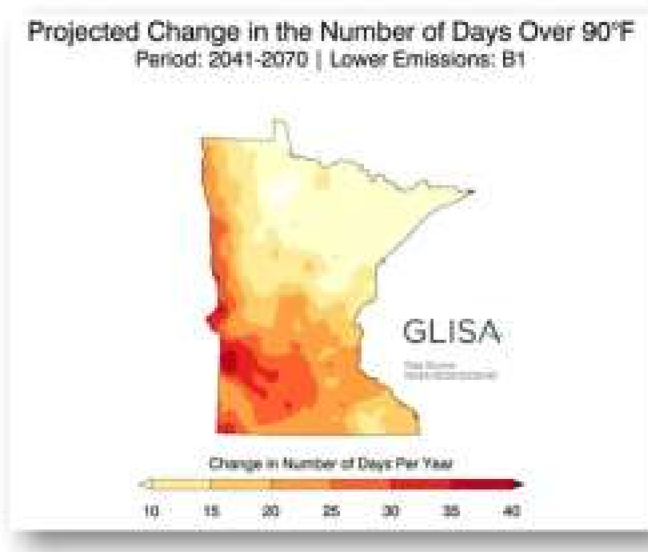
Climate models used in the 2014 National Climate Assessment project that Minnesota will have a greater tendency toward extreme heat, especially by the middle of the 21st century. Even the lower-emissions scenarios lead to significantly more hot days than Minnesota experiences presently (see Figure 9).

This projected increase is a likely outgrowth of the warmer winters, which will provide warmer baseline conditions during transition into summer, making it much easier to attain extremes of heat.

The future drought situation in Minnesota is less clear and appears to depend on how much greenhouse gas concentrations increase by mid-century (see Figure 10).

The majority of models used for the 2014 National Climate Assessment indicate that although drought will remain a part of Minnesota's climate, the state will continue growing wetter through the century. In lower-emissions scenarios, these models project no significant change statewide in the number of consecutively dry days between precipitation events — indicating that climate change will not significantly increase drought likelihood in a given year.

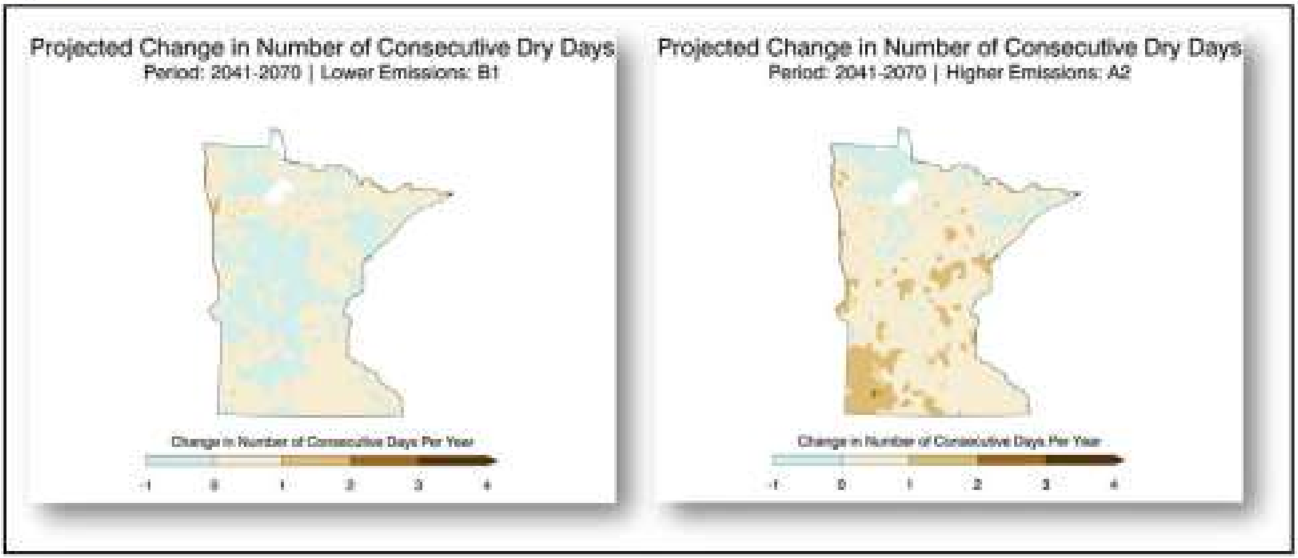
Figure 9



Projected changes by mid-century in number of days annually with high temperatures above 90°F, relative to the 1971-2000 climate period. Projection uses the "ensemble" or model average for a lower emissions scenario. Image derived from output used for the 2014 National Climate Assessment, courtesy of GLISA (Great Lakes Integrated Science + Assessments).

When these same models are run with higher emissions scenarios, however, they depict Minnesota becoming more prone to dry periods. Combined with dramatic increases in hot days, these dry periods would increase Minnesota's short-term, and possibly even long-term drought risk, suggesting that drought indeed could become worse as a result of climate change.

Figure 10



Projected changes by mid-century in annual average number of dry days between precipitation events. More consecutive dry days would suggest greater potential for at least short-term drought. Note that lower emissions scenario (left) yields no net change statewide, while higher emissions result in a nearly statewide increase. Both images show the "ensemble" or model averages given emissions scenarios. Images derived from output used for the 2014 National Climate Assessment, courtesy of GLISA (Great Lakes Integrated Science + Assessments).

Other hazards

The science is unclear about what will happen to the frequency and severity of tornadoes, damaging thunderstorms, and ice storms in Minnesota. It is clear that Minnesota will continue to experience all of these throughout the century, though research suggests their frequencies may decrease. Tornadoes and damaging thunderstorm hazards may become more concentrated on fewer days, indicating the potential for more "outbreaks," even major ones, in the years and decades ahead. However, the body of research into these hazards remains quite limited, and projections of future trends will change as more research is completed.

Section A4

Appendix 4
Data References and Resources

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The following are data references and resources used for this report:

Section 1 Introduction

State of Minnesota, Department of Natural Resources
https://www.dnr.state.mn.us/climate/climate_change_info/index.html
http://glisa.umich.edu/media/files/Minn-StPaulMN_Climatology.pdf
US Climate Resilience Toolkit
https://toolkit.climate.gov/
Metropolitan Council, Local Planning Handbook
https://lphonline.metc.state.mn.us/commportal
Intergovernmental Panel on Climate Change
http://www.ipcc.ch/
NOAA National Centers for Environmental Information
https://www.ngdc.noaa.gov/
NASA
https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

Section 2 Climate Change in the Midwest

US Climate Resilience Toolkit
https://toolkit.climate.gov/
US National Climate Assessment
https://nca2014.globalchange.gov/

Section 3 Climate Change in Minnesota

US Climate Resilience Toolkit
https://toolkit.climate.gov/
US National Climate Assessment
https://nca2014.globalchange.gov/
State of Minnesota, Department of Natural Resources
https://www.dnr.state.mn.us/climate/climate_change_info/index.html
http://glisa.umich.edu/media/files/Minn-StPaulMN_Climatology.pdf
https://www.dnr.state.mn.us/climate/summaries_and_publications/mega_rain_events.html
Minnesota Public Radio:
https://www.mprnews.org/story/2015/02/02/climate-change-primer
US EPA (January 2017 Snapshot)
https://19january2017snapshot.epa.gov/climatechange_.html
https://www.epa.gov/sites/production/files/2016-09/documents/climate-change-mn.pdf

Section 4 Local Climate Change

NOAA National Centers for Environmental Information
https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=27%2CMINNESOTA
University of Michigan, Climate Center
http://graham-maps.miserver.it.umich.edu/ciat/home.xhtml
US Climate Resilience Toolkit, Climate Explorer
https://toolkit.climate.gov/climate-explorer2/
Minnesota Public Radio:
https://www.mprnews.org/story/2015/02/02/climate-change-primer
Minnesota Pollution Control Agency:
https://www.pca.state.mn.us/featured/minnesotas-new-normal-%E2%80%93-heavy-rains-%E2%80%93-poses-new-challenges
US Climate Resilience Toolkit
https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing#tab2-images
US National Climate Assessment
https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing#statement-16556
Environment Minnesota Research and Policy Center
https://environmentminnesota.org/sites/environment/files/reports/When%20It%20Rains,%20It%20Pours%20vMN.pdf
Union of Concerned Scientists
http://www.climatehotmap.org/global-warming-locations/minneapolis-st-paul-mn-usa.html
DOE Databook
http://www.asicontrols.com/wp-content/uploads/2014/05/11.jpg

Section 5 City on The Move

University of Michigan, Climate Center
http://graham-maps.miserver.it.umich.edu/ciat/home.xhtml
State of Minnesota Pollution Control Agency

Section 6 Climate Risk to The Population

National Climate Assessment
https://nca2014.globalchange.gov/highlights/report-findings/human-health
US Global Change Research Program
https://health2016.globalchange.gov/populations-concern
Centers for Disease Control and Prevention
https://www.cdc.gov/climateandhealth/brace.htm
American Public Health Association
http://thenationshealth.aphapublications.org/content/46/9/1.1

Section 7 Climate Impact Multipliers

University of Minnesota, Remote Sensing and Geospatial Analysis Laboratory Department of Forest Resources
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwjMqOyh5oLaAhUn8IMKHbW7BZIQFgg7MAE&url=https%3A%2F%2Fconservancy.umn.edu%2Fbitstream%2Fhandle%2F11299%2F183470%2F2015_UTC_report.pdf%3Fsequence%3D5%26isAllowed%3Dy&usg=AOvVaw0G7D-T2uTs4BCDIi0-r1_2
Earth Define
https://www.arcgis.com/home/webmap/viewer.html?webmap=e3d71d9cbb5e4a6cbe39cc48aa49c582
State of Minnesota Pollution Control Agency
https://www.pca.state.mn.us/sites/default/files/trees_likely_to_thrive.pdf
University of Minnesota Remote Sensing and Geospatial Analysis Laboratory
https://rs.umn.edu/datalayers
http://land.umn.edu/maps/impervious/landbrowse.php?year_imp=2000&type=county&county
State of Minnesota Department of Natural Resources
https://www.dnr.state.mn.us/whaf/about/scores/hydrology/impervious.html#imperv_calc
Department of Soil, Water, and Climate, University of Minnesota
https://www.swac.umn.edu/urban-heat
World Resources Institute, Aqueduct Water Risk Atlas
http://www.wri.org/applications/maps/aqueduct-atlas/#x=8.00&y=0.44&s=ws!20!28!c&t=waterrisk&w=def&g=0&i=BWS-16!WSV-4!SV-2!HFO-4!DRO-4!STOR-8!GW-8!WRI-4!ECOS-2!MC-4!WCG-8!ECOV-2!&tr=ind-1!prj-1&l=3&b=terrain&m=group
FEMA
https://msc.fema.gov/portal/search
National Flood Services
http://www.floodtools.com/Map.aspx

Section 8 Climate Resilience Indicators

United States Census Bureau
https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml
Data USA
https://datausa.io/
County Health Rankings & Roadmaps Program
http://www.countyhealthrankings.org/app/minnesota/2017/overview
Minnesota Pollution Control Agency
http://mpca.maps.arcgis.com/apps/MapSeries/index.html?appid=f5bf57c8dac24404b7f8ef1717f57d00
US EPA Environmental Justice Screen
https://ejscreen.epa.gov/mapper/
Centers for Disease Control
https://svi.cdc.gov/map.aspx?txtzipcode=55428&btnzipcode=Submit

Metropolitan Council, Local Planning Handbook
https://lphonline.metc.state.mn.us/commportal
Harvard University, Joint Center for Housing Studies
http://www.jchs.harvard.edu/research/interactive-maps

Section 9 Vulnerable Populations

United States Census Bureau
Census 2011-2015 American Community Survey 5-Year Estimates
https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml
United States Census Bureau, Quick Facts Table
https://www.census.gov/quickfacts/fact/table/US/PST045217
Data USA
https://datausa.io/
USDA Economic Research Service, Food Atlas
https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/
See also references and resources for Section 6 Climate Risk to The Population

Section 10 Findings

Deep Root, Fiona Watt and Bram Gunther, New York City Department of Parks
http://www.deeproot.com/blog/blog-entries/tree-cover-how-does-your-city-measure-up
Project Sunroof
https://www.google.com/get/sunroof/data-explorer/
NOAA National Centers for Environmental Information
https://www.ncdc.noaa.gov/stormevents/

See also references and resources for Section 6 Climate Risk to The Population
See also references and resources for Section 7 Climate Impact Multipliers
See also references and resources for Section 8 Climate Resilience Indicators
See also references and resources for Section 9 Vulnerable Populations

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