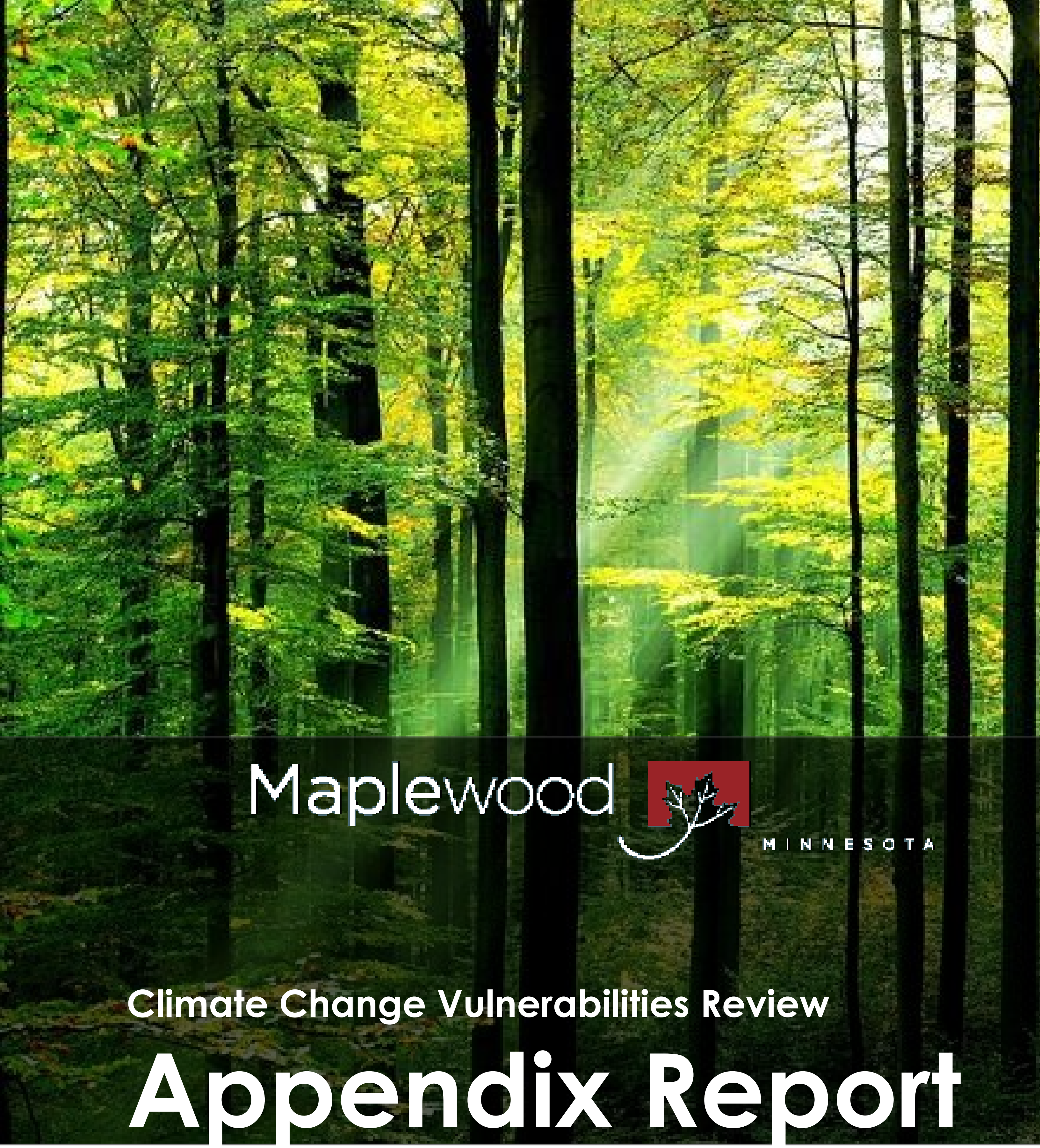


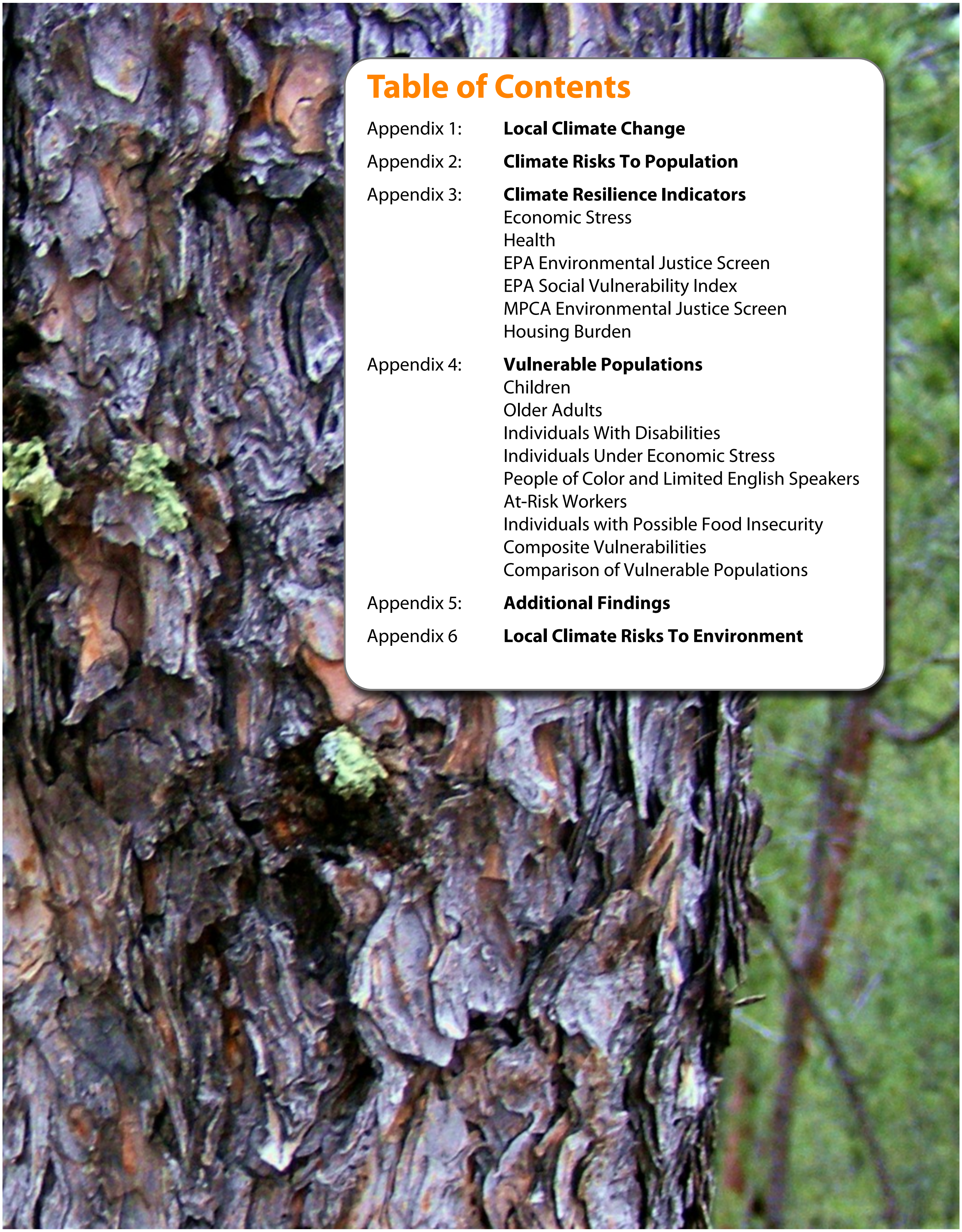
Maplewood MINNESOTA

Climate Change Vulnerabilities Review

Appendix Report

February 2020

Prepared by: paleBLUEdot LLC — making change personal



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Appendix A1

Local Climate Change

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Climate Change in Ames

The climate in City of Maplewood has already changed. From 1980 through 2018, the City 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.

Some of the most significant changes in the climate relate to variability. Climate variability can be seen in the changes in annual precipitation for Ames. Overall annual precipitation has increased, however, this increase is not evenly distributed throughout the year. Spring and Fall precipitation have increased up to 25%, while Summer and Winter precipitation have decreased 3-6%.

(Sources: US Climate Resilience Toolkit, Climate Science Special Report, High Plains Regional Climate Center, US NOAA, Union of Concerned Scientists)

Looking Back

From 1950 through 2015, Maplewood has experienced:

Increase in annual average temperature:	3.2°
Increase in annual precipitation:	21%
Increase in heavy precipitation events:	58%
Increase in Days above 95:	3 days
Decrease in Days below 32:	-10 days
Increase in growing season:	16 days

Storm Weather Events

Number of Events Reported In Ramsey County:

From March 1999 to March 2009: 99 events

From March 2009 to March 2019: 101 events - an increase of 2%

Average Annual Storm Weather Economic Damage 1999-2019: $1,550,000

(source: NOAA National Centers for Environmental Information)

The City '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 City 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 city-wide electricity consumption of : 72%

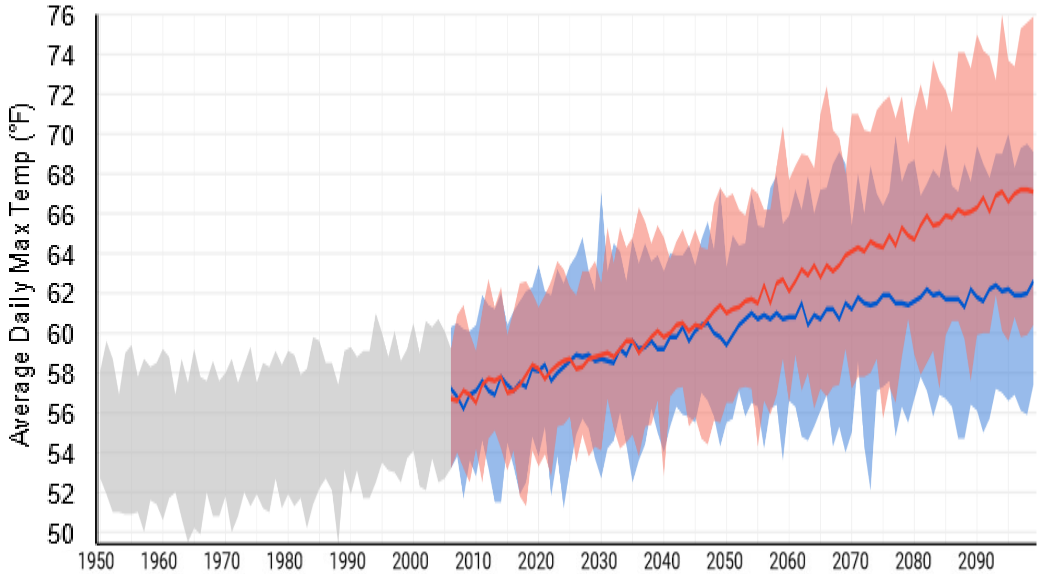
Looking Forward

By 2100, Maplewood Can Expect:

Increase in annual average temperature:	5-9°F
Increase in annual precipitation:	-5 to 5% With Significant Seasonal Variation
Increase in heavy precipitation events:	30%
Increase in Days above 95:	+55 days
Decrease in Days below 32:	-45 days
Increase in growing season:	30 days
Increase in Air Conditioning Demand:	288%

Mean Daily Maximum Temperature

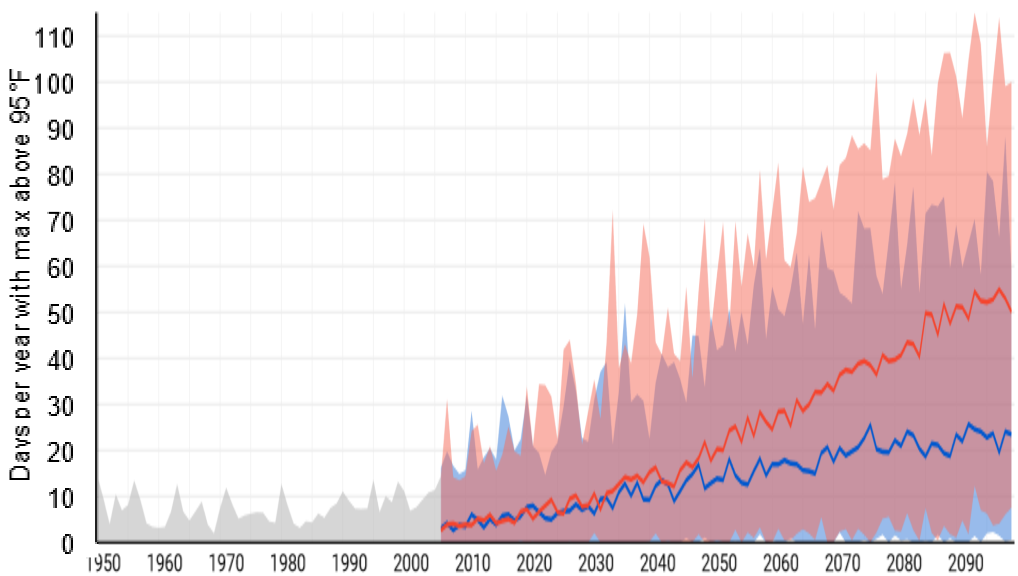
This chart shows observed average daily maximum temperatures for Ramsey County from 1950-2010, the range of projections for the historical period, and the range of projections for two possible futures through 2100. Maximum temperature serves as one measure of comfort and safety for people and for the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



(Source: US Climate Resilience Toolkit)

Days with Maximum Temperature Above 95°F

This chart shows observed average number of days with temperatures above 95°F for Ramsey 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.

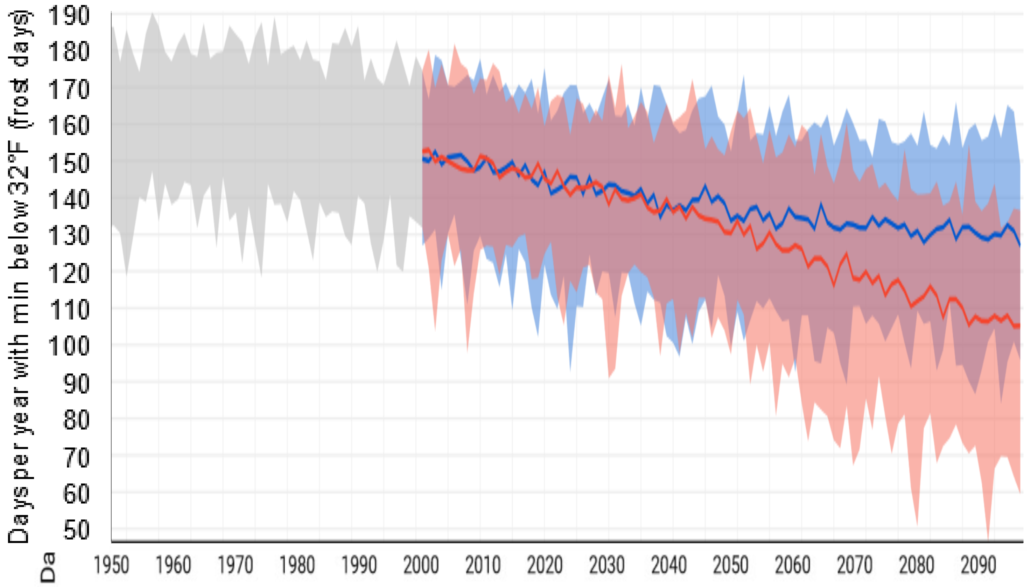
Starting from the left and moving right, the red toned band, or area, shows the range of future projections assuming global greenhouse gas emissions continue increasing at current rates. The darker red line shows the median of these projections. For planning purposes, people who have a low tolerance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

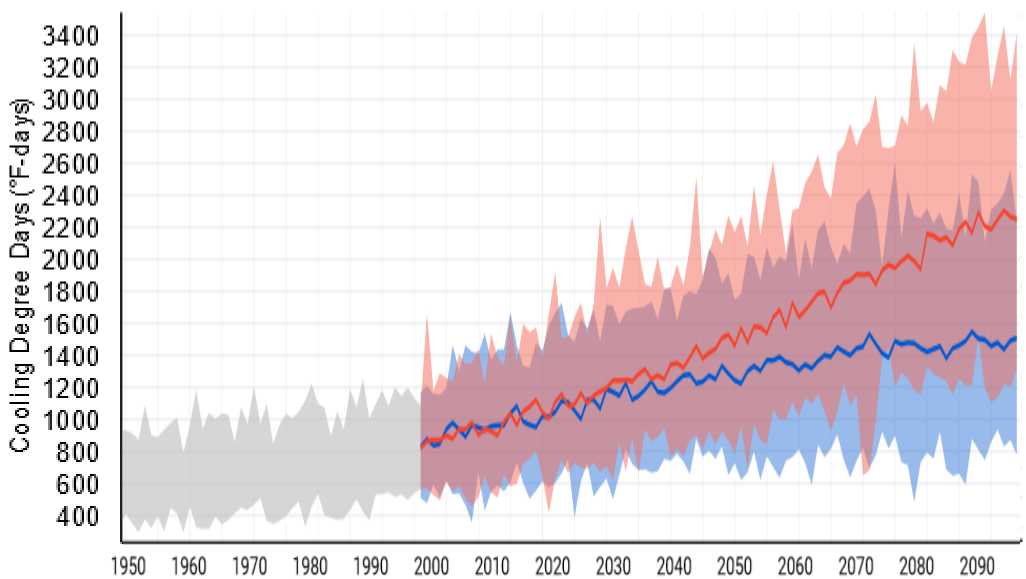


(Source: US Climate Resilience Toolkit)

Cooling Degree Days

This chart shows observed average degree cooling days for Ramsey 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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Appendix A2

Climate Risks to The Population

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Climate Risks to Maplewood

The projected changes to the City'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 the more significant risks to the City'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."

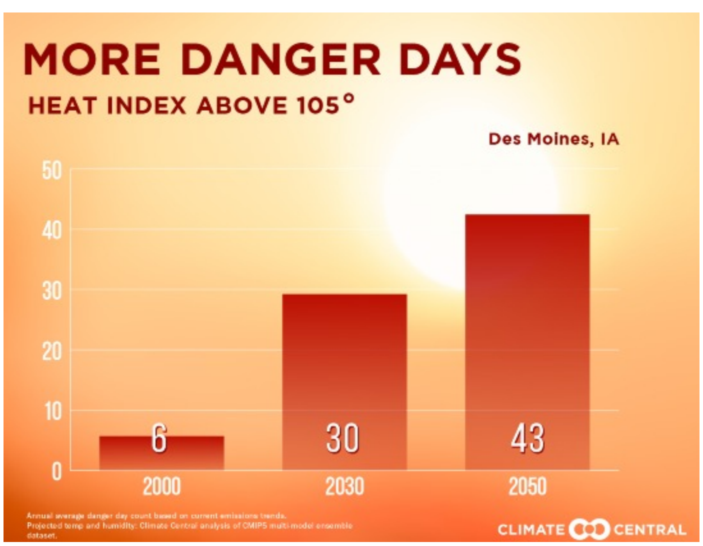
In addition, extreme weather can cause economic stress. Property damage, business closure, crop loss, job loss, and employment "down time" can all be caused by extreme storms, weather, and temperatures. These economic impacts can affect individuals, families, businesses, and communities at large.

According to the North American Electric Reliability Corporation, the leading cause of electric transmission outages (in terms of electric outage count) in Minnesota is Severe Weather - Heat Wave.

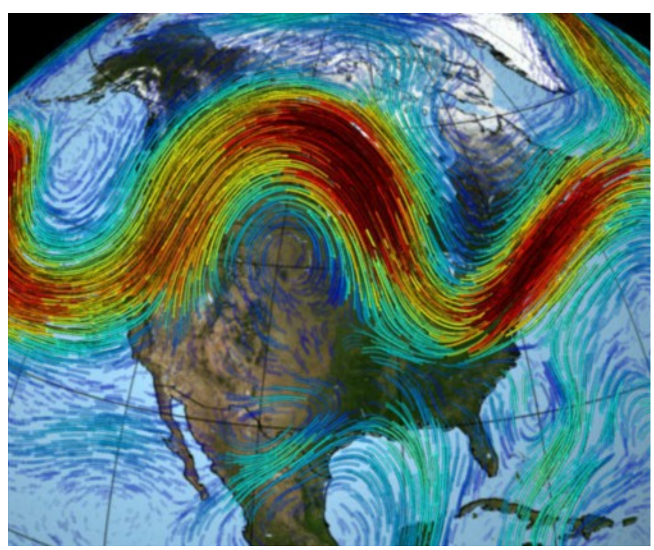
More than **110,000** people in Minnesota are especially vulnerable to extreme temperatures.

(Source: US Climate Resilience Toolkit, NASA, Climate Central)

Increased Risk of Extreme Heat



Increased Risk of Extreme Cold



Climate Risks to Maplewood

Extreme Weather / Temperature (continued)

Increased Risk of Extreme Cold

Though global temperatures are rising, there is evidence that the region is at risk of increased likelihood of extreme cold temperatures during winter "cold snaps" due to variations in the jet stream caused by warming ocean temperatures and a warming Arctic region. The jet stream—a powerful river of wind high in the atmosphere—shapes the Northern Hemisphere's weather, and it plays a key role in weather extremes. This powerful river of wind transports moisture and moves masses of cold and warm air and storm systems along its path.

The jet stream is driven partly by the temperature contrast between masses of cold air over the North Pole and warmer air near the equator. Climate change has led to faster warming in the Arctic than in the temperate zones, reducing the temperature differences between the two regions and weakening the jet stream. As the jet stream becomes weaker, it has periods of "wobble" in which it coils much more significantly dipping far to the South. As the jet stream coils southward it brings bitter cold arctic air southward along with it. Studies indicate that as arctic temperatures continue to rise, increases in jet stream "wobble" and extreme winter cold snaps may increase in occurrence.

Flood and Drought 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. 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.

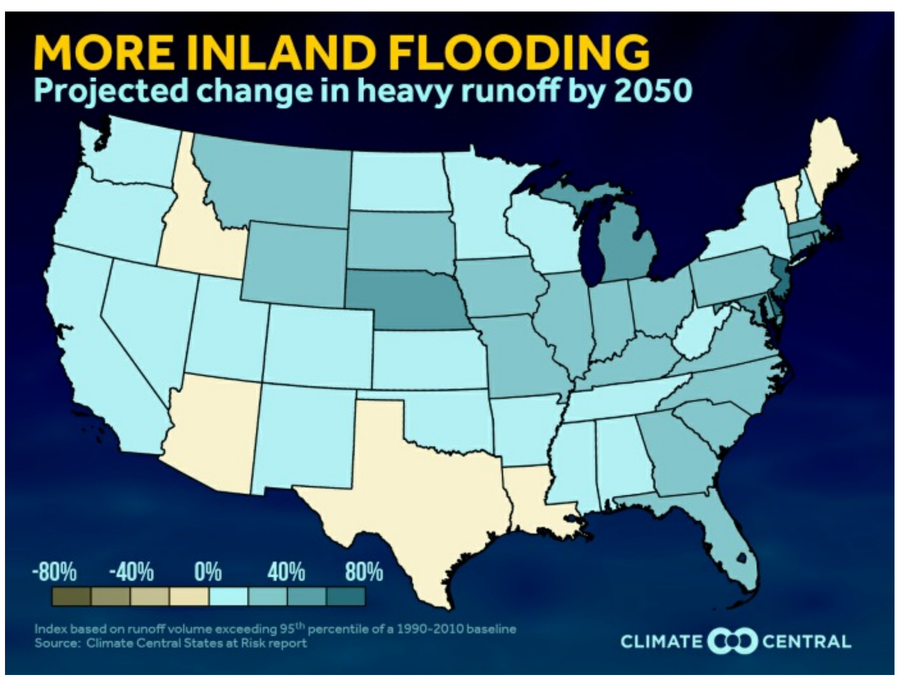
Flooding causes economic stress. Property damage, business closure, crop loss, job loss, and employment "down time" can all be caused by extreme storms, weather, and temperatures. These economic impacts can affect individuals, families, businesses, and communities at large.

By 2050, Minnesota is projected to see:

An increase of flood risk by up to **20%**

As well as a **250%** increase in its index of the severity of widespread drought.

(Source: US Climate Resilience Toolkit, Climate Central)



Climate Risks to Maplewood

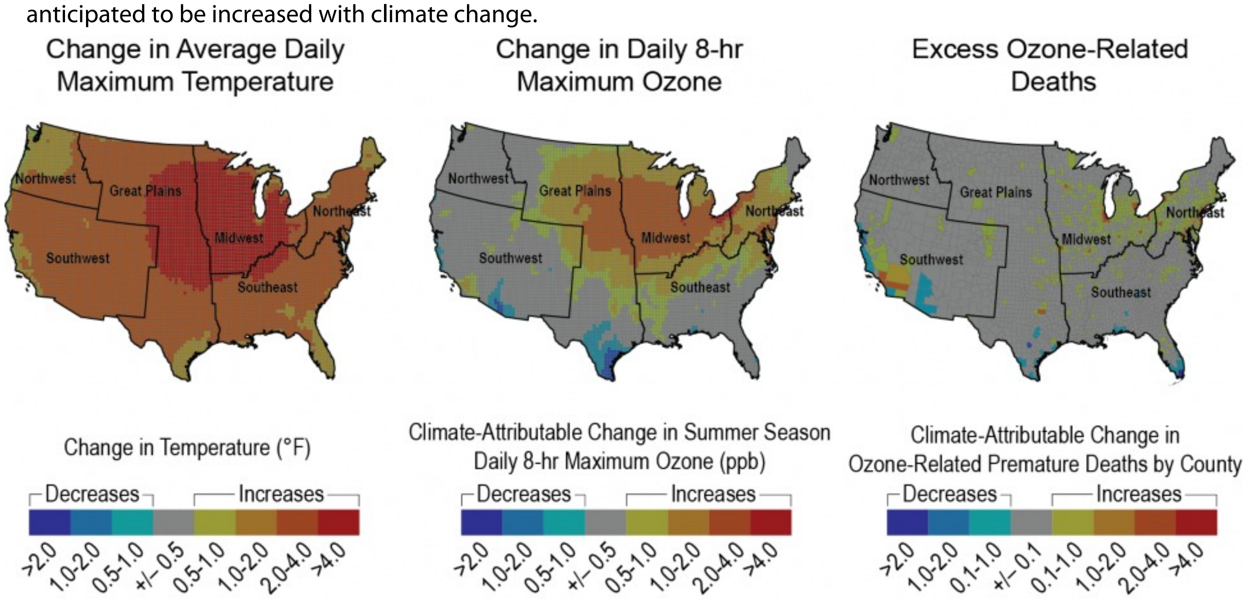
Air Quality Impacts

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 visit the Minnesota State DNR: https://dnr.wi.gov/topic/AirQuality/ You can also download Plume Lab's free mobile phone air quality monitoring app: https://plumelabs.com/en/air/

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.



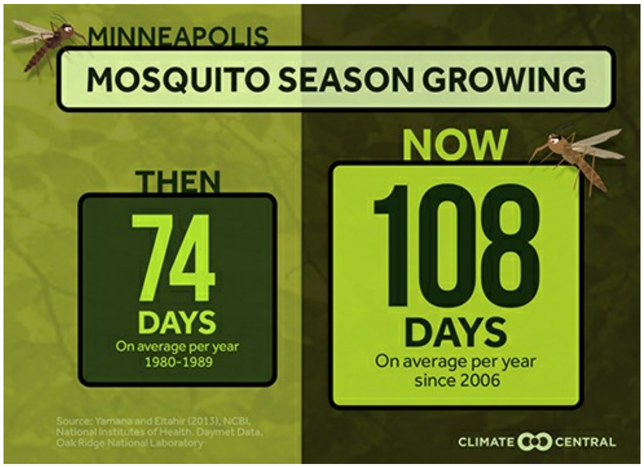
Projected Change in Temperature, Ozone, and Ozone-Related Premature Deaths in 2030
Projected changes in average daily maximum temperature (degrees Fahrenheit), summer average maximum daily 8-hour ozone (parts per billion), and excess ozone-related deaths (incidences per year by county) in the year 2030 relative to the year 2000.

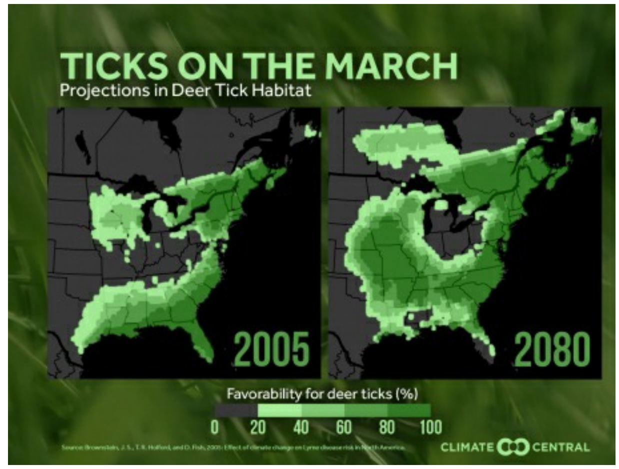
(Source: US Climate Resilience Toolkit)

Climate Risks to Dubuaue

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.





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. 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.
- Extreme weather events, such as flooding, drought, and wildfires can contaminate crops and fisheries with metals, chemicals, and toxicants released into the environment.
- Degraded soil health and soil erosion, exacerbated by increasing drought/flood cycles and increasing storm intensities.

Climate Risks to Maplewood

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.

Infrastructure Failure

Extreme weather events, flooding and flash flooding, as well as increasing daily stresses caused by increasing climate variability all represent potential causes of failure of our aging infrastructure. Power outages, road damage, bridge collapse, water infrastructure failure - each of these represent significant physical climate risks to the community, especially individuals who are climate vulnerable.

Number of Power Outages by State, 2014

(Source: US Department of Energy)

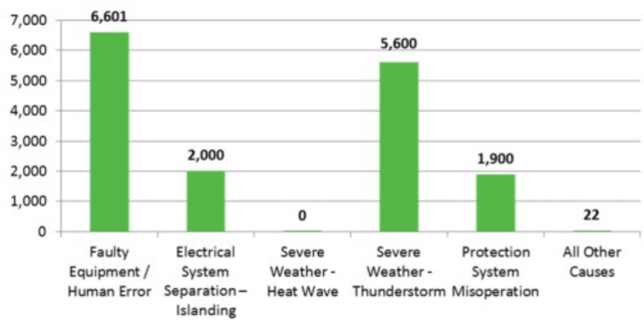
Power Outages

Minnesota Residents effected by electric outages annually:	**449,995**
Average Annual duration of electric outages in Minnesota:	**46.2** hrs/yr
Leading cause of electric outages in Minnesota (in terms of number of customers effected):	**Weather/ falling trees**

Climate Risks to Maplewood

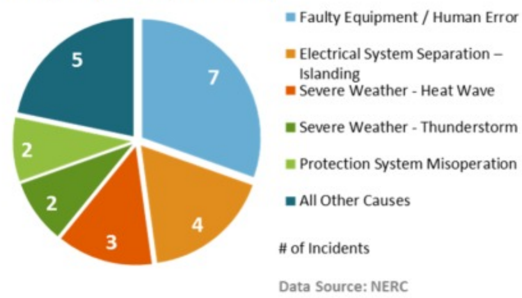
Infrastructure Failure (continued)

Electric Customers Disrupted by NERC-Reported Electric Transmission Outages by Cause (1992–2009)



Data Source: NERC

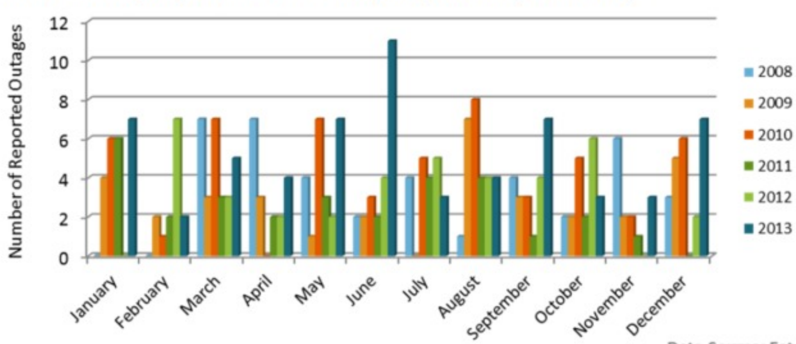
Number of NERC-Reported Electric Transmission Outages by Cause (1992–2009)



Data Source: NERC

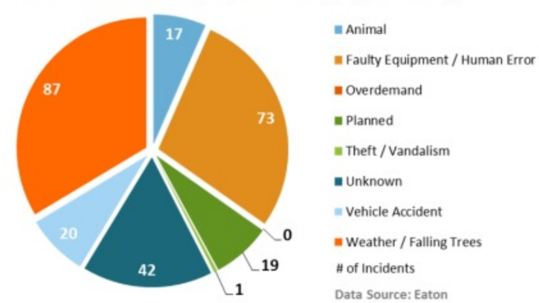
(Source: US Department of Energy)

Electric-Utility Reported Power Outages by Month (2008–2013)



Data Source: Eaton

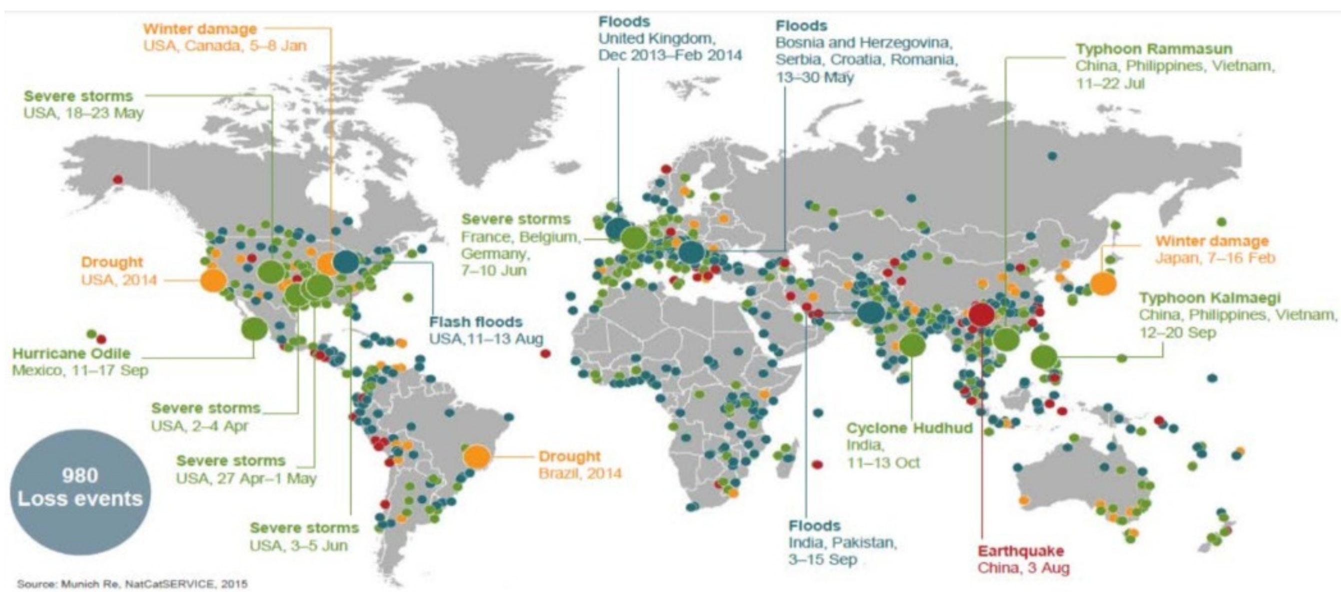
Causes of Electric-Utility Reported Outages (2008–2013)



Data Source: Eaton

(Source: US Department of Energy)

Global Loss Events, 2014



Appendix A3

Climate Resilience Indicators

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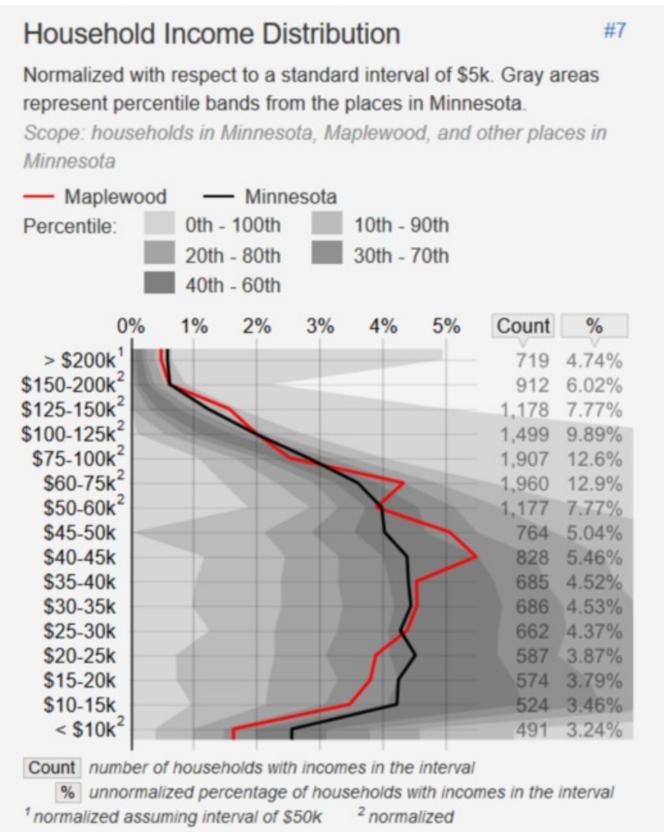
Climate Resilience Indicators

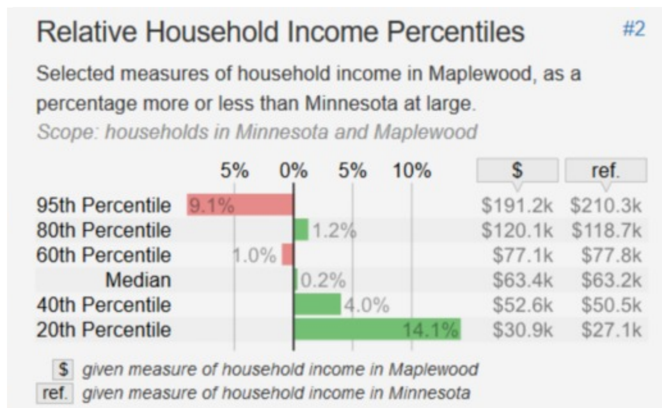
Similar to Climate Impact Multipliers, a community's overall resilience can have a multiplying or a mitigating affect on the population's ability to adapt to climate risks and rapidly recover from extreme weather events. Understanding and tracking the state of these Resilience Indicators will help identify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

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

Ames 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 or low tax bases, or low tax rates, can have a lag in infrastructure planning, maintenance, and redevelopment. These stressors on a city'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.





(Source: US Census, Statistical Atlas)

Maplewood Resilience Indicators - Health

The potential magnitude of the population climate risks outlined in section A2 “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 the City 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.

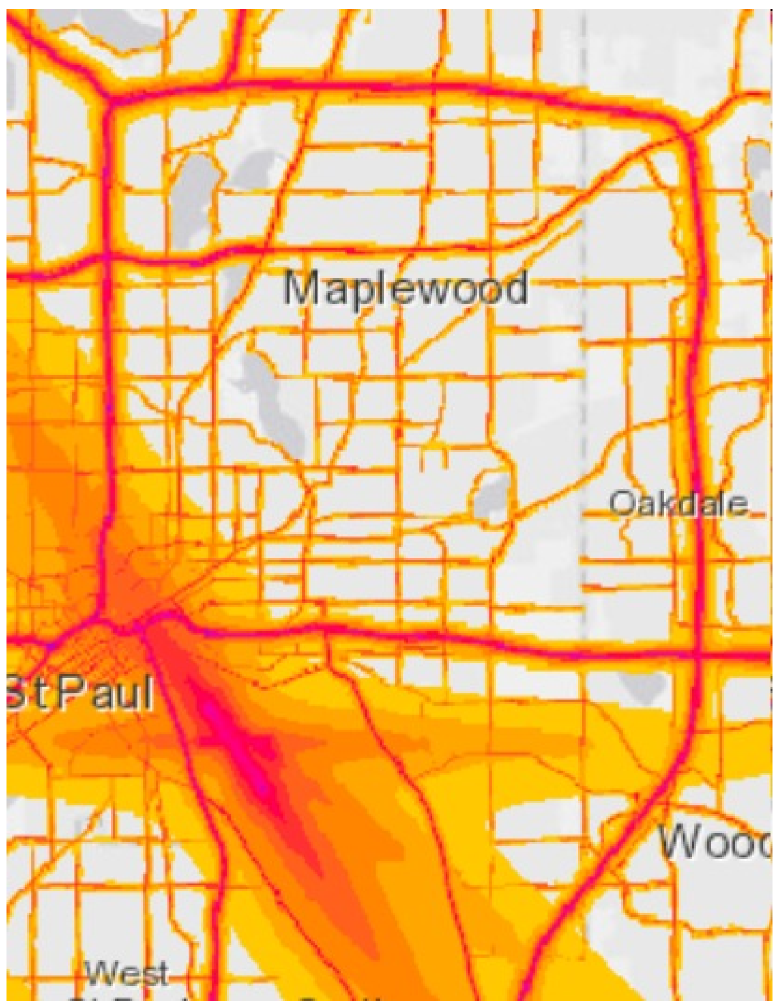
	State	County
Poor/Fair Health	12%	**12%**
Uninsured	7%	**8%**
Asthma emergency department visits (per 10,000)	35.5	**55.6**
Pulmonary Disease Hospitalizations (COPD per 100,000)	15.5	**19.1**
Heart attack hospitalizations (per 100,000)	26.5	**26.7**

(Source: County Health Rankings & Roadmaps program, Minnesota Public Health Tracking Portal)

Health and Heavy Traffic

Vehicles are a significant and widespread source of air and noise pollution in Iowa communities. Heavy traffic and busy roads increase the relative health risks caused by all air pollutants coming from cars, trucks, and buses. When it gets hot outside, the impacts of pollution on health are even worse. Hotter summers influenced by climate change may mean more health problems for people living, working, or going to school in communities near major roadways. People who live, work, or attend schools near high-traffic roadways are more exposed to traffic-associated air pollutants. Even people passing through these areas while commuting, walking, or biking are more at risk.

The map to the right shows concentrations of on-road vehicle noise and particulate pollution in the city. Darker areas indicate higher air pollution and, subsequently, those locations pose greater risk to human health.
(Source: US Department of Transportation)



Maplewood Resilience Indicators - EPA Environmental Justice Screen

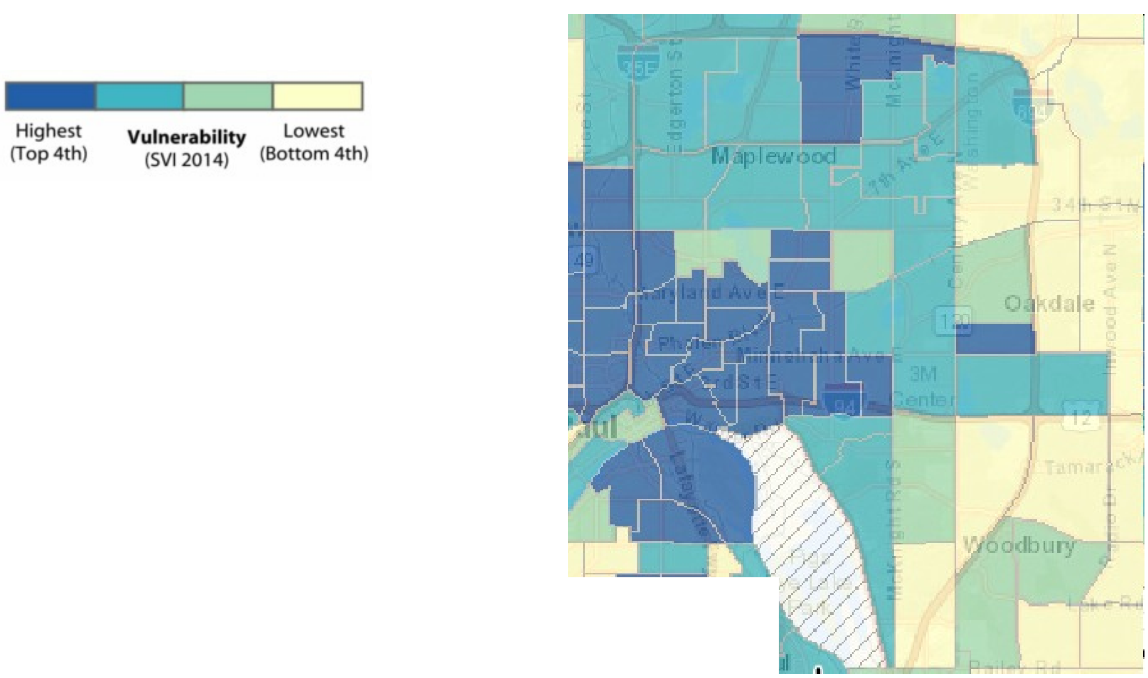
EJSCREEN is an environmental justice mapping and screening tool that provides EPA with a nationally consistent data set and approach for combining environmental and demographic indicators. All of the EJSCREEN indicators are publicly-available data. EJSCREEN simply provides a way to display this information and includes a method for combining environmental and demographic indicators into EJ indexes. Below are the EJSCREEN results for the City. All values circled in orange are values in the upper 35 percentile for the State, representing areas of potential focus for the City.

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 $\mu g/m^3$)	7.38	6.68	81	8.63	13	8.3	24
Ozone (ppb)	36.1	36.2	38	43.4	5	43	14
NATA* Diesel PM ($\mu g/m^3$)	0.497	0.333	78	0.446	60-70th	0.479	60-70th
NATA* Cancer Risk (lifetime risk per million)	30	24	85	26	80-90th	32	<50th
NATA* Respiratory Hazard Index	0.4	0.31	80	0.34	80-90th	0.44	<50th
Traffic Proximity and Volume (daily traffic count/distance to road)	610	440	84	530	78	750	72
Lead Paint Indicator (% Pre-1960 Housing)	0.34	0.31	62	0.38	52	0.28	65
Superfund Proximity (site count/km distance)	0.23	0.18	81	0.13	89	0.13	88
RMP Proximity (facility count/km distance)	0.22	0.76	35	0.82	37	0.74	41
Hazardous Waste Proximity (facility count/km distance)	0.42	1.2	52	1.5	43	4	49
Wastewater Discharge Indicator (toxicity-weighted concentration/m distance)	0.00012	0.27	61	0.82	44	14	55

Maplewood 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 Maplewood has areas in all four levels of vulnerability (lowest quartile through highest quartile)

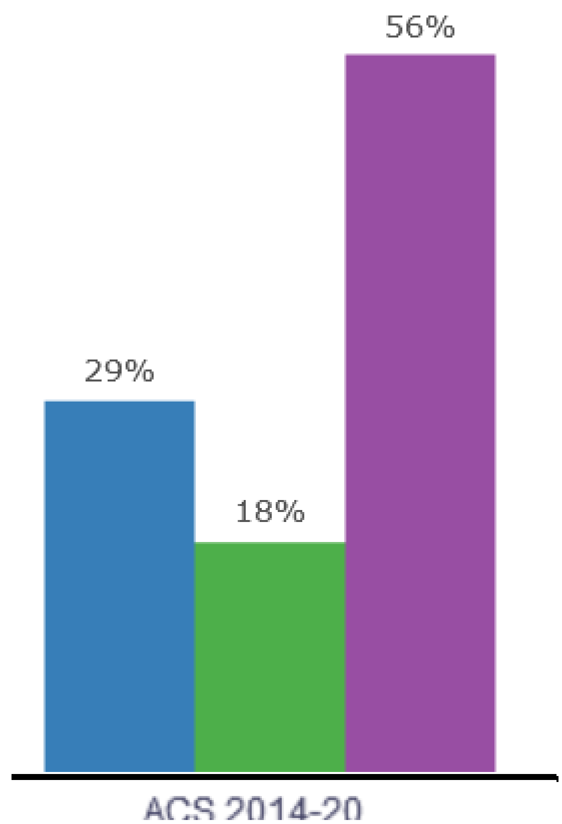


Maplewood Resilience Indicators - Housing Burden

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.

According to the Metropolitan Council Community Profile data, the City of Maplewood has 29% of all households experiencing housing burden, with Burden rates among homeowners at 18% and Burden rates among renters at 56%.

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

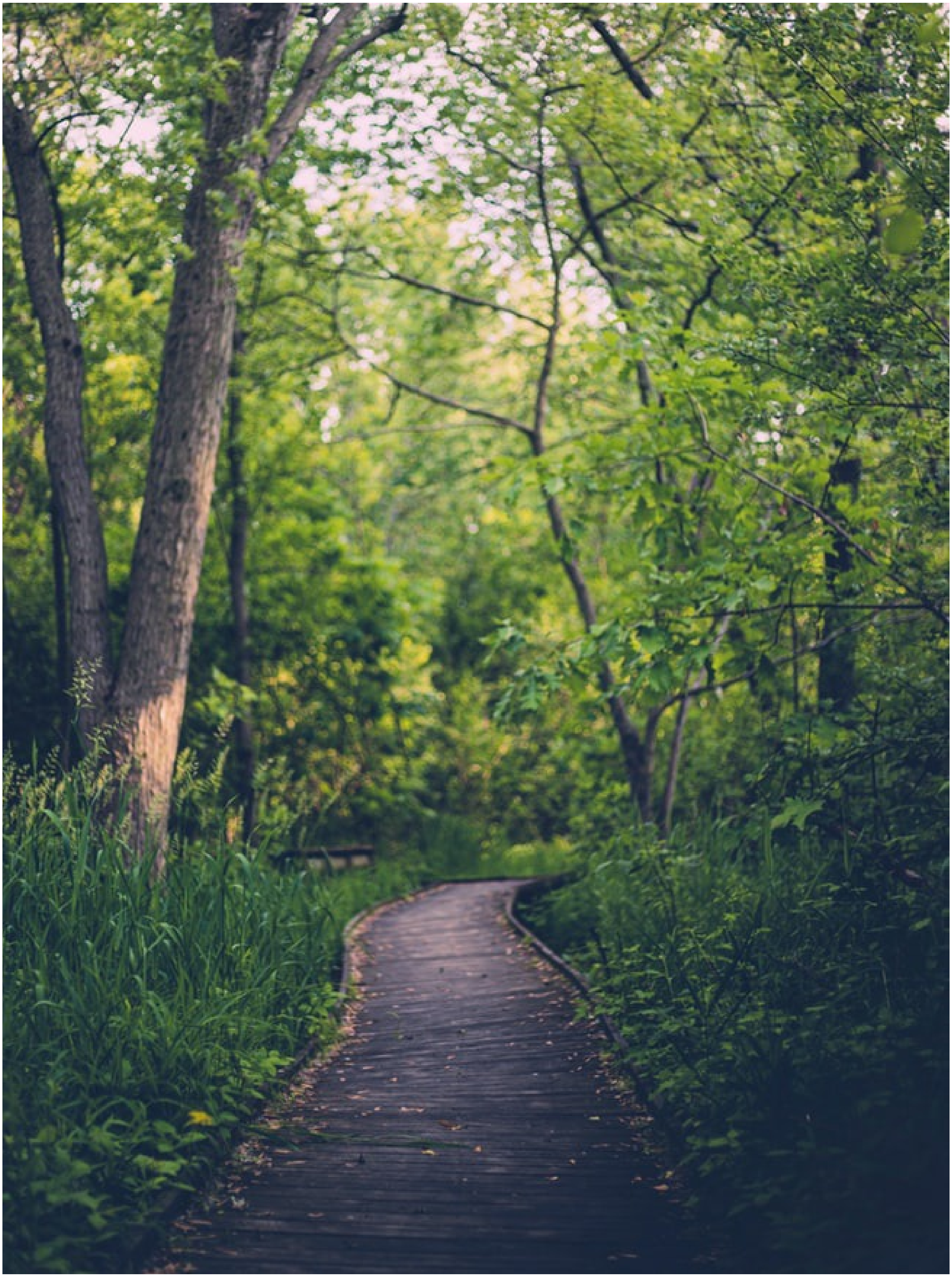
The type of structure a resident lives in can impact the level of housing burden experienced by community members. According to a 2005 study by the US Housing and Urban Development Agency, renters, on average, have 10% more of their monthly income going to utility costs. Those who live in mobile home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

Maplewood Housing by Type and Occupancy

Housing Type	Housing Units			Owner-Occupied			Renter-Occupied		
	Number	% of Total	State Ave	Number	% of Total	State Ave	Number	% of Total	State Ave
1, detached	8,872	58.10%	67.00%	8,345	77.40%	85.50%	525	11.70%	20.40%
1, attached	2,123	13.90%	7.80%	1,315	12.20%	7.50%	808	18.00%	8.40%
2 apartments	122	0.80%	2.20%	43	0.40%	0.60%	81	1.80%	6.10%
3 or 4 apartments	199	1.30%	2.10%	75	0.70%	0.50%	117	2.60%	6.20%
5 to 9 apartments	260	1.70%	2.20%	32	0.30%	0.40%	229	5.10%	6.80%
10 or more apartments	3,023	19.80%	15.90%	323	3.00%	2.20%	2,706	60.30%	50.50%
Mobile home	672	4.40%	2.80%	647	6.00%	3.20%	22	0.50%	1.50%
Total Occupied Units	15,270			10,782	70.6%	71.6%	4,488	29.4%	28.4%

(Source: US Census Bureau)



Appendix A4

Vulnerable Populations

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Vulnerable Populations in Maplewood

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.

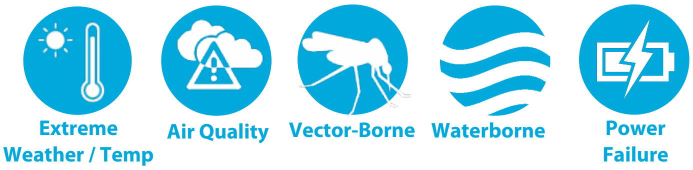
People or communities can have greater or lesser vulnerability to health risks depending on age, social, political, and economic factors that are collectively known as social determinants of health. Some groups are disproportionately disadvantaged by social determinants of health that limit resources 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 map the populations particularly vulnerable to the risks of climate change impacts within the City of Maplewood.

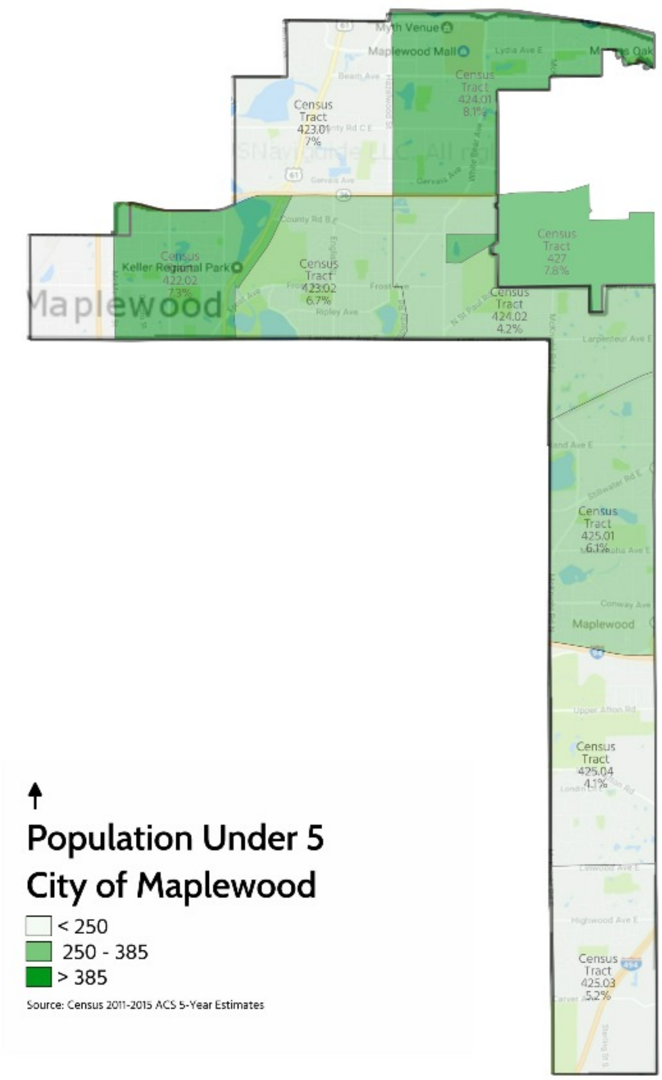
Children

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):



Map of Vulnerable Population Distribution Within Community



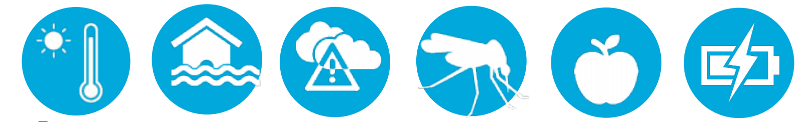
Observations for Maplewood

Children under five are most concentrated in the North and West sections of the City. These sections represent both the highest estimated population as well as the highest share of the total population of these tracts - ranging from 7% to over 8% of the total population of those neighborhoods.

Older Adults (65 and over)

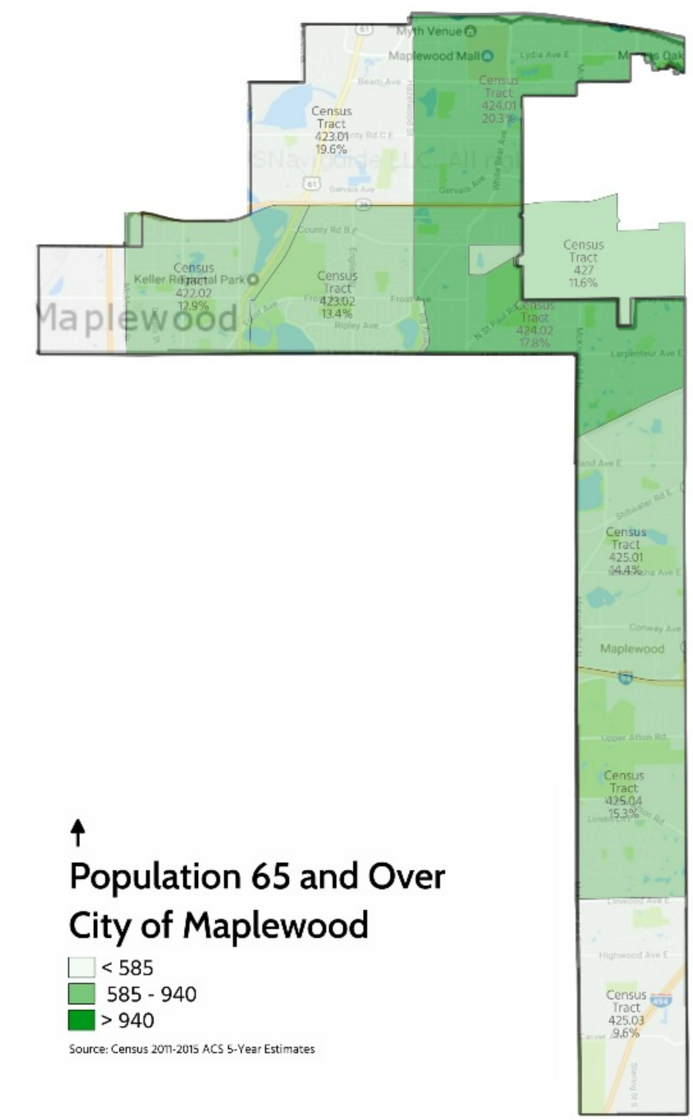
Older adults are also vulnerable to the health impacts associated with climate change and weather extremes. Vulnerabilities within older adults are not uniform due to the fact that this demographic is a diverse group with distinct sub-populations that can be identified not only by age but also by race, 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):



Extreme Weather / Temp | Flood | Air Quality | Vector-Borne | Food Insecurity | Power Failure

Map of Vulnerable Population Distribution Within Community



Observations for Maplewood

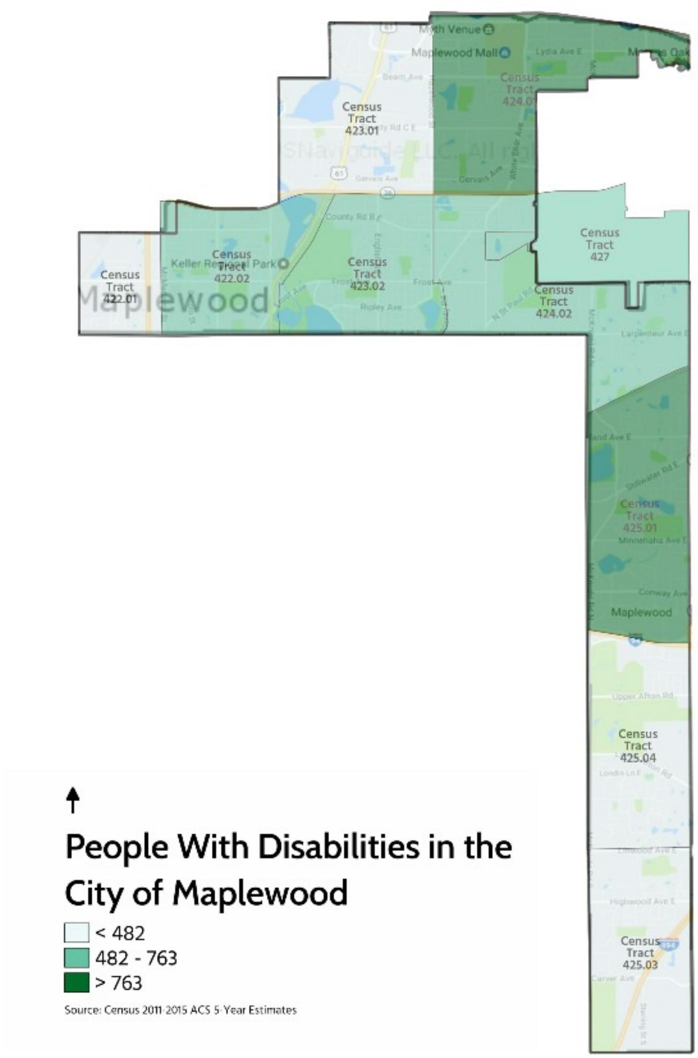
Older Adults are most concentrated in the Central sections of the City. These sections represent both the highest estimated population as well as the highest share of the total population of these tracts - ranging from 10% to over 20% of the total population of those neighborhoods.

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):

Map of Vulnerable Population Distribution Within Community



Observations for Maplewood

Individuals with disabilities are most concentrated in the North and Central sections of the City. These sections represent both the highest estimated population as well as the highest share of the total population of these tracts - ranging from 10% to over 15% of the total population of those neighborhoods.

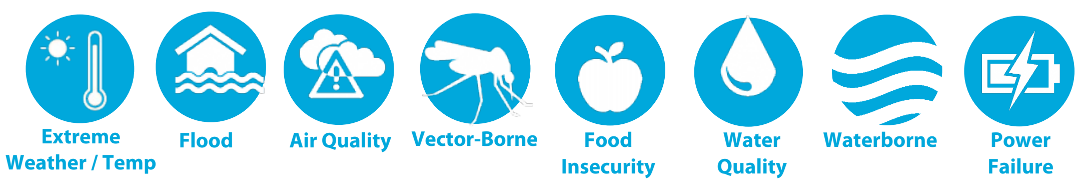
Individuals Under Economic Stress

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 Iowa, food insecurity affects 1 in 9 people. 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:



Map of Vulnerable Population Distribution Within Community

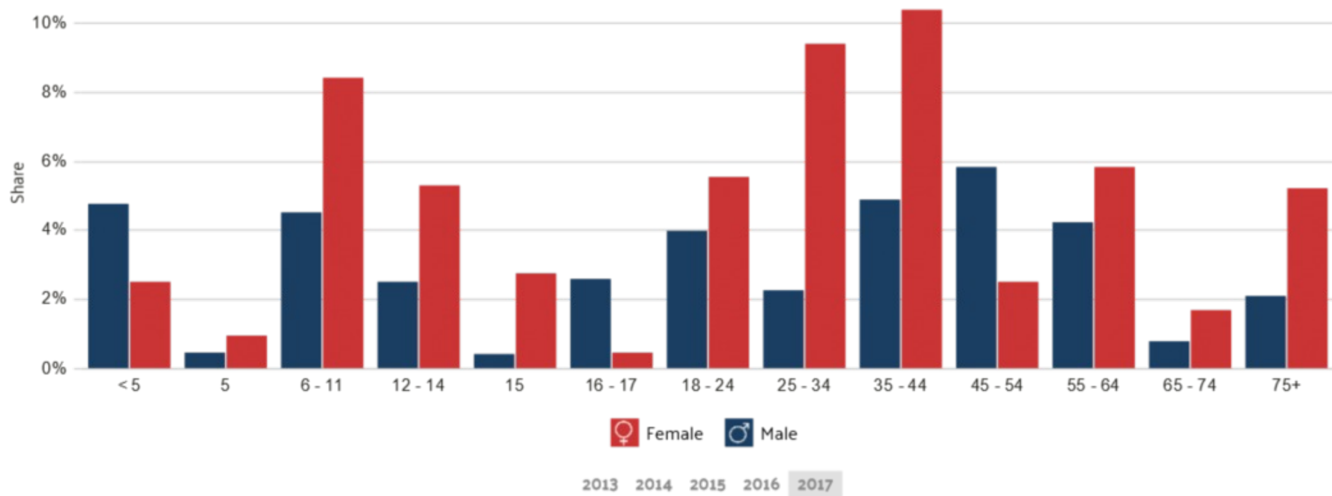
See maps on next page.

Observations for Maplewood

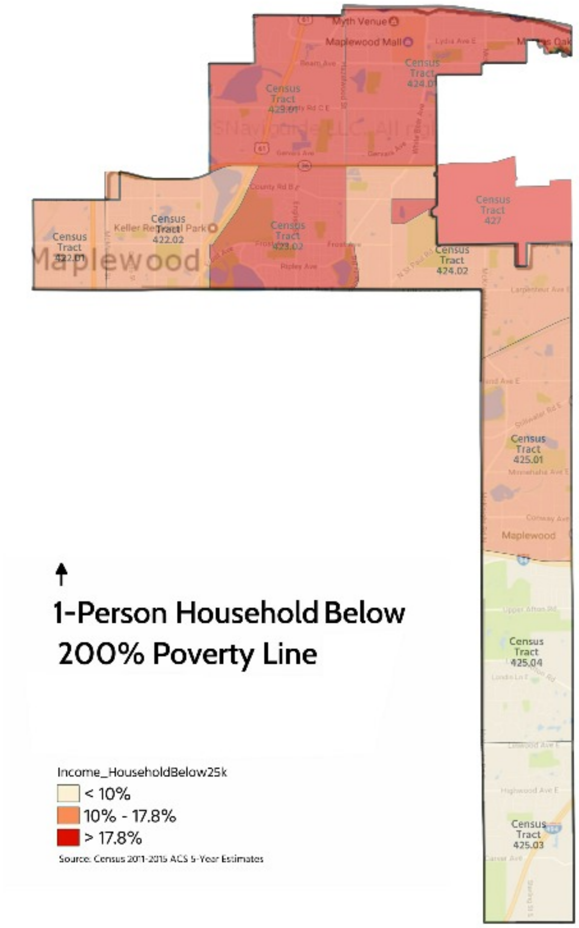
Families living in economic stress are most concentrated in the Central and West Central sections of the City, making up 30% or more of the households in those neighborhoods. Individuals living in economic stress are most concentrated in the Central and North sections of the City and make up to 17% of the population in those areas.

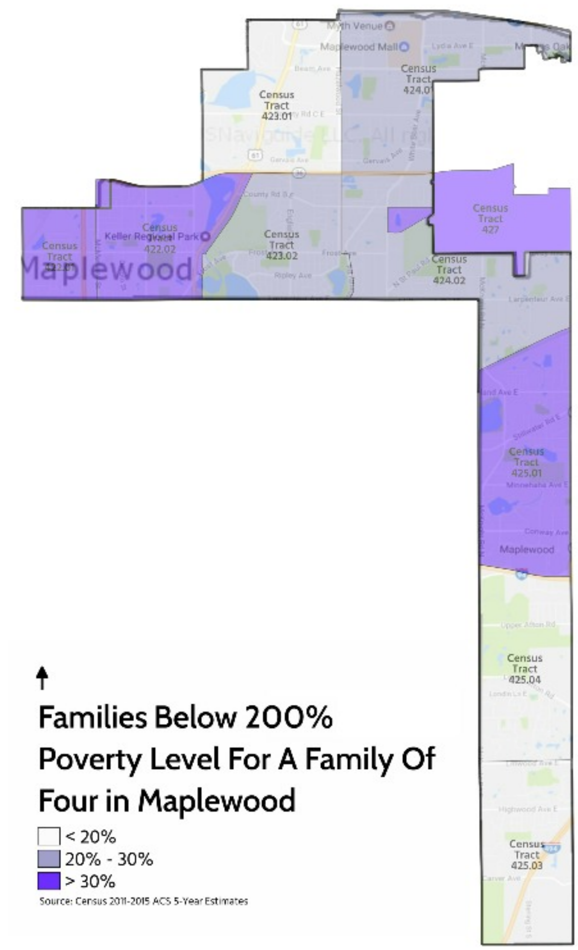
Poverty by Age and Gender

8.72% of the population in Maplewood live below the poverty line. The largest demographic living in poverty is female 35-44, followed by Female 25-34 and then Female 6-11. 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.



Map of Vulnerable Population Distribution Within Community





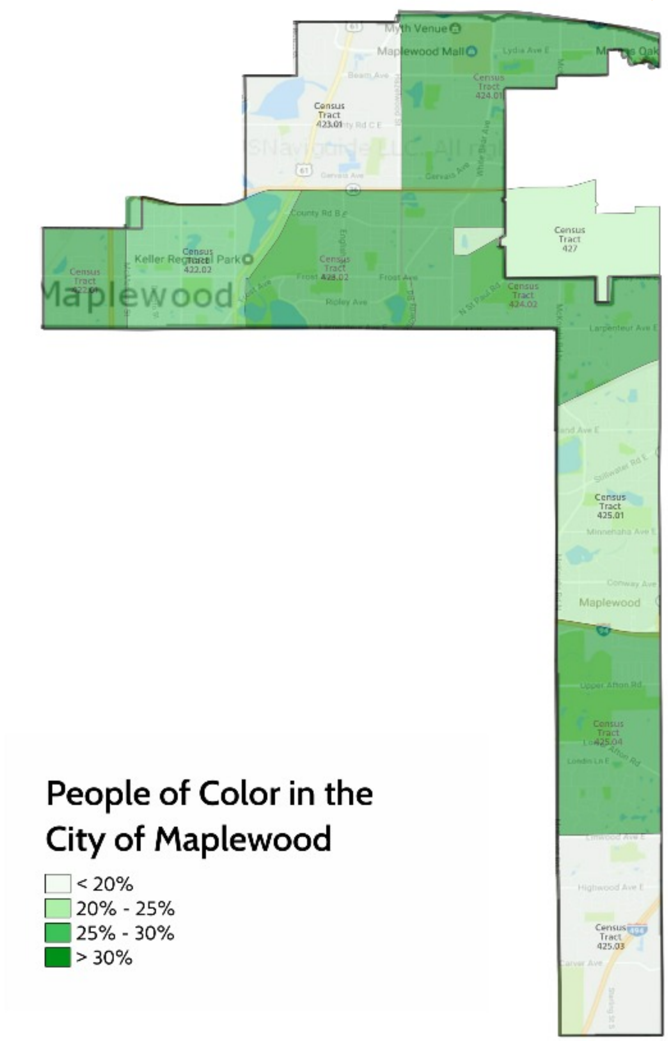
People of Color and Limited English Populations

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:

Map of Vulnerable Population Distribution Within Community

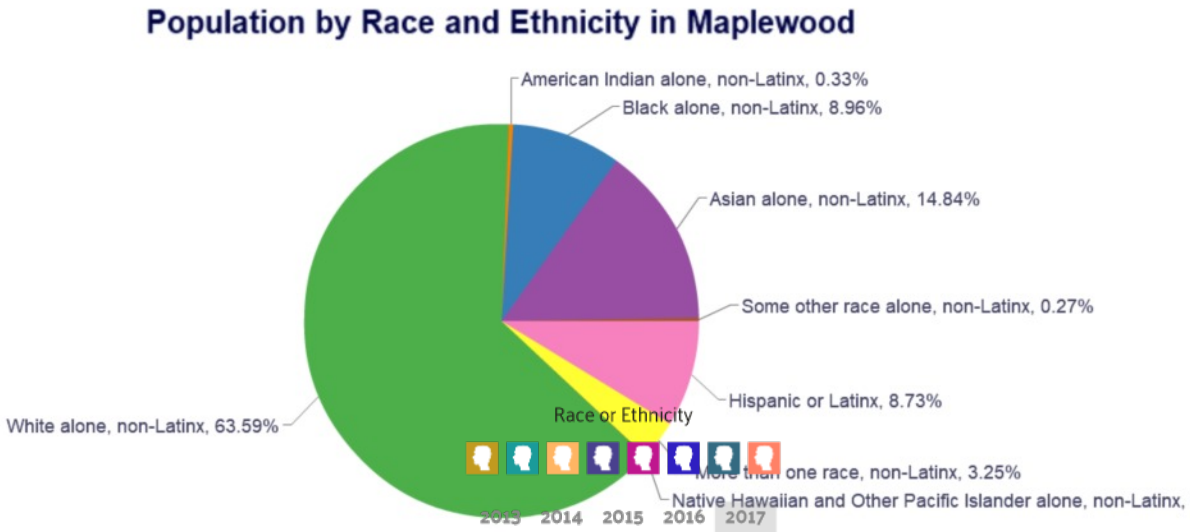


Observations for Maplewood

Populations of color are most concentrated in the Central and West Central sections of the City. These sections represent both the highest estimated population of color as well as the highest share of the total population of these tracts - ranging from 20% to over 30% of the total population of those neighborhoods

There are an estimated 7,306 limited English speakers in the City. 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. The City should review its current and future communications for translation opportunities targeting the city's non-English primary languages to the greatest extent feasible.

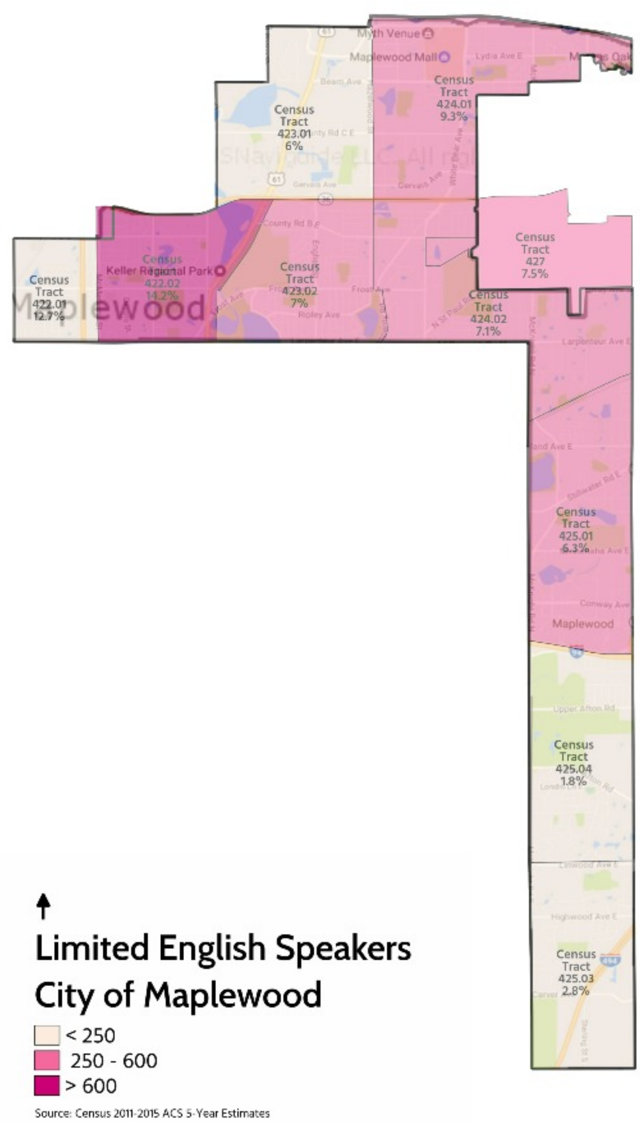
Breakdown of Race and Ethnicity



Language other than English spoken at home, percent of persons age 5 years+, 2014-2018

Total:	**23.2%**
Hmong:	6.35%
Spanish:	3.33%
An African Language:	3.08%
Cambodian:	1.84%
Vietnamese:	0.89%
Hindi:	0.5%
Another language:	7.21%

Source: US Census



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; construction workers; paramedics, firefighters and other first responders; and transportation workers.

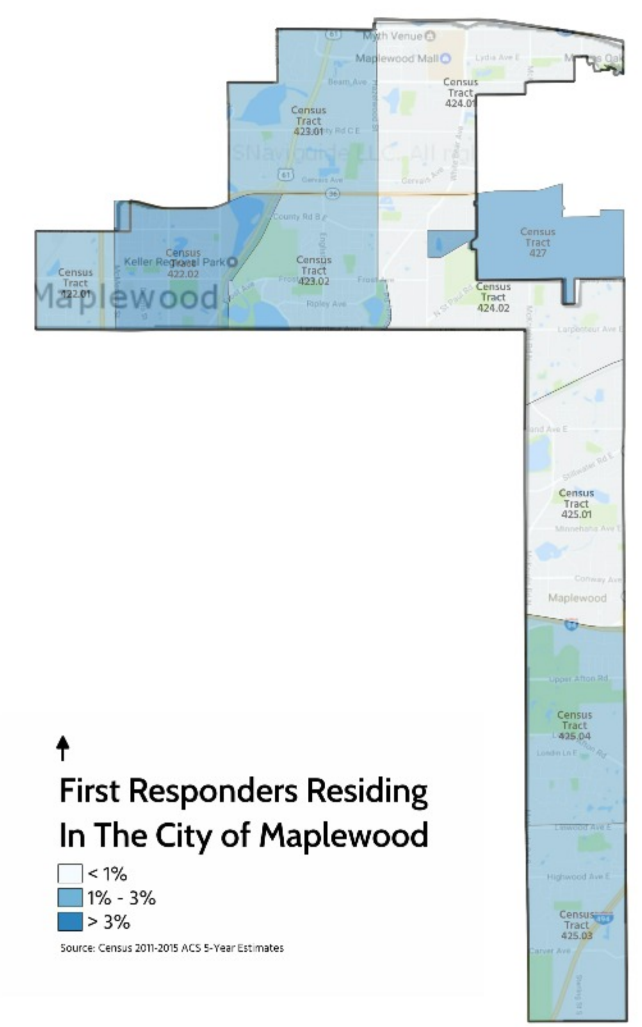
For individuals employed in climate vulnerable jobs who also fall within other vulnerable population categories, the health effects of climate change can be cumulative. For these individuals, the risks experienced in their work can be exacerbated by exposures associated with poorly insulated housing 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.

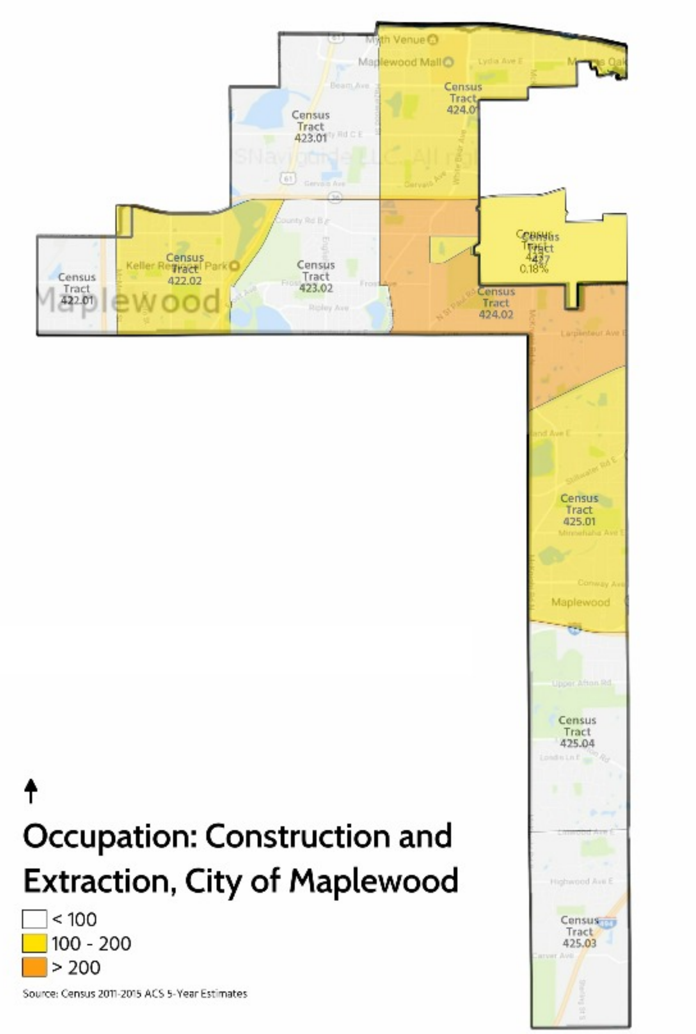
Individuals employed in at-risk occupations may be particularly sensitive to the following Climate Risks:

At-Risk Occupations Breakdown

This series of maps illustrates the breakdown of workers employed in the primary at-risk occupation categories.

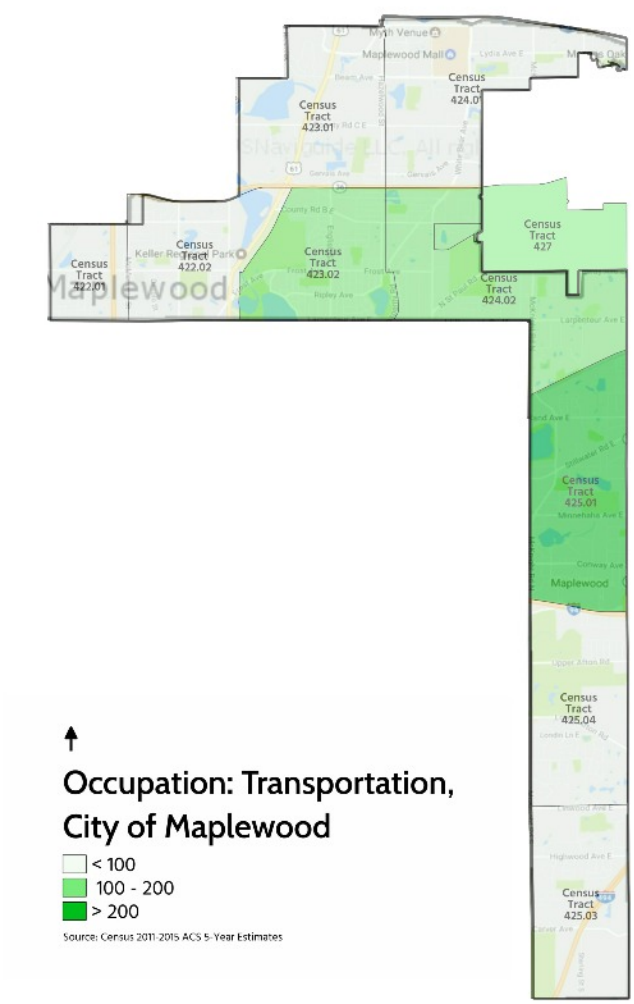
Map of Vulnerable Population Distribution Within Community





Total Employment by Occupation

Employment in Maplewood, MN grew at a rate of 3.49%, from 2016 to 2017. The chart above shows the share breakdown of the primary jobs held by residents of Maplewood.



(Source: Feed America)

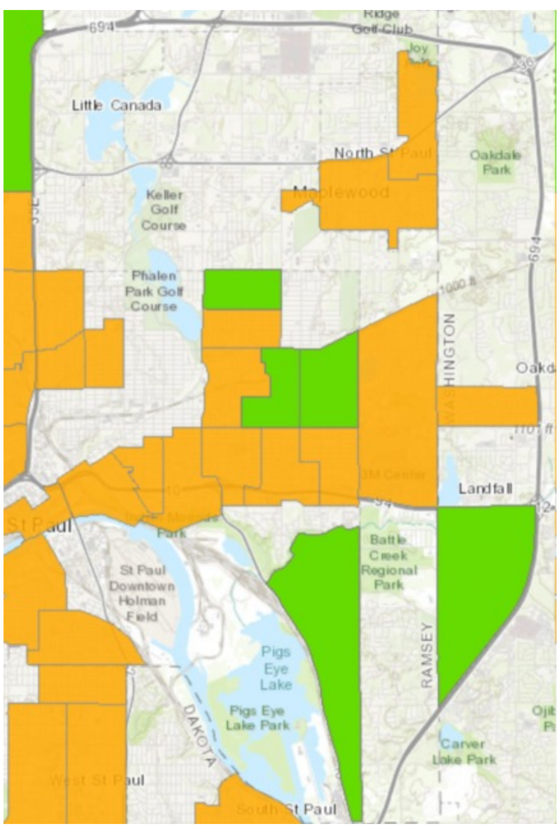
Individuals with Possible Food Insecurity

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:

Food Access

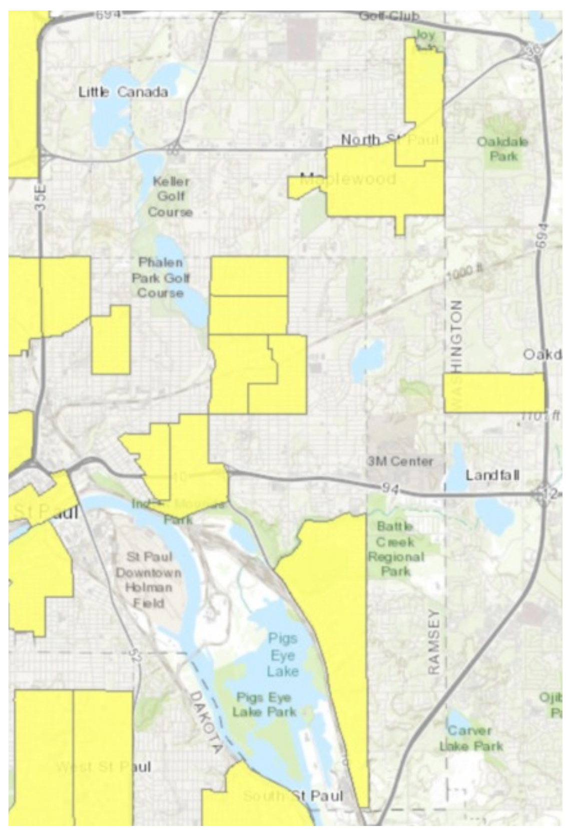
On the map below, highlighted sections represent low-income census tracts (tracts where 20% or more of the population is at or below poverty, or where family median incomes are 80% or less of State median) where a significant number (at least 500 people) or share (at least 33 percent) of residents are distant from the nearest supermarket. In sections which are green, residents are more than 1 mile (urban) or 10 miles (rural), while in orange sections residents are more than ½ mile (urban) or 10 miles (rural) from nearest supermarket.



Vehicle Access

On the map 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)



Climate Migrant Populations

In the United States alone, within just a few decades, hundreds of thousands of homes on US coasts will be chronically flooded. According to a study by the Union of Concerned Scientists, over 170 communities in the United States will be chronically inundated from sea level rise by the end of this decade. More than half of these 170 communities are currently home to socioeconomically vulnerable neighborhoods.

By 2060 the number may more than double to 360 communities and by 2100 double yet again to over 670 communities chronically inundated. By that time more than 50 heavily populated areas—including Oakland, California; Miami and St. Petersburg, Florida; and four of the five boroughs of New York City—will face chronic inundation. These effects of sea level rise could displace 13,000,000 people within the United States by the end of this century.

In addition to these internal-US climate migrants, the UN forecasts estimate that there could be anywhere between 25 million and 1 billion environmental migrants by 2050.

Human migration is a natural response to these climate change pressures, and is one of many adaptation measures that people will take in response to climate change. Understating how human migration will be affected by climate change is therefore a critical input in the decision making process of many governments and organizations. In particular, it is important to understand how climate change driven migration will differ from "business as usual" forms and motivations humans have to migrate, increasing the volume rate of migration brining with it indirect impacts on the communities likely to receive migrants.

The impacts of climate migration will cause accelerated changes for inland areas, particularly urban areas, that will observe much higher levels of incoming migrants than they would have without climate impacts. It is projected that 86% of all communities with populations of over 10,000 will be impacted with climate migration this century. These changes can in turn take the form of tighter labor markets and increased housing prices, and impacts on income inequality. This climate migration can also have positive impacts such as improved productivity, broadened skillsets within the labor force, and expanded human capital.

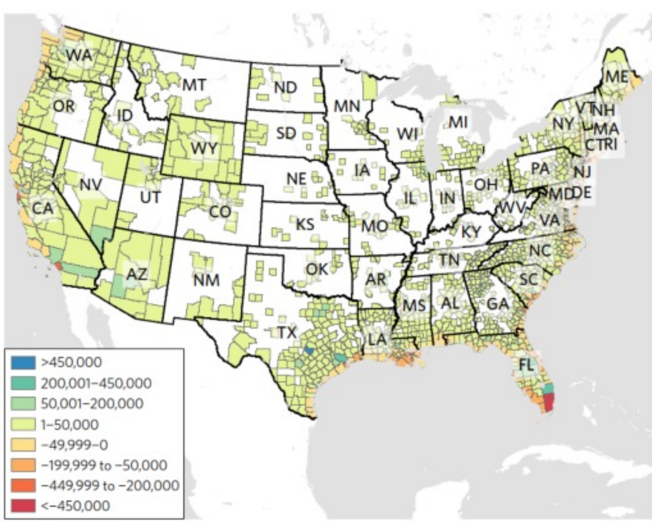
Projected Potential Climate Migrant Population by 2100

Ramsey County: **20-70,000**

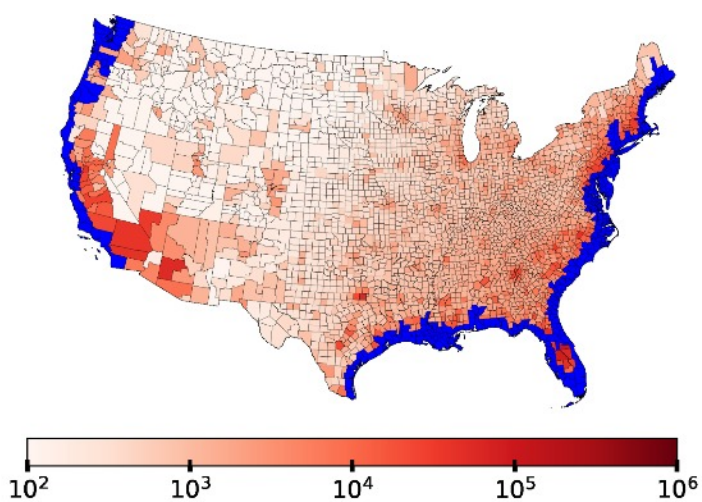
City of Maplewood: **2-5,500**
(Pro rata share)

Below are two modeled projections for US climate migration induced by sea level rise only through 2100:

Hauer Projection - Migration induced by sea-level rise in US



Robinson Projection - Migration induced by sea-level rise in US



(Sources: United Nations International Organization on Migration
Hauer, M. Migration induced by sea-level rise could reshape the US population landscape. Nature Clim Change 7, 321–325 (2017). https://doi.org/10.1038/nclimate3271
Robinson C, Dilkina B, Moreno-Cruz J (2020) Modeling migration patterns in the USA under sea level rise. PLoS ONE 15(1): e0227436. https://doi.org/10.1371/journal.pone.0227436)

Appendix A5

Additional Findings

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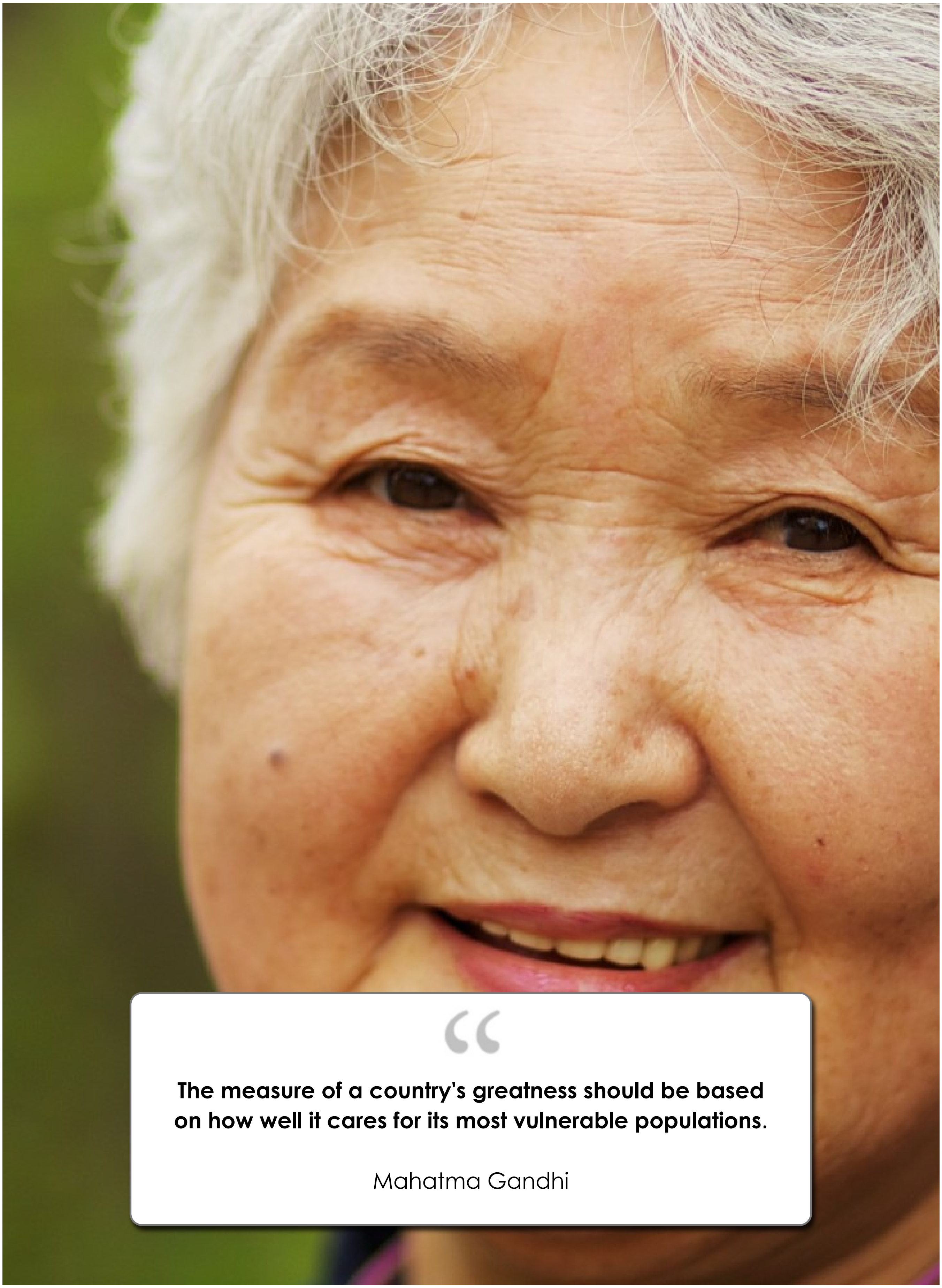


> **The measure of a country's greatness should be based on how well it cares for its most vulnerable populations.**
>
> Mahatma Gandhi

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.

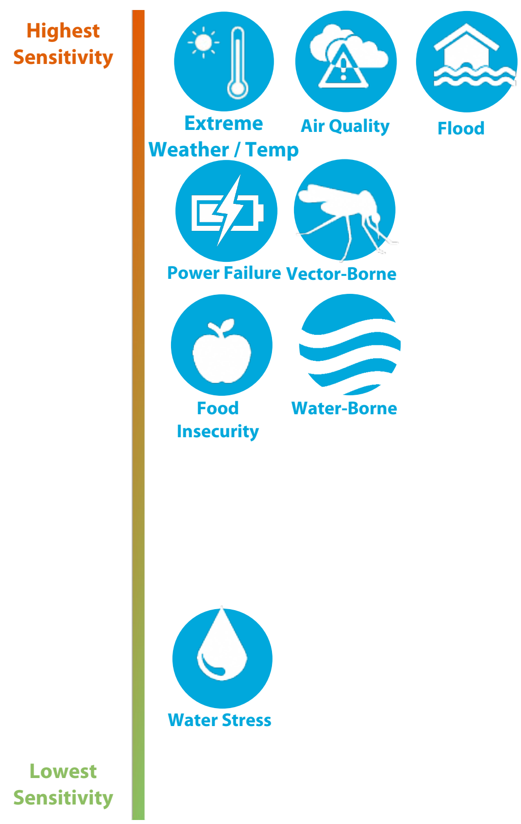
Comparing Vulnerable Populations Within The City of Mapleood

Vulnerable Populations of Maplewood in order of estimated total population share:

- Individuals living in Economic Stress
- Older Adults
- People of Color
- Individuals with Disabilities
- Food Insecure Individuals
- Individuals with Limited Vehicle Access
- Limited English Speakers
- At-Risk Workers
- Children Under 5

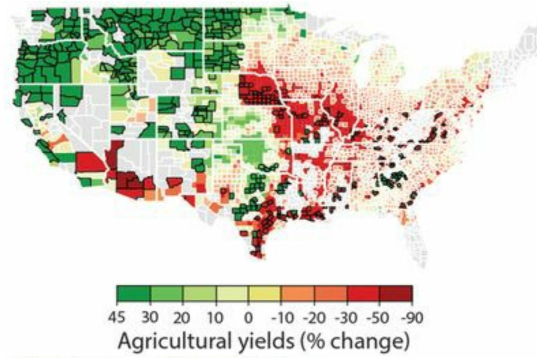
Maplewood Risk Sensitivity

Based on the estimated vulnerable populations within the City of Maplewood and a review of the climate risks each group is particularly sensitive to, the following is an estimation of the overall risk sensitivity for the City:



Projected Economic Impacts of Climate Change

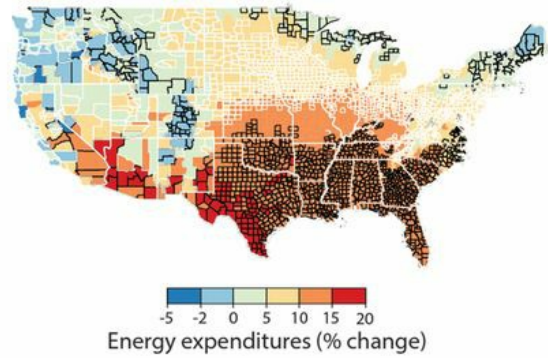
"Estimating economic damage from climate change in the United States", a 2017 study completed by Solomon Hsiang and others from the University of California at Berkeley assessed the economic impact of current climate projections throughout the United States. The sectors assessed, and the findings for Ramsey County Minnesota and the City of Maplewood are below:



Agricultural Yields Through 2100

Agricultural yields are projected to decline with the increase of Global Mean Surface Temperature in addition to impacts related to precipitation changes. Although increased CO2 levels are anticipated to offset a portion of these yield loses, the impact for much of the United States will be a net negative. Local projections:

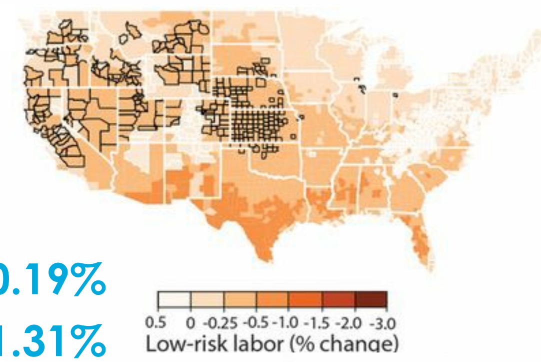
Ramsey County and City of Maplewood: **N/A**



Energy Expenditures Through 2100

As average annual temperatures increase, demand for energy will increase, resulting in increased energy expenditures. Local projections:

Ramsey County and City of Maplewood: **+8.49%**

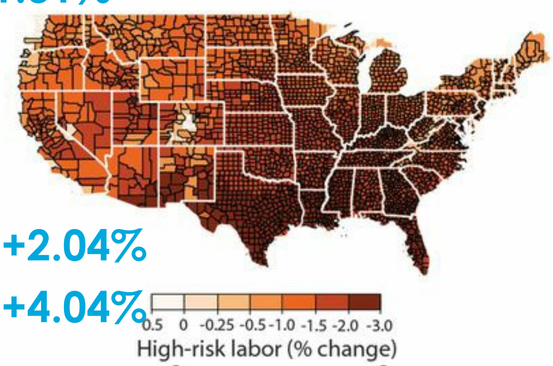


Reduced Labor Productivity Through 2100

Labor productivity declines with the instance of increased temperature. Rates vary for "low-risk" workers who are predominantly not exposed to exterior conditions and for "high-risk" workers (those identified as "At Risk Workers" in Section 9). Local projections:

Low-Risk Labor Loss for Ramsey County and City of Maplewood: **-0.19%**

High-Risk Labor Loss for Ramsey County and City of Maplewood: **-1.31%**

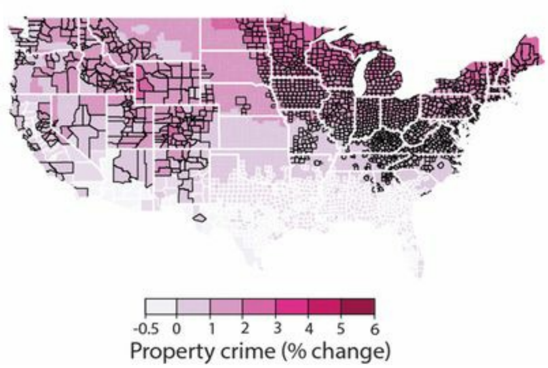


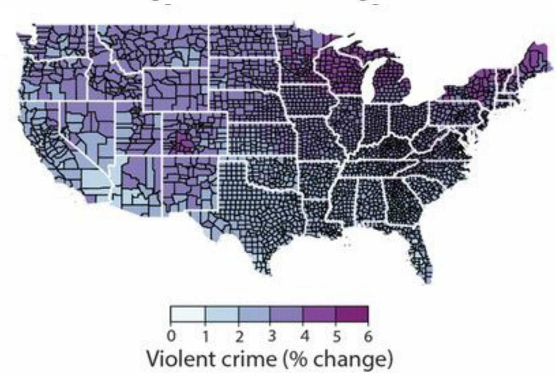
Increases in Crime Rates Through 2100

Studies indicate property crime increases as the number of cold days decrease due to the property crime suppression effect cold days have. Violent crime rates have been shown to increase linearly at a relatively precise 0.88% per 1°C. Local projections:

Property Crime Increase for Ramsey County and City of Maplewood: **+2.04%**

Violent Crime Increase for Ramsey County and City of Maplewood: **+4.04%**

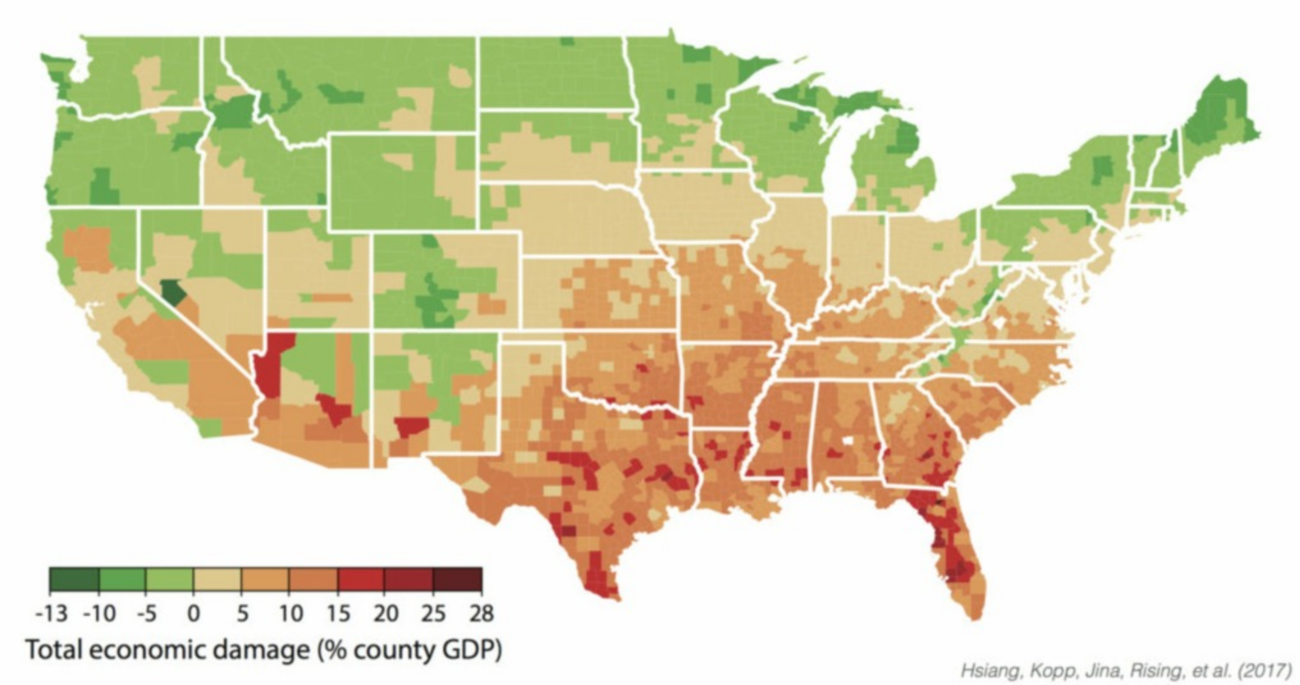


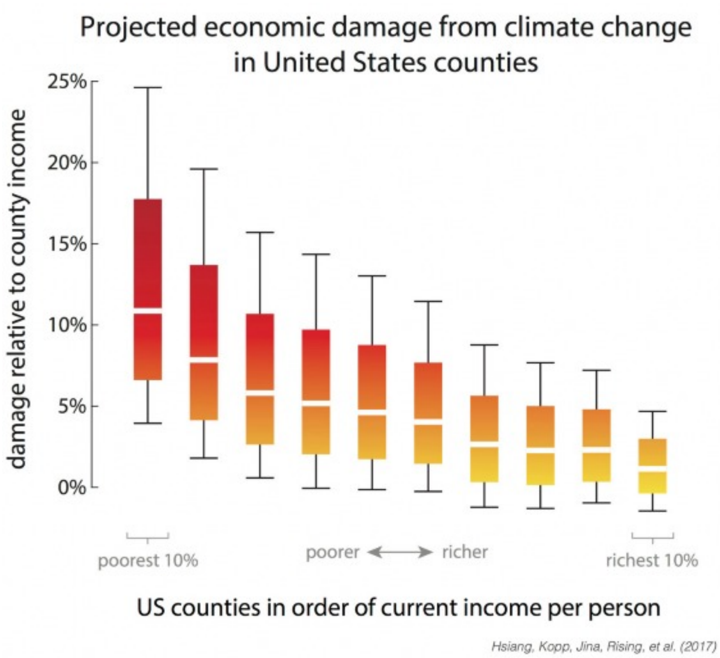


Total Projected Economic Impacts Through 2100

According to research completed for "Estimating economic damage from climate change in the United States", a 2017 study completed by Solomon Hsiang and others from the University of California at Berkeley the total annual economic impact for Story County Iowa by 2100 will be: **$474,910,256 annually (2018 dollars)**

Estimating the total annual economic impact for the City of Maplewood on a Pro Rata share results in:
$35,618,269 annually (2018 dollars)





Inequity of Economic Impacts Through 2100

According to the study "Estimating economic damage from climate change in the United States", climate change economic impacts will increase the unpredictability and inequity of future economic outcomes. The projected economic effects are unequally borne. As the graphic to the left illustrates, the poorest 10% are likely to receive 5 to 10 times the negative economic impacts of the wealthiest 10% in the community.

Source: "Estimating economic damage from climate change in the United States" Muir-Wood, Paul Wilson, Michael Oppenheimer, Kate Larsen and Trevor Houser Solomon Hsiang, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen, Robert
DOI: 10.1126/science.aal4369
Science 356 (6345), 1362-1369.

Review of Climate Hazards for the City of Maplewood

A "Climate Hazard" is a physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources. Climate Hazards are reviewed based on current hazard level, anticipated change over time, and projected future hazard level.

The chart below reviews the current, future, and timeline of change for each of the primary Climate Hazards for the city. In addition, the columns on the right illustrate the reported number of events, % change, and annualized economic impact of each of these hazards over the last 20 years.

Climate Hazards

Climate Hazard Type	Current hazard risk level	Expected change in intensity	Expected change in frequency	Timeframe	Number of Events 1999-2009 vs 2009-2019 (NOAA)	% Change	County Impacts over 20 year period
Extreme Heat	Low	Increase	Increase	Medium-term	0 events to 4 events	N/A	216 injuries
Extreme Cold	Moderate	Increase	Decrease	Medium-term	0 events to 8 events	N/A	2 deaths, 2 injuries
Extreme Precipitation	Moderate	Increase	Increase	Short-term	7 events to 7 events	0%	See Flood
Floods	Moderate	Increase	Increase	Short-term	9 events to 10 events	110%	$5M
Droughts	Low	Increase	Increase	Medium-term	0 events to 0 events	N/A	N/A
Storms	Moderate	Increase	Increase	Short-term	74 events to 83 events	112%	$26M
Forest/Wild Fires	Low	Not known	Not known	Not known	0 events to 0 events	N/A	N/A
Air Quality Impacts	Moderate	Increase	Increase	Long-term	N/A	N/A	N/A

Review of Climate Risks for the City of Maplewood

A "Climate Risk" is the potential for negative consequences and outcomes for human health, systems, or communities. The most common way of evaluating the level of risk associated is "likelihood of Occurrence" x "Impact Level" or vulnerability.

Two charts are provided below. The first reviews the expected impacts, likelihood of occurrence, impact level based on Population vulnerability reviewed in Section 9, potential timeframe, and resulting overall risk level for Climate Risks to Population (Health Impacts). The second reviews the infrastructural and institutional Climate Risks to the Community. Each chart includes a brief review of the expected impacts and indicators.

Climate Risks to Population

Health Impacts	Expected Impact(s)	Likelihood of Occurrence	Impact Level (Population Vulnerability)	Timeframe	Risk (Likelihood x Impact)	Impact-related indicators
Extreme Heat	Increased demand for cooling; heat stress and emergency visits, heat related health	Likely	High	Medium-term	Very High	Cooling Degree Days, days above 95
Flooding	damage to property; flood related health impacts; infrastructure impacts	Likely	Moderate	Medium-term	Moderate	Flood events, flash flood occurances, wettest 5-day periods, number of heavy rain events, disaster declarations, change in NOAA storm
Drought	Damage to crop/tree/ecosystem, reduced drinking water source, increased flash flood potential due to decreased soil permeability	Possible	Low	Medium-term	Low	Consecutive days without rain, acquafer level, surface water condition, river flow
Air Quality Impacts	Increased particulate matter, increased ozone impacts, increased instances of asthma	Likely	High	Medium-term	High	Air quality index
Vector-Borne Diseases	Increased instances of lyme disease, encephalitis, heart worm, malaria, zika virus,	Likely	Moderate	Long-term	Moderate	Disease records
Nutrition Insecurity	Food price volitility/change, fluctuation in availability	Possible	Moderate	Medium-term	Moderate	Food price index, Foodshelf demand, % of school children qualifying for free and reduced lunch
Water Quanity/Quality Impacts	Water shortage, surface water quality impacts due to heat and stormwater runoff	Possible	Moderate	Long-term	Low	Acquafer health; Water quality test results
Water Borne Disease	Bacteria exposusure at infected surface water locations, contamination of drinking water due to flood	Likely	High	Medium-term	High	flood events; algea blooms

Climate Risks to Infrastructure and Institutions

Impacted Policy Sector	Expected Impact(s)	Likelihood of Occurrence	Potential Impact Level	Timeframe	Risk (Likelihood x Impact)	Impact-related indicators
Buildings	Increased demand for cooling, need for weatherization	Likely	Moderate	Short-term	High	Low income housing units, % of residents with housing burden, housing stock age, % of units without weatherization improvements
Transport / Roads	Increased freeze/thaw damage, increased salt/sand use and maintenance budgets	Likely	High	Short-term	Very High	% of flooded or flood damaged roads and bridges, City road maintenance budget
Energy	Increased power outages, increased demand and cost expediture	Likely	High	Medium-term	High	Energy outage occurances, number of customers without power, cooling degree day increases
Water	Increased scarcity, water quality impacts	Possible	High	Long-term	Moderate	Water infrastructure damage, acquafer health, flood contamination
Waste	Damage to waste infrastructure and processing, particularly wastewater	Unlikely	Moderate	Long-term	Low	Flood impacts at wastewater facilities, sewage release, flooding at landfill/RDF sites
Land Use Planning	Stormwater management impacts, heat island impacts, flood management,	Likely	High	Short-term	Very High	Heat Island co-efficient; stormwater runoff projections, citywide tree canopy coverage, citywide impervious surface coverage, % of complete streets
Agriculture & Forestry	Reduction in crop yield, forest + tree species loss due to changes in hardiness zone and pests	Likely	Moderate	Medium-term	Moderate	% change in crop yeild, impacts to crop planting and harvesting; tree canopy loss to pests, tree canopy loss to hardiness zone changes
Environment & Biodiversity	Insect infestation, increased disease vectors, ecosystem degradation	Likely	Moderate	Medium-term	Moderate	% of habitat loss, invasive species
Law Enforcement and Emergency Response	Increased property and violent crime, increased emergency response demand and mortality rate	Likely	Moderate	Long-term	Low	Property and violent crime statistics (particularly durring extreme heat), instances of mental health need, calls for emergency response (particularly during extreme heat and weather)
Tourism	Decline in tourism demand	Not known	Not Known	Not known	Not Known	Tourism statistics, hotel occupancy levels
Economic Impact	Impacts on regional Ag business, energy expenditures, labor impacts	Likely	Moderate	Medium-term	Moderate	Disaster declarations, economic indicators, employment rates

Priority Climate Risks for the City of Maplewood

The priority climate risks to the population of Maplewood include Extreme Heat, Air Quality Impacts, and Waterborne disease while the priority climate risks to infrastructure/institutions include Roads, Land Use Planning, Buildings, and Energy.

Appendix A6

Local Climate Risks to the Environment

Click to Return to TOC

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")

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