



City of Fitchburg
Climate Vulnerability Assessment

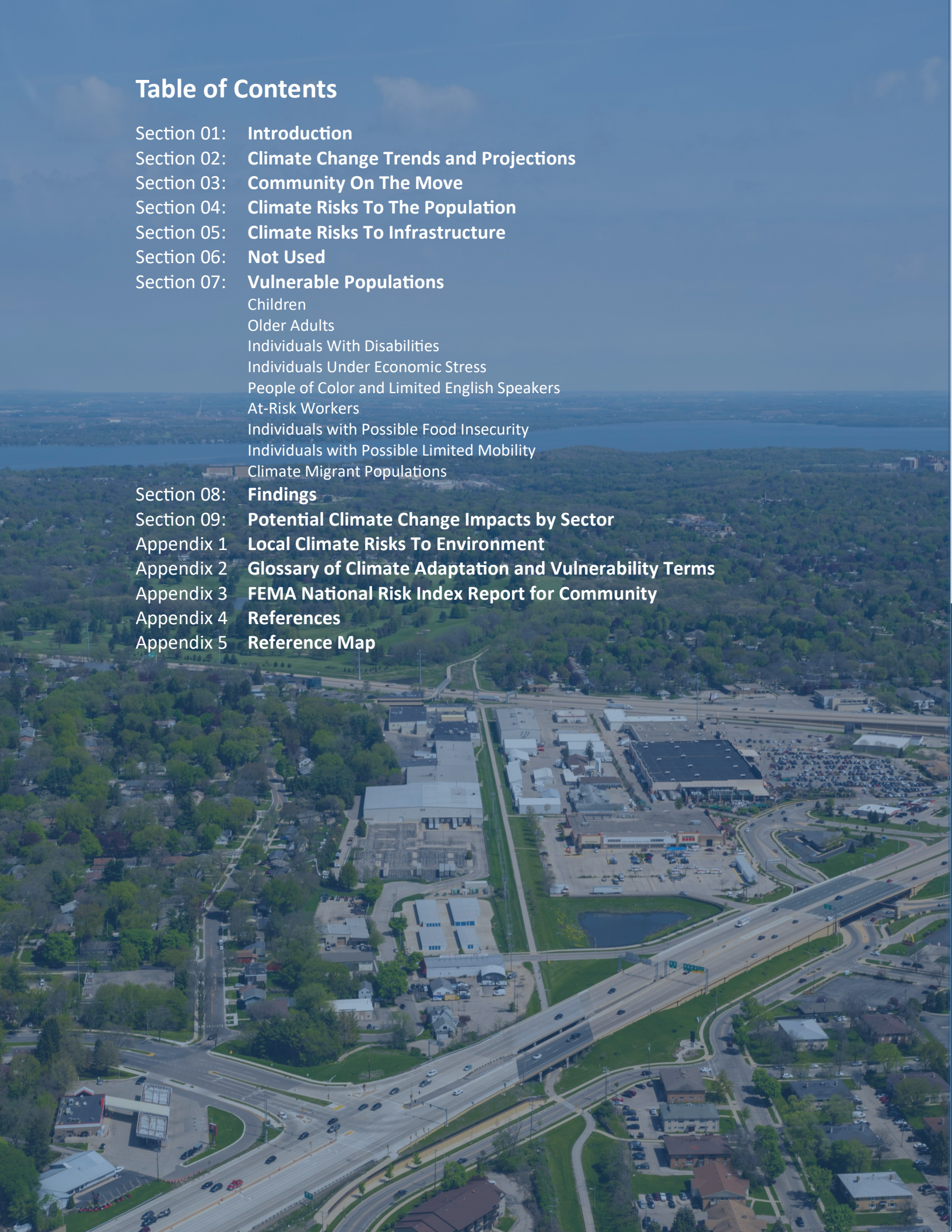
August 2023
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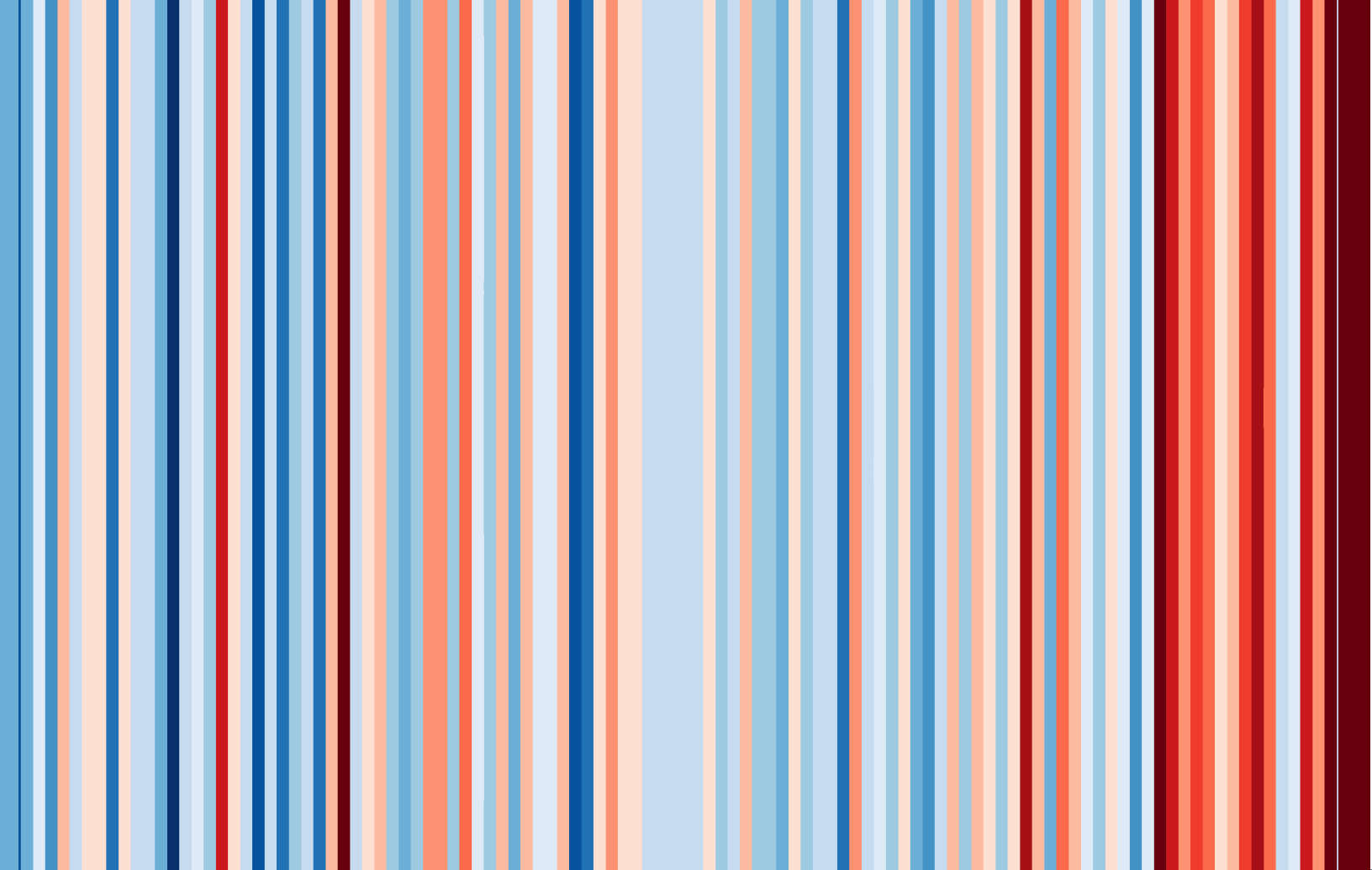
Prepared by:



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← 1895 **Wisconsin's Annual Temperature Trends¹** 2021 →
 Each stripe represents the temperature Wisconsin averaged over a year. Blue = Below Average Red = Above Average

The City's Future Climate

By 2050, without successfully reducing global GHG emissions, City of Fitchburg's climate can be expected to be:²



+3-5°F
 warmer average annual
 temperature than now.



+5% higher
 Annual average rainfall
 than now



+12-15 more days
 annually with a high temperature
 over 95°F.



+20% more
 Days with heavy precipitation
 events (1" or more) annually



+45% more
 air conditioning demand and
 energy needed than now.



+11-20 days longer
 Growing, allergy, and mosquito
 season (days with minimum
 temp >32)

SECTION 01

Introduction

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Introduction

Climate change is a global phenomenon driven by human made emissions of Greenhouse Gases (GHG) that creates local impacts. Three changes to Wisconsin’s climate are occurring already: shorter winters with fewer cold extremes; more heavy and extreme precipitation; and an increase in annual average temperatures. In the future, there is high confidence that these changes will continue to increase in frequency and intensity, and also that Wisconsin 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.

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

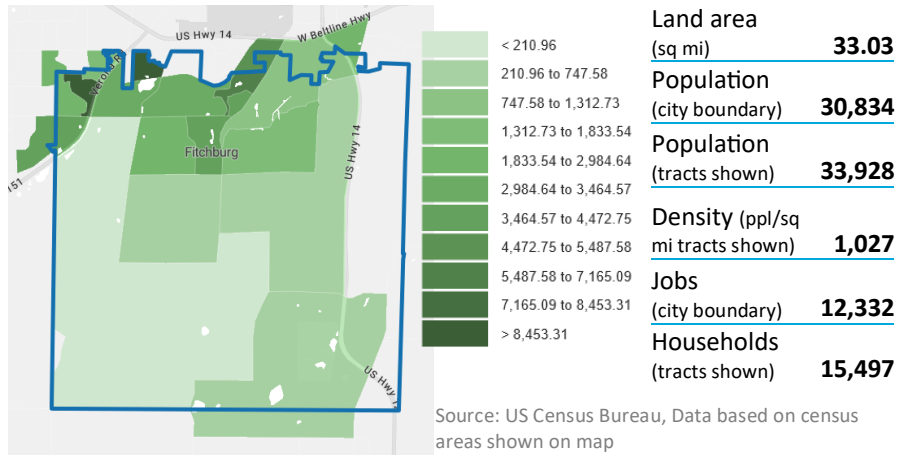
Incorporating this knowledge not only protects our communities from growing risk, but climate adaptation strategies can also increase jobs, improve public health and the overall livability of our communities. Strategies which strengthen resilience in time of emergency also help communities thrive even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

Mapping And Demographic Data in This Report

This assessment includes population data or maps at the Census Tract or Block Group level, as needed to relate to relevant US Census Bureau data. Census boundaries may differ from actual community boundaries. All areas within the official community boundaries are included in the plan this Baseline Document supports, even if not shown on a map. Other assessments might use data at the Census "Place" or city boundary level, leading to differences in reported population counts due to Census boundary variations. See Appendix 5 Reference Map for census areas included in this report.

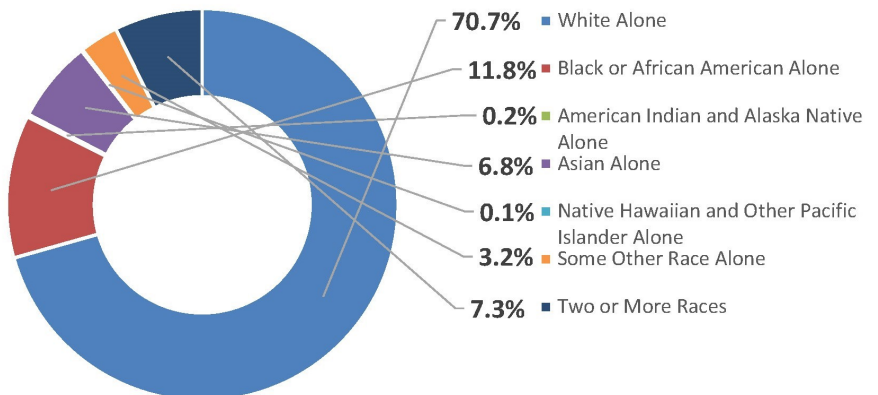
Population Density by Census Block Group

(Source: US Census Bureau 2021)



Population by Race

(Source: US Census Bureau 2021)





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 Wisconsin and the Midwest \$96 billion in damage and resulted in 440 deaths.¹

In addition, climate conditions affect 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. Longer growing seasons can 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, and anticipating potential climate impacts. Climate adaptation focuses on development and implementation of strategies to address those vulnerabilities, and 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.”²

SECTION 02

Climate Change Trends + Projections

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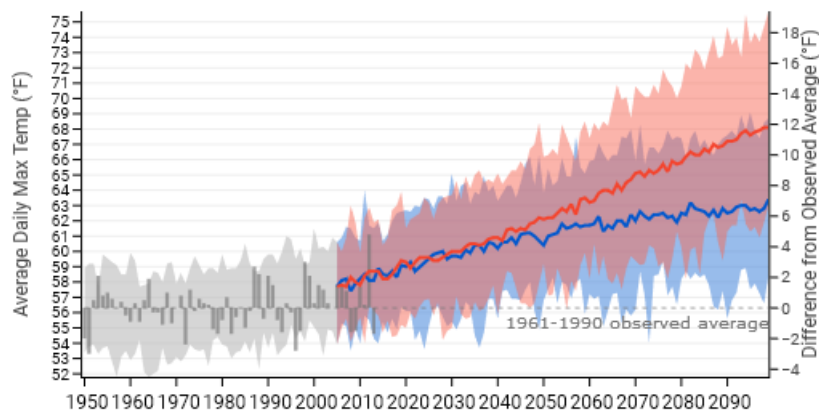
Climate Trends and Projections for City of Fitchburg

To evaluate vulnerability to climate change, we first look to understand the changes that have already occurred as well as those that the City is likely experience over the next 30–80 years. The following information summarizes historical trends and future projections in climate factors that are likely to impact the community, which include air temperature, extreme heat, precipitation (rain and snow), extreme precipitation, storms, flooding, and drought.

Air Temperature

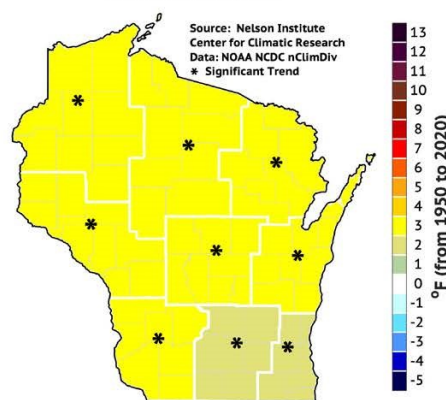
Temperatures in Wisconsin have risen 2–3°F over the last 70 years. Seasonal changes in temperature have been more extreme, with much larger changes (3–7°F) observed in winter low temperatures (i.e., minimum daily temperature averaged for the months of December, January, and February) and relatively little change (0–2°F) observed in summer high temperatures (i.e., average maximum daily temperatures for June, July, and August). By mid-century (2041–2060), average annual temperatures in Dane County are likely to increase by 3–5°F compared to 1981–2010, and by late-century (2081–2100) annual temperatures are likely to be 8–10°F higher than the 1981–2010 average.^{1, 2, 4}

City of Fitchburg Average Daily Maximum Temperature Projections¹



Graphic Source:
US Climate Resilience Toolkit Climate Explorer

Historical Change in Annual Temperature from 1950 to 2020



Graphic Source: Wisconsin's changing climate: Impacts and solutions for a warmer climate. 2021

In City of Fitchburg^{1, 2}

Since 1950:

+2–3°F increase in annual temperatures

By 2050:

+5–6°F increase in annual temperatures
15% decrease in frost-free nights (23 nights)

By 2100:

+10–12°F increase in annual temperatures
33% decrease in frost-free nights (50 nights)



Cause of Warming

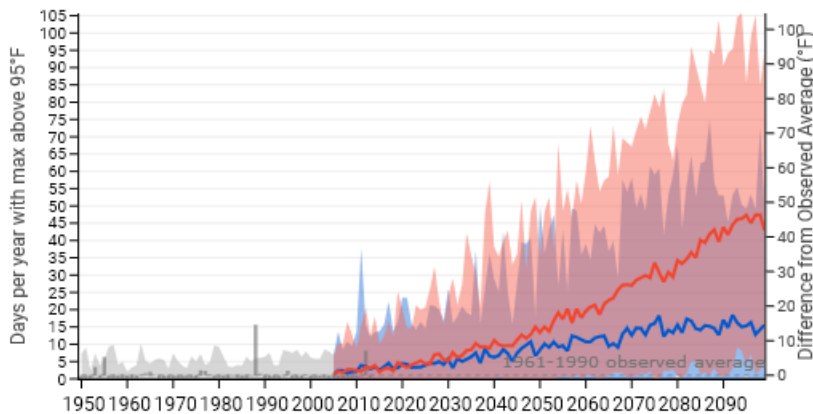
Greenhouse gasses absorb heat energy reflected from Earth's surface, warming surface level air. So far impacts in Wisconsin have been felt most in winters and nights, resulting in shrinking hemispheric snow cover and "cold air reservoirs."



Extreme Heat

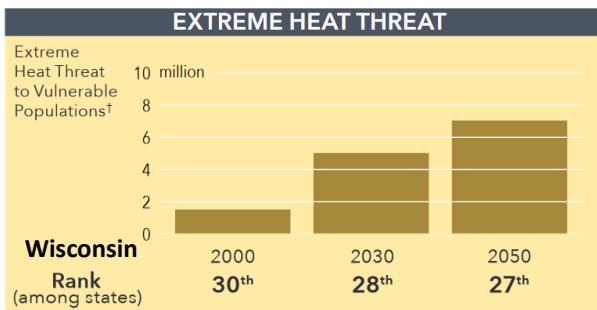
Extreme heat events are likely to increase significantly over the coming decades. The number of days in Dane County with maximum temperatures over 95°F are likely to increase from an average of 2–3 per year from 1984–2013 to 10–17 days per year by mid-century. By the end of the century, Dane County may experience an average of 45 days per year with high temperatures over 95°F, representing a 1500% increase in extreme heat days annually.^{1,2}

City of Fitchburg Days Above 95°



Graphic Source:
US Climate Resilience Toolkit Climate Explorer

By 2050, Wisconsin is projected to see an increase in the Extreme Heat Threat of fourfold. With this increase, by 2050, Wisconsin is projected to be ranked 27th for extreme heat threat within the United States.³



Graphic Source: Climate Central

In City of Fitchburg^{1,2}

By 2050:

10-17 days over 95°F
(500-600% increase)

By 2100:

45 days over 95°F
(1800% increase)

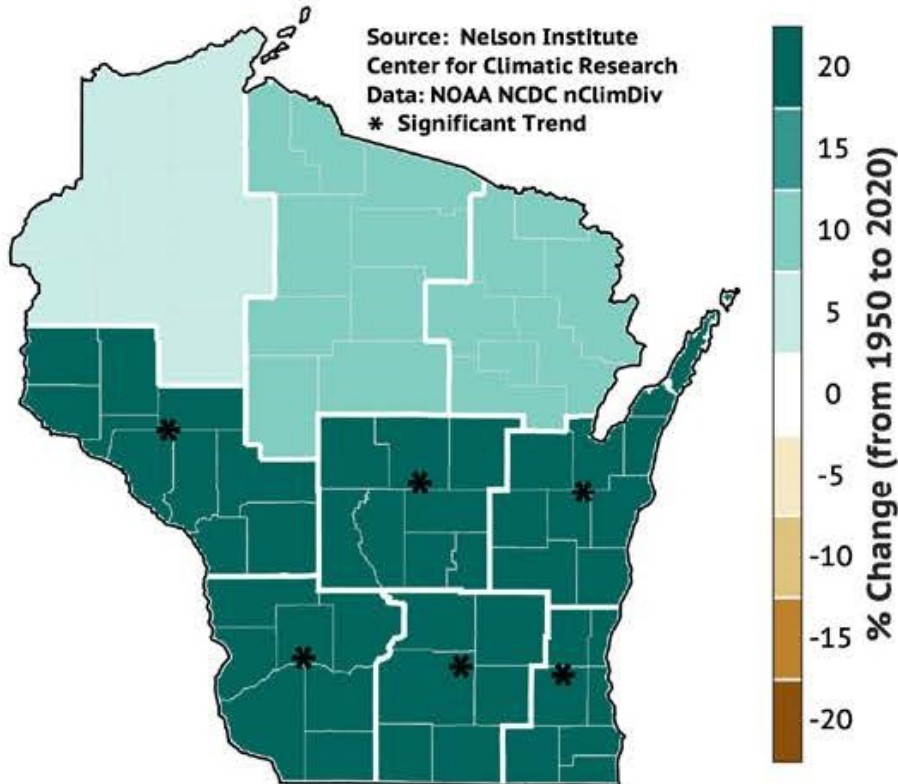
Road buckling caused by extreme heat
May 2018 (photo: Ozaukee County
Sheriff's Office via Facebook)



Annual Rainfall

Annual precipitation in Wisconsin has increased by 5–20% over the past 70 years, with more extreme increases occurring in the southern half of the state (see map below). Around Fitchburg, precipitation has increased significantly year-round, though the changes have been slightly less in the summer (~15%) compared to other seasons (~20%).²

Historical Change in Annual Precipitation from 1950 to 2020



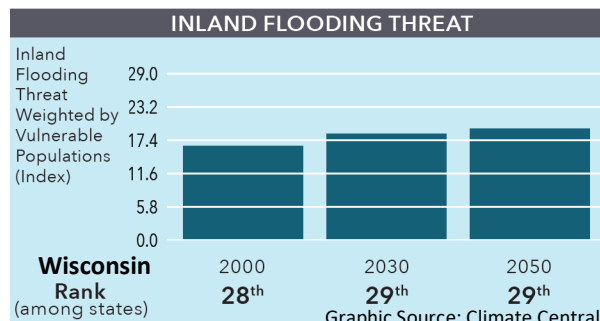
Graphic Source: Wisconsin’s changing climate: Impacts and solutions for a warmer climate. 2021

Projected Annual Precipitation

By mid-century (2041–2060), annual mean precipitation in Wisconsin is likely to increase by 5–10% compared to 1981–2010, and by late-century (2081–2100) annual precipitation is likely to increase by 10–15%, with expected changes in Fitchburg falling towards the lower end of that range.¹

Inland Flooding Threat in Wisconsin

By 2050, Wisconsin is projected to see an increase in inland flooding threat of 20 percent—with threat being calculated by severity of flooding weighted by the State’s estimated flood vulnerable population.³



In City of Fitchburg^{1, 2}

Since 1950:
+10% increase in annual precipitation

By 2050:
+5% increase in annual precipitation

By 2100:
+10% increase in annual precipitation





In City of Fitchburg^{1,2}

By 2050:

25% increase in days with precipitation over 2"

100% increase in days with precipitation over 5"

By 2100:

50% increase in days with precipitation over 2"

400% increase in days with precipitation over 5"

Extreme Precipitation, Storms, and Flooding

Extreme precipitation, which is strongly associated with severe flooding events, has been increasing over the last several decades. The number of days with 1" or larger rain events has increased by 45%. Throughout the entire Great Lakes region, rainfall in the heaviest 1% of rain events increased by 31 percent between 1958 and 2007.

Storm Weather Events

Number of Events Reported In Dane County:⁵

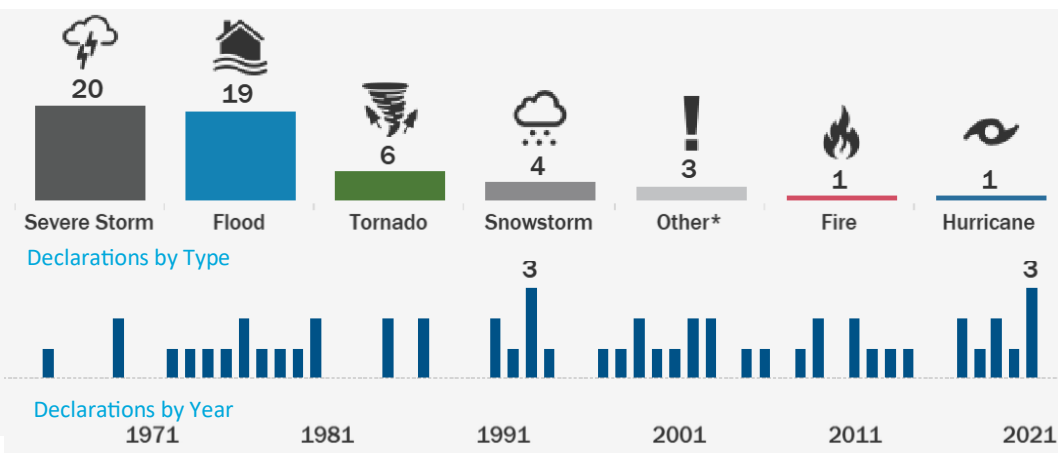
From April 2000 to April 2023: **1,039 events**

Storm Weather Damage 2002-2022: **\$300,989,000 + 9 deaths**

There are few detailed projections for storm activity because the complex forces involved in storm processes are difficult for scientists to model. However, according to the Nature Communications study "More frequent intense and long-lived storms dominate the springtime trend in central US rainfall" the amount of precipitation associated with spring storms increased by 25% per decade from 1979 to 2014.⁶

Wisconsin already suffers regular flooding. The increase in heavy precipitation events over the last decades has coincided with an increase in flood disaster declarations in the State. The projected increase in the frequency of heavy precipitation events is likely to result in increasing risks from flooding and flash flooding.

All Disaster Declarations in State of Wisconsin Since 1953⁷



54 Disasters Declared
In Wisconsin
(May 2, 1953 - Aug 15, 2023)

Dane County Share:
35% of State Total

Graphic Source: FEMA

Cause of Drought

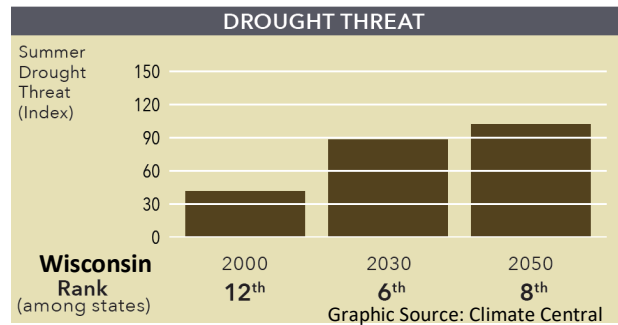
Wet trends have decreased drought over the last 50 years in Wisconsin, but future precipitation increases are projected to occur over fewer days, meaning longer dry spells.



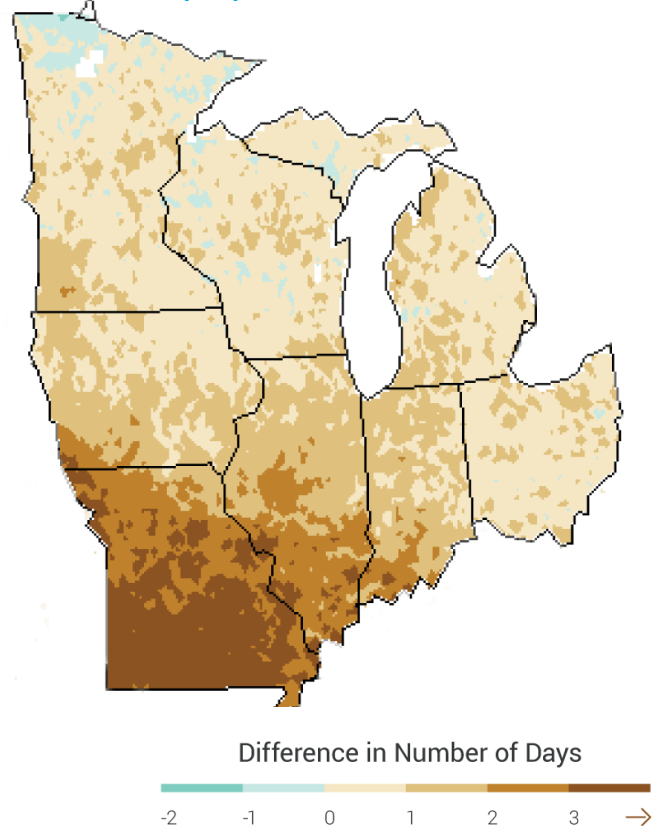
Drought

Although annual precipitation is projected to increase in Wisconsin over the coming century, summer rainfall is expected to remain relatively consistent. However, projections anticipate a greater proportion of that rainfall to occur during increasingly heavy rainfall events. This means that the swings between wet periods and dry periods will become more extreme and the number of dry days between rainfall events will increase. In addition, because warmer temperatures increase the amount of water that is lost to the atmosphere through evaporation, there may be an overall net loss of water in the ecosystem during these periods of time. Consequently, it is likely that droughts will become more common in the City, even as overall annual precipitation increases.

Currently, Wisconsin's severity of widespread summer drought is *average*. By 2050, the severity of widespread summer drought is projected to see an increase of 150% making Wisconsin's projected threat level *above average*.³



Consecutive Dry Days⁸



SECTION

03

Community On The Move

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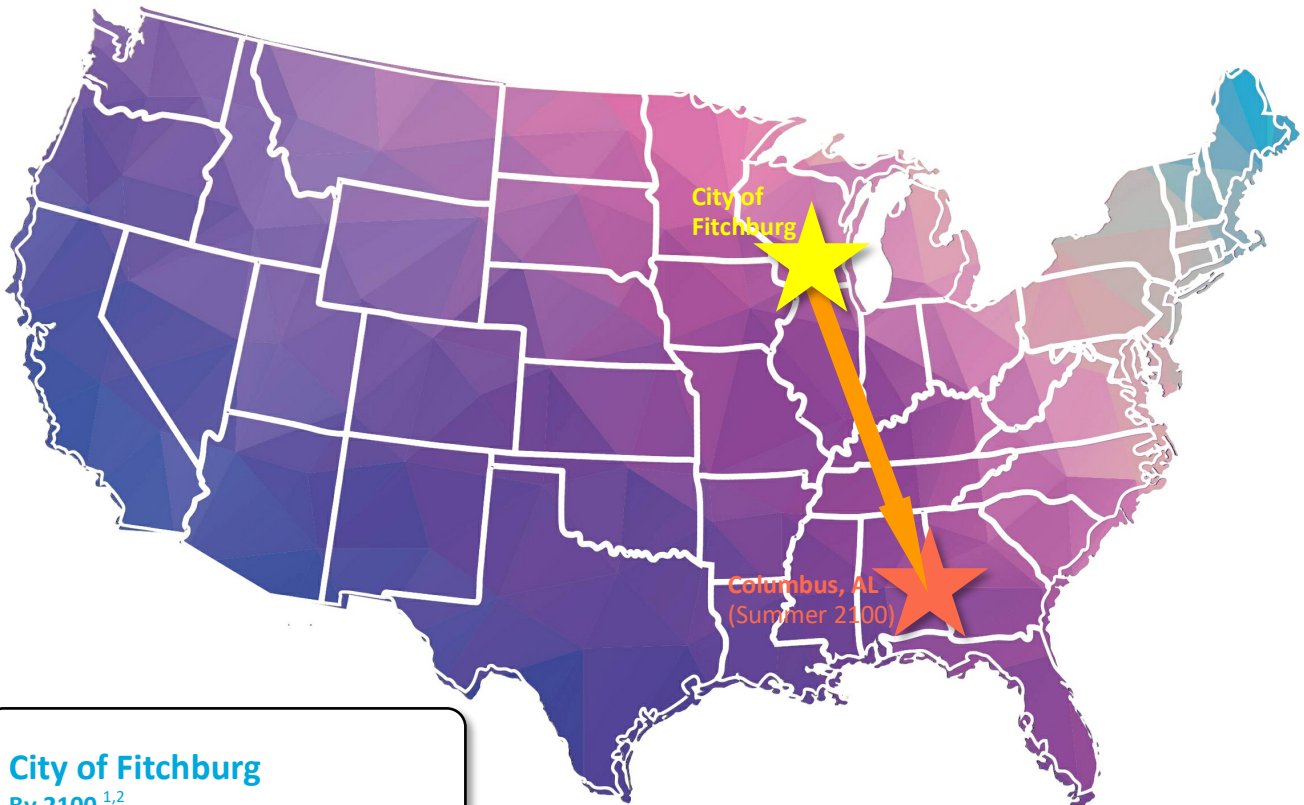
Projected changes in annual average temperatures and growing seasons will result in a change in the overall climate of City of Fitchburg. Summertime conditions for mid-twenty first century in City of Fitchburg are projected to be similar to the conditions currently felt 300-400 miles or farther to the South. By the end of the century, summertime temperatures in City of Fitchburg will be similar to those felt 800 miles farther to the South.^{1,2}

10
Miles

Distance southward City of Fitchburg's
climate experience moves every year.

Which is equal to moving


145
Feet every day



City of Fitchburg

By 2100^{1,2}

Average Summer High: **+ 10°F**

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The projected changes to the community'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 under 5, seniors over 65, and those with disabilities – see Vulnerable Populations section for more information. Below are some of the more significant risks to the community's population:



Extreme Weather / Temperature

Certain groups face higher risks from extreme weather events, leading to injuries, carbon monoxide poisoning, asthma attacks, hypothermia, mental health issues, and even death. Events like tornadoes, wildfires, and heatwaves can pose threats. Heat stress vulnerability rises due to health conditions such as diabetes, heart issues, socio-demographic factors like age (e.g., those over 65 living alone), and environmental aspects like low tree canopy coverage. US studies link heatwaves to increased heat-related deaths and a surge in emergency medical service calls and hospital admissions.

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.”¹

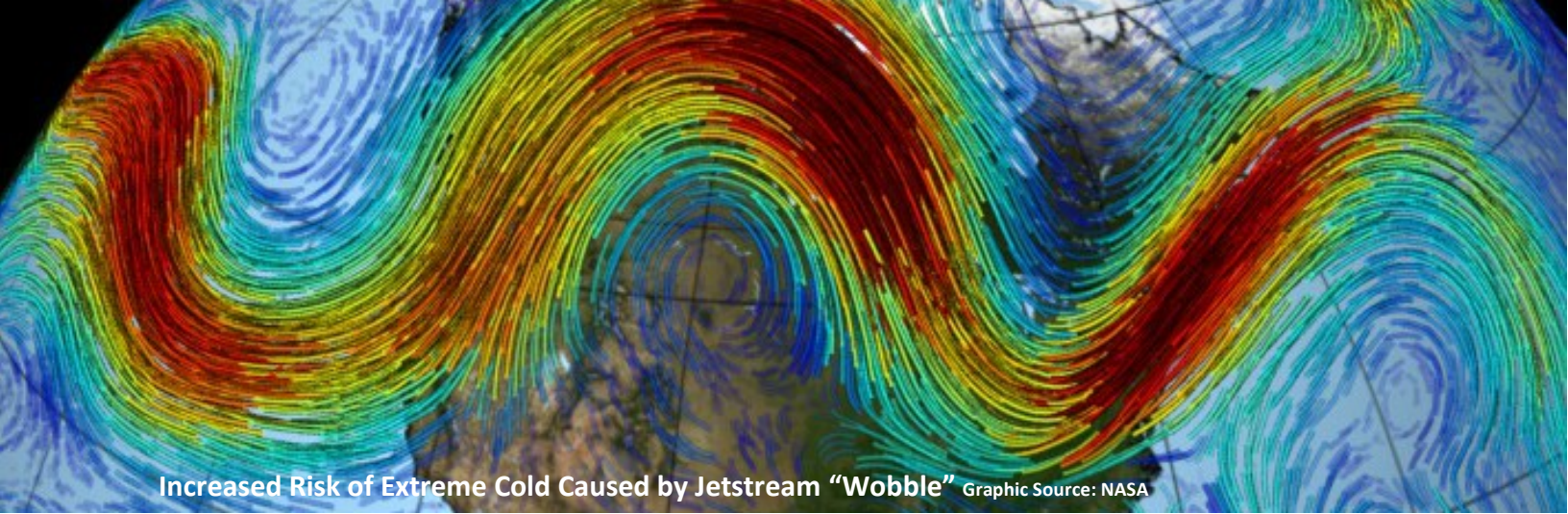
In addition, extreme weather can cause economic stress. Property damage, business closure, crop loss, job loss, and employment “down time” can all be caused by extreme storms, weather, and temperatures. These economic impacts can affect individuals, families, businesses, and communities at large. According to the North American Electric Reliability Corporation, the leading cause of electric transmission outages (in terms of electric outage count) in the United States is weather.²



Increased Risk of Extreme Cold

Despite global warming, the City may face heightened risks of extreme cold spells during winter due to changes in the jet stream, influenced by warming oceans and Arctic temperatures. The jet stream, a significant high-altitude wind flow, governs the Northern Hemisphere's weather by moving moisture, cold and warm air, and storm systems. It's primarily driven by the temperature contrast between the Arctic and equatorial regions. Climate change has caused the Arctic to warm faster than temperate zones, diminishing this temperature contrast and thereby weakening the jet stream. This weakening results in periods where the jet stream “wobbles,” making pronounced southward coils, dragging severe arctic cold with it. Research suggests that as Arctic warming persists, these pronounced wobbles and resultant cold snaps could become more frequent.





Flood and Drought Vulnerability

The latest National Climate Assessment reveals that the occurrence of intense precipitation events has risen both nationally and specifically in Wisconsin. Predictions suggest that Wisconsin will experience even more of these heavy rainfalls in the future. This escalation in extreme and overall rainfall is a factor in the uptick of severe flood incidents in several communities. Among all weather-related dangers in the U.S., floods rank as the second most lethal. Following heavy rains and floods, there's an increase in water-related illnesses and mold growth due to water intrusion in buildings. This can negatively impact indoor air quality and heighten respiratory issues, including asthma and pneumonia, for those in humid environments.³

Floods cause economic harm, including property and crop damage. But the effects go further. They disrupt local economies by reducing work hours and GDP, as resources shift to recovery instead of regular tasks.⁴ The damage also affects businesses connected to farmers. For instance, in 2019, heavy rain in the U.S. Corn Belt led to \$6 billion in lost corn sales. Additionally, firms linked to farming faced a \$2.9 billion decline in direct sales and \$4.5 billion in total losses.⁵



Wildfire

Wildfires present considerable dangers to homes, ways of life, and health, particularly as communities encroach further on natural habitats. Between 1980 and 2021, the U.S. experienced 20 wildfires that resulted in damages exceeding a billion dollars each.⁶ According to the National Oceanic and Atmospheric Administration, 16 of these catastrophic fires took place after 2000.⁷ Climate change is amplifying the duration of the wildfire season, intensifying the frequency of fires, and expanding the affected areas. Elements such as warmer springtime temperatures, longer summer droughts, and arid ecosystems are aggravating this situation. Earlier snow melts in spring and reduced snowpack decrease water reserves during sweltering times, heightening fire hazards. As a result, fires not only start more readily but also blaze more fiercely. The pattern of prolonged wildfire durations and more severe fires is expected to continue due to increasing and enduring droughts. Furthermore, the smoke from wildfires degrades air quality across the country and research has shown wildfire smoke contribution to poor air quality has grown substantially in the US over the last two decades.⁸ While smoke exposure is detrimental to all, those with underlying health issues, such as cardiac and respiratory disorders, as well as older adults, children, and expectant mothers are at an even greater risk.⁹



Air Quality Impacts

Based on existing research, there's a strong link between air pollution and a range of health concerns such as premature death, higher hospital admissions for respiratory and cardiovascular issues, unfavorable birth outcomes, and lung cancer. The U.S. Environmental Protection Agency (EPA) uses the Air Quality Index (AQI) to offer a consistent and straightforward method for communicating daily air quality conditions. The AQI values for each state are derived from hourly measurements of five pollutants: fine particles (PM2.5), ground-level ozone (O3), sulfur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO). The concentrations of these pollutants can be influenced by both climate effects and the greenhouse gas emissions that are modifying Wisconsin's climate dynamics.¹⁰

The potential health implications of these pollutants vary. For instance, exposure to ozone can result in health problems such as breathing difficulties, chest discomfort upon deep inhalation, coughing, wheezing, temporary lung function decline, and infections in the lower respiratory system. Continuous exposure to fine particulate matter (PM2.5) has been linked with several health complications. Notably, a 10 µg/m³ increase in PM2.5 is tied to an 8% rise in lung cancer mortality, a 6% increase in cardiopulmonary deaths, and a 4% escalation in overall mortality. The yearly average of PM2.5 gives insight into the long-term trends and their associated health consequences.¹¹

Anticipated shifts in climate are expected to influence air quality in multiple ways, such as heightened surface temperatures, variations in rainfall, drought, wildfires, allergen production and intensity, and increased levels of ozone, PM2.5, and dust. Several of these pollutants can directly induce or exacerbate respiratory ailments, particularly in vulnerable groups like children and the elderly. Other air quality concerns related to health include allergens, pollen, and wildfire smoke (even minor amounts that can cause respiratory problems can travel vast distances). All these factors are projected to rise due to climate change.¹²

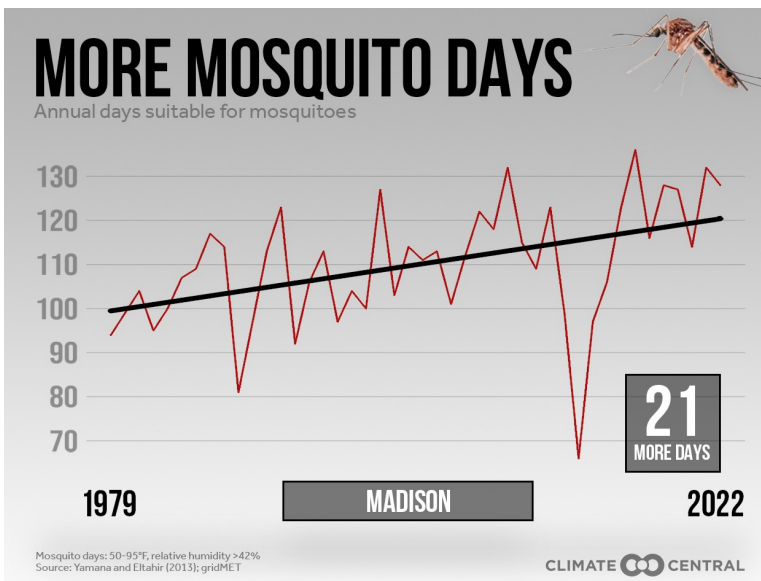
For current and forecasted air quality throughout the state visit: <https://gispub.epa.gov/airnow/>

You can also download Plume Lab's free mobile phone air quality monitoring app: <https://plumelabs.com/en/air/>



Vector-Borne Diseases

Diseases transmitted by carriers like ticks and mosquitoes are known as vector-borne diseases. The expected consequences of climate change are believed to amplify the dissemination of such diseases, including West Nile virus and Lyme disease. This is because changes in climate conditions can influence the life cycle and dynamics of these carriers and the pathogens they transport. A rise in global temperatures has the potential to expand the habitats of these disease-spreading insects. Additionally, increased rain, flooding, and humidity create more suitable environments for their breeding and hasten the breeding process.¹³ Moreover, the extended growing season and milder winters in Wisconsin can boost the numbers of these disease carriers and may introduce the region to new species.¹⁴



Graphic source: Climate Central





Food Insecurity and Food-borne Diseases

Our national food infrastructure is susceptible to the effects of climate change. Factors such as extreme weather conditions, threats to crops and livestock like excessive heat, the rise of invasive insect populations, alterations in natural yearly cycles, and socioeconomic challenges all play a role.¹⁵

States in the Pacific region are especially at risk due to diminished water resources, warmer winter seasons, and unpredictable springtime conditions. Grain cultivation faces threats from inconsistent weather, hotter winters, heatwaves, sultry summer nights, and flood risks, especially in the Great Plains and the Midwest. Beef, chicken, and pork production is at risk due to the heightened occurrence and severity of extreme weather conditions in areas like the Great Plains and the Southeast.¹⁶ These productions are also vulnerable to disruptions in essential resources such as feed, water, and electricity, which can be affected by extreme weather and other climate-induced factors. Within a highly integrated national food system, these regional vulnerabilities are all linked to impacts that can be felt in Wisconsin.

Currently, the challenge of food insecurity, which is the disruption in the availability of nutritious food due to financial constraints or lack of access, is disproportionately borne by those with lower incomes. They are almost three times more prone to face this issue.¹⁷ As we move forward, we should expect climate change to influence the earnings and lives of food cultivators, especially those who operate on a smaller scale. Climate-induced disruptions in our food system can lead to price fluctuations, making food access even more challenging for already vulnerable populations.¹⁸



Water Quality/Quantity

Water risks pertain to both the amount and purity of water. Quantity issues stem from changing rainfall patterns, water supply fluctuations, and increased consumption due to population growth and warmer climates. Water demand can increase during periods of extreme temperatures, exacerbating water quantity concerns. Stress on water supplies can also negatively impact agriculture, causing potential crop losses, limited food availability, and rising food costs. It's vital for all communities to focus on water conservation, particularly those at greater risk of water shortages.¹⁹

Water quality is also compromised by climate events. More rain or fast-melting snow can lead to flooding, bringing contamination from sewage and pollutants. Rising temperatures may cause harmful algae growth, reduced oxygen in water, shifts in fish species, and more mercury in fish. Intense rainfalls can further muddy waters, reducing clarity and quality.^{20, 21}



Waterborne Illness

Diseases transmitted through water stem from a mixture of microorganisms, biotoxins, and detrimental contaminants. Conditions like cholera, schistosomiasis, and various digestive problems can arise from them. The frequency of these diseases often surges after pronounced rainfall or snow events. Due to the amplified frequency and magnitude of weather disturbances brought on by climate change, communities could confront a rising tide of these waterborne maladies. A rise in extreme weather events can overwhelm water and sewage treatment plants, further escalating the risk of such diseases.^{22, 23}

Elevated air temperatures and more frequent heatwaves are also connected with increases in the potential for waterborne diseases. Research into cholera cases in Zanzibar revealed that a 1°C increase in temperature was associated with a doubling in disease instances. Similarly, research in Newfoundland found that for every single degree rise in average weekly temperature, there was a 4.5 percent increase in reported cases of the bacterial infection known as campylobacteriosis.^{24, 25}

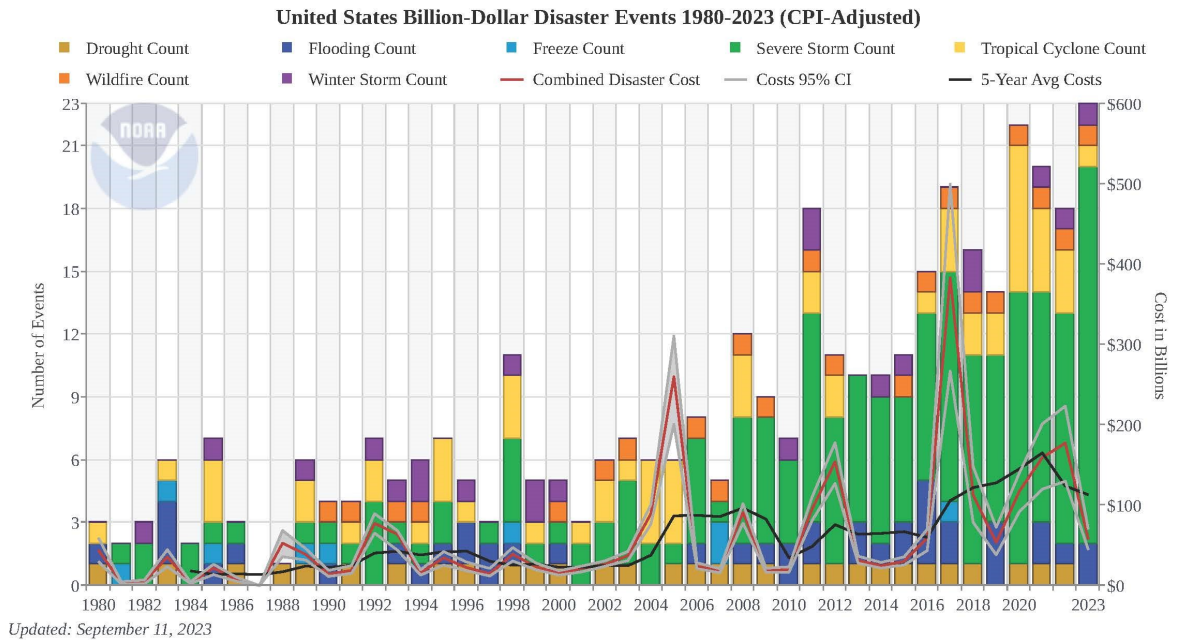


Power and Infrastructure Failure

Climate change can increase electricity demand while jeopardizing its supply. Our current power grid, much of which is above ground, was designed for a bygone climate, making it vulnerable to modern weather extremes like intense rainfall, powerful winds, severe droughts, and escalating wildfires. As such, disruptions in power supply and delivery are growing.²⁶ A Climate Central study found that from 2011-2021, the U.S. saw a 64% rise in major power outages compared to the previous decade. Of the outages across these two decades, 83% were weather-induced, with such outages seeing a 78% annual increase in the latter decade.²⁷

Beyond the power grid, other infrastructure, including roads, bridges, and transit systems, is also at risk from climate effects. Extreme temperatures can warp roads and rail lines, while fluctuating cold and heat cause pavement damage. Intense rainfalls can result in floods, disrupting major transport routes and business districts.²⁸

Since 1980 the United States has had 371 extreme weather and climate disasters whose damage exceeded \$1 Billion (CPI adjusted dollars to 2023). The statistics also clearly show an increasing rate of these billion-dollar storms. During the 1980s, there was an average of 3.3 events annually; this number rose consistently, reaching an average of 13.3 events annually in the 2010s and further increasing to 18 events annually between 2018 and 2022.²⁹



Graphic source: NOAA National Centers for Environmental Information



Economic Vulnerabilities

Besides the main climate change effects discussed earlier, there are several related economic consequences. Researchers from the University of California at Berkeley have found that for every 1°C rise in average global temperature, there's an expected annual loss of 1.2% in gross domestic product on a per-county basis.³⁰ Here are the major economic outcomes highlighted in their study:



Crop Yield

As outlined in "Food Insecurity, current and projected climate change impacts threaten US agriculture production and the food system. Research illustrates that although increased CO2 levels are anticipated to offset a portion of these yield losses, the impact for much of the United States will be a net negative. The agricultural system in many regions in the country face serious economic effects of the projected climate impacts. These economic impacts, in turn, are likely to result in price volatility increasing food insecurity risks for vulnerable populations.^{30,31}



Mortality

Studies indicate global death rates are likely to increase due to climate change by 4.2% for higher income regions and as much as 6.2% for regions with high poverty. In the United States, research indicates mortality impacts due to climate change are likely to be unevenly experienced. Southern areas of the U.S. are generally better equipped to handle heat, so additional warming might not notably raise death rates, and they may even witness a drop in cold-related deaths. In contrast, Northern areas, being less accustomed to heat, could see a significant rise in heat-related deaths that surpasses any decrease in cold-related mortality.^{30, 32, 33}



Energy Costs

Every region in the United States is experiencing increasing temperatures. With the warming climate, it's anticipated that Americans will consume more energy, primarily in the form of electricity, for cooling purposes. This surge in demand raises the likelihood of power outages or disruptions. While the need for heating during winter months may decrease due to warmer conditions, the heightened energy requirements during summer for cooling are projected to eclipse any savings from reduced winter heating. Given these rising temperatures, economists predict a rise in net energy expenses for almost every area of the contiguous United States, except the chilliest regions.³⁰



Property Crime

Research suggest that colder weather curbs property crime and highlight a connection between fewer cold days and a rise in property crime rates. According to a Harvard study, the United States may experience 3.1 million additional burglaries through the end of the century due to climate change.^{30, 34}



Violent Crime

Research indicates that violent crime rates also increase as temperatures increase. For violent crime, the relationship is relatively consistent linear relationship with a violent crime increase of nearly 1% for every 1°C increase in global mean temperature. Throughout the United States, this impact is estimated to be millions in combined additional murders, rape, assaults, robberies, and theft through the end of the century due to climate change.^{30, 35}

Fitchburg Risk Index

According to the FEMA National Risk Index, the City of Fitchburg has an overall climate change risk score of 58.³⁵ This means that the community is in the 58th percentile of risk nation-wide. This risk score is considered “relatively low.”

Risk Index scores for specific hazard types are derived using data related solely to that hazard. They take into account a community's anticipated yearly loss value, relevant risk factors, and the adjustment factor applied to determine the risk value.³⁵

About the National Risk Index

The National Risk Index is a digital tool and dataset that showcases the U.S. communities most susceptible to 18 natural disasters.³⁶ FEMA, in tandem with academic experts, governmental bodies at various levels, and the private sector, developed this tool.

The equation underpinning the Risk Index consists of three parts: a section detailing natural hazards,³⁷ a segment that amplifies consequences,³⁸ and a part that minimizes consequences.³⁹ The data for the natural hazards section uses estimates in 2022 U.S. dollars. For the latter two components, datasets have been standardized using a min-max normalization method before being integrated into the National Risk Index's risk assessment.

Compared to the rest of the United States, Dane County's risk for each hazard type is:


Avalanche	N/A
Coastal Flooding	N/A
Cold Wave	
Drought	
Earthquake	
Hail	
Heat Wave	
Hurricane	
Ice Storm	
Landslide	
Lightning	
Riverine Flooding	
Strong Wind	
Tornado	
Tsunami	N/A
Volcanic Activity	N/A
Wildfire	
Winter Weather	

Overall Risk Index:

52







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The projected changes to the community's climate in the coming decades represent potential risks to the community's infrastructure. Many of the risks have the potential of co-occurring, such as extreme heat and drought immediately followed by extreme precipitation events. Potential risks to infrastructure include:

Housing

Warming temperatures will increase demand for air conditioning. Although most homes have air conditioning currently, the increased demand will mean increased costs. Over 8% of households in the City already live under high energy burden (households spending 6% or more of total income on energy).¹ Rising energy costs may be very difficult for these and other households to bear, increasing their vulnerability to extreme weather events. Heavier rains may cause more local flooding, which could cause damage and limit mobility for some neighborhoods in more flood-prone areas of the city.

Stormwater Management

Increasing precipitation will increase demands on stormwater infrastructure and increase flash flooding risks. The City's stormwater infrastructure may not be able to handle the amount of runoff that is expected in the future, and considerable resources would be needed to make needed upgrades.

Transportation

Flooding is not a significant concern for City of Fitchburg now, but increasing likelihood of heavy-precipitation events in the future may increase the risk of local flooding, potentially blocking roadways and trails. Increasing temperatures and more days with maximum temperatures over 95° may increase damage to transportation infrastructure including buckling and cracking of road pavement and warping of rail lines. The high reliance on personal vehicles and limited transit services within portions of the City limits residents' options, especially during times of extreme events.

Power Distribution

Increased extreme temperature events are likely to increase demand on power generation and distribution systems and may increase potential for power failure. Increased potential for drought combined with increased risk of heavy rain events pose an increased risk of fallen trees. In turn, this may increase the risk of damage to power lines, particularly during extreme weather events when power demand may be highest.

Critical Facilities

Critical facilities in the community include hospitals, first responder facilities like police and fire, emergency communications facilities, nursing homes, power plants, water and wastewater treatment facilities, schools, and security facilities. Increased risk of extreme temperatures may place increased stress on heating and cooling systems of critical facilities and increase potential of system failure during times of highest demand. Increased potential of extreme weather events may pose an increased risk to facilities from high winds, falling trees, sleet/hail, or other impacts. The projected increase of heavy precipitation may pose increased risk to facilities from flooding and flash flooding, even in areas without history of flooding.

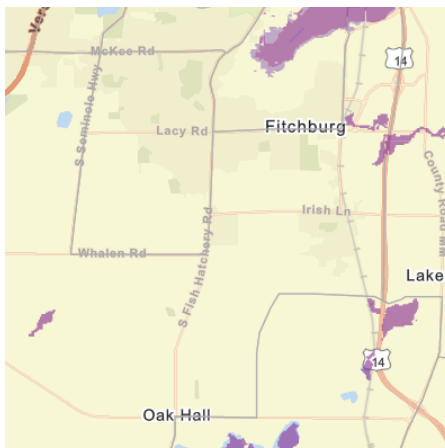


Critical Facilities

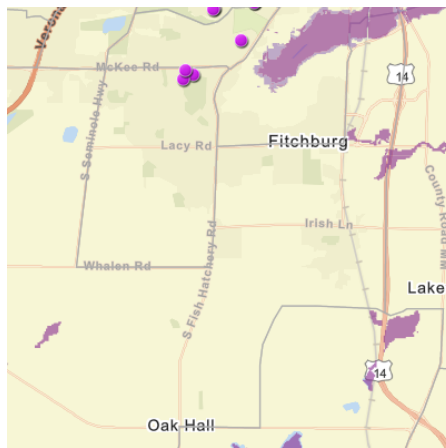
As the maps below indicate, according to the US FEMA facility database, potential critical facilities in the City of Fitchburg may not have heightened risk to flooding.²

The series of maps below are “screen capture” images from the US Federal Emergency Management Administration (FEMA) Resilience Analysis and Planning Tool (RAPT) and are provided as a convenience to the City of Fitchburg. To identify specific properties or further explore the tool access RAPT here: <https://www.fema.gov/emergency-managers/practitioners/resilience-analysis-and-planning-tool>

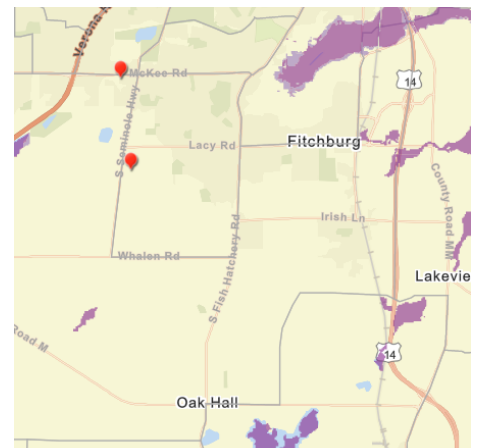
(0) Urgent Care and Hospitals



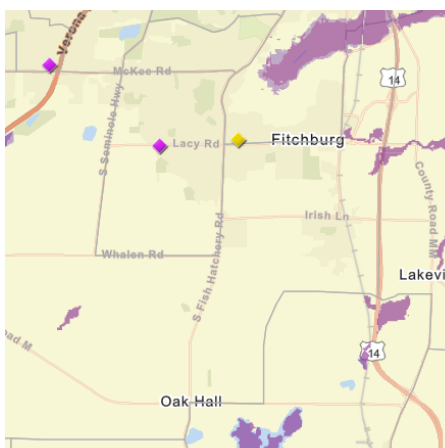
(4) Nursing Care Facilities



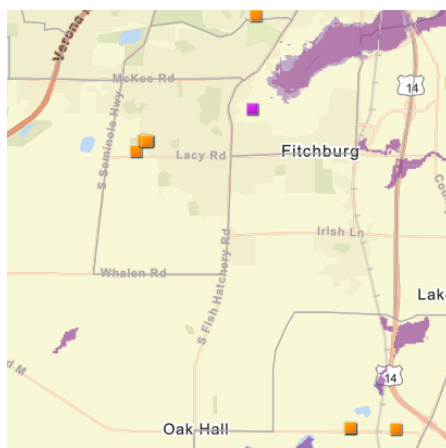
(2) Power Plant Facilities



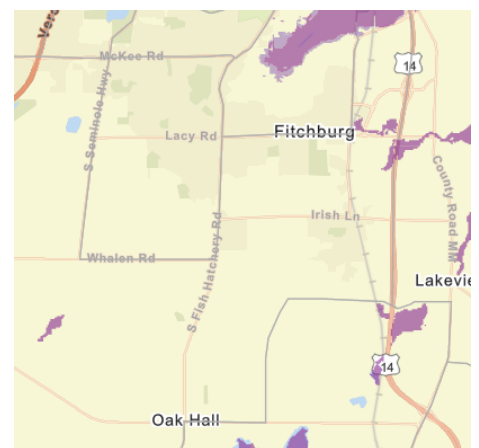
(1) Law Enforcement and Fire



(4) Public and Private Schools



(0) Mobile Home Parks



City of Fitchburg Flood Risk Factor:³ **Moderate**



Residential **Moderate Risk**
608 out of 5,749 homes ⓘ

Road **Moderate Risk**
1 out of 3 miles of roads ⓘ

Commercial **Moderate Risk**
130 out of 571 commercial properties ⓘ

Critical Infrastructure **Minor Risk**
1 out of 19 infrastructure facilities ⓘ

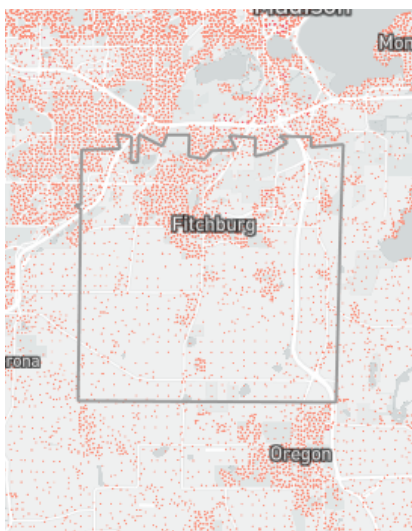
Social Facilities **Minor Risk**
2 out of 22 social facilities ⓘ

(Graphic Source: First Street Foundation)

Besides property damage, flooding can disrupt utilities, emergency services, transportation, and affect an area's economic health. Fitchburg faces a moderate flood risk over the next 30 years, likely affecting daily life. This is based on property risk levels, not the number of properties at risk.

There are 552 properties in Fitchburg that have greater than a 26% chance of being severely affected by flooding over the next 30 years. This represents 13% of all properties in Fitchburg.

City of Fitchburg Heat Risk Factor:³ **Minor**



7,388 ⓘ
Total properties at risk

Heat Factor® distribution of properties

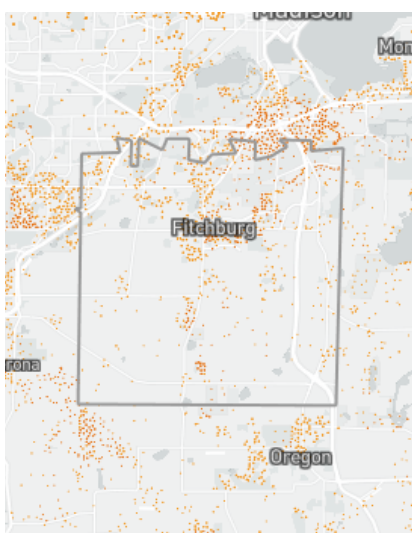
- Minimal - 33
- Minor - 7.3K
- Moderate - 32
- Major - 0
- Severe - 0
- Extreme - 0

(Graphic Source: First Street Foundation)

Fitchburg has minor, but increasing, risk from heat. This is due to “feels like” temperatures increasing, and because 99% of homes in Fitchburg have a Minor Heat Factor.®

A property's Heat Factor indicates its relative risk to heat, taking into account both how heat in the area compares to the rest of the country, and how things like shade, greenspace, and proximity to water affect heat at the property relative to other nearby properties.

City of Fitchburg Wildfire Risk Factor:³ **Minor**



Residential **Minor Risk**
2,187 out of 5,749 homes ⓘ

Commercial **Minor Risk**
340 out of 571 commercial properties ⓘ

Critical Infrastructure **Minor Risk**
14 out of 19 infrastructure facilities ⓘ

Social Facilities **Minor Risk**
12 out of 22 social facilities ⓘ

(Graphic Source: First Street Foundation)

In addition to damaging properties, wildfire can also cut off access to utilities, emergency services, impact evacuation routes, and may impact the overall economic well-being of an area. Overall, Fitchburg has a minor risk of wildfire over the next 30 years. This is based on the level of risk the properties face rather than the proportion of properties with risk.

There are 2,869 properties in Fitchburg (38% of all) that have some risk of being affected by wildfire over the next 30 years.





CITY HALL

Vulnerable Populations In The City of Fitchburg

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Climate change causes economic impacts, which in turn, increase the unpredictability and inequity of future economic outcomes.¹ Some populations may also be subjected to multiple pressures including both climate change impacts as well as non-climate related stressors. For instance, those residing in economically disadvantaged urban zones, remote rural regions, flood-prone areas, or places with a history of significant chemical pollution are more exposed not only to severe weather and ongoing climate shifts but also to socio-economic challenges. Often, these challenges can appear in tandem or one after the other.²

Individuals or communities may experience varying levels of health risk vulnerabilities based on factors like age, socio-economic conditions, and political influences, commonly referred to as social determinants of health. Some demographics are unfairly impacted by these determinants, which restrict their access to resources and opportunities for promoting healthier living conditions, such as favorable living/working environments and medical care access. Certain populations are especially at risk when it comes to the effects of climate change. This increased risk can be attributed to a group's exposure, sensitivity, or their ability to adapt to climatic changes.²

Who is Most Vulnerable?

Throughout the United States, there are variations in how individuals and communities experience, are affected by, and adapt to the threats of climate change. The subsequent sections outline factors that might lead to unequal climate change impacts on different groups. Included are maps that show the concentration of these populations in the City's census tracts. These maps can assist government representatives and the climate planning team in identifying potential inequalities and understanding the circumstances that lead to them.

This information may be used as a preliminary guide and indicator of areas where special attention may need to be paid to potential disparities in climate-related hazards (e.g., flooding, extreme heat, air pollution) and/or to ensuring just distribution of the benefits of actions designed to address these climate impacts.

Community members who are most vulnerable include:^{2, 3, 4, 5, 6}



Children Under 5



Elders 65 +



Individuals with Disabilities



Individuals in Economic Distress



People of Color



At-Risk Workers



Food Insecure Individuals



Individuals Without Vehicle Access





Children Under 5

Children are more susceptible to negative health consequences from environmental factors because of their still-developing bodily systems, distinct ways they encounter these factors, their heightened biological reactions, and limited adaptability. Kids consume a notably larger amount of air, food, and water compared to their body size than adults do. Moreover, their specific behaviors and how they engage with their surroundings might raise their chances of coming into contact with pollutants like dust, pesticides, mold particles, and allergens.²

Children are particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Seniors Over 65

Elderly individuals are particularly susceptible to health issues linked with climate change and extreme weather conditions. It's important to note that vulnerabilities among the elderly vary widely since this group is diverse, encompassing various sub-groups. These can be differentiated not just by age but also by factors such as race, level of education, economic standing, social support structures, general physical and mental well-being, and any disabilities. As stated by the US Global Change Research Program, the potential health consequences of climate change for the elderly encompass rising temperatures and heatwaves; a heightened chance of severe floods, droughts, and wildfires; deteriorating air quality; risks of infectious diseases; and other climate-induced threats²

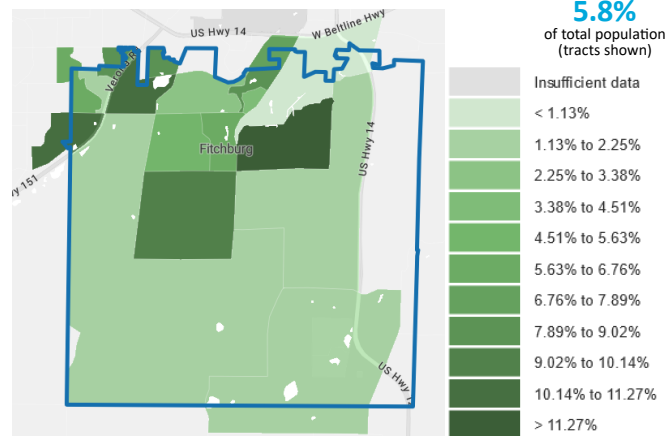
Older Adults are particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City:

1,955
5.8%

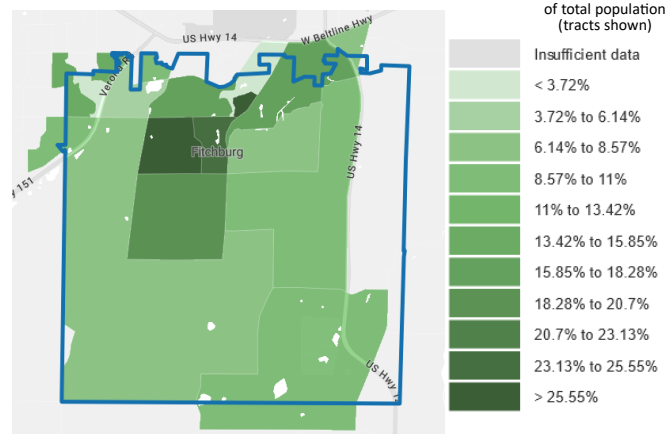
of total population (tracts shown)



Total in demographic in City:

4,086
12.0%

of total population (tracts shown)





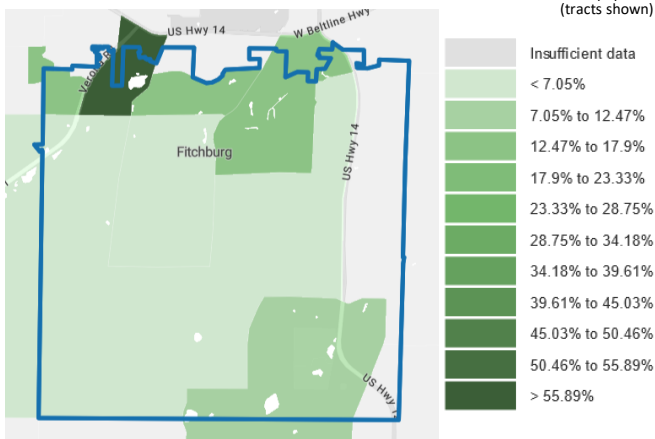
Individuals with Disabilities

Individuals with disabilities often face elevated levels of social challenges, including poverty and limited education, which can lead to worse health results during severe incidents or climate-driven crises. These challenges amplify the risks arising from functional limitations and hinder effective preparation and emergency reactions. A disability is defined as any physical or mental condition that restricts an individual's capability to engage in specific tasks or reduces their participation in typical life activities like education, employment, or leisure activities.²

Individuals with disabilities are particularly sensitive to the following Risks (see Section 4 for Climate Risk information):



Total in demographic in City: **3,297**
9.7%
of total population (tracts shown)



Note: map illustrates data at Census Tract level due to data availability.

Individuals in 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 reduces the range of options available in response to crisis. For those living in poverty, extreme weather events or illness in the family can lead to devastating financial setbacks.²

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 (see Section 4 for Climate Risk information):



Total in demographic in City: **6,760**
19.9%
of total population (tracts shown)





People of Color

These groups face a heightened exposure risk because they are more likely to reside in areas prone to dangers, zones with aging or inadequately maintained infrastructure, or regions burdened by pollution. Furthermore, these segments of the population often have a greater prevalence of ongoing health issues, which can be intensified by the effects of climate change. Their ability to prepare for, react to, and handle health risks associated with climate change might be hindered by socio-economic challenges, restricted transportation options, limited health access, and social isolation due to language differences.^{2, 7}

People of Color may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Limited English Speakers

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. Though not specifically a “person of color” category, individuals with limited English frequently overlap with populations of color, making this group potentially doubly vulnerable.^{2, 7}

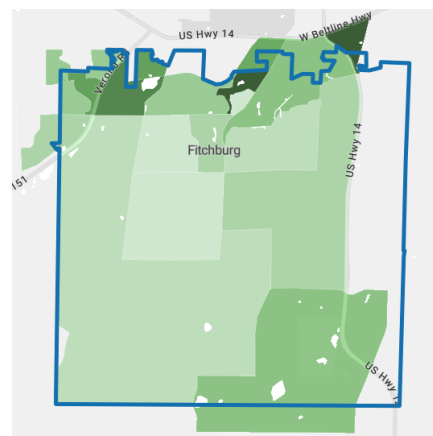
Limited English Speakers may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City:

9,953
29.3%

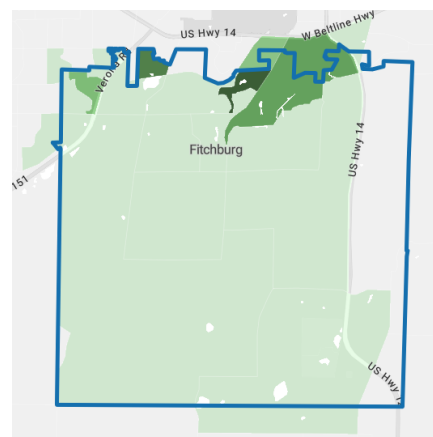
of total population (tracts shown)



Total in demographic in City:

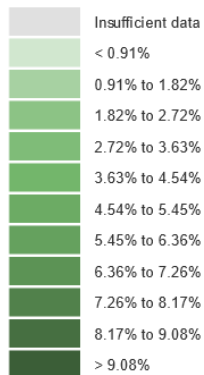
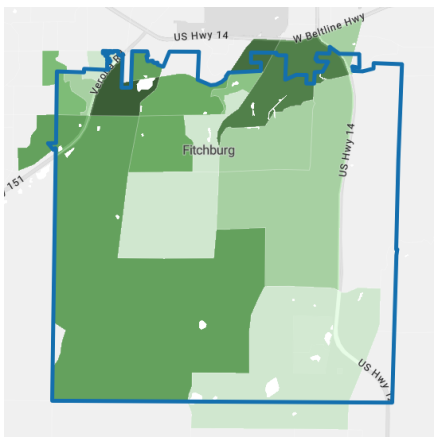
1,425
4.2%

of total population (tracts shown)





Total in demographic
in City: **3,833**
11.3%
of total population
(tracts shown)
19.1%
of jobs in City
(city boundary)



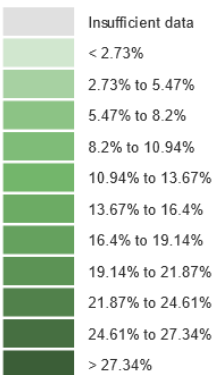
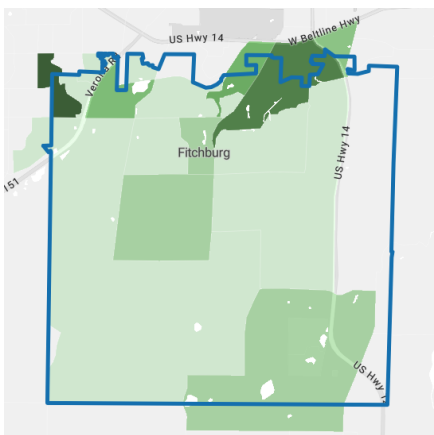
At Risk Workers

Climate change is likely to intensify the frequency and severity of job-related environmental hazards. As our environment evolves, new occupational risks may also arise. We can anticipate that climate change will impact the well-being of outdoor workers due to rising average temperatures, frequent and prolonged heatwaves, diminishing air quality, severe weather events, diseases transmitted by vectors, and exposure in industrial settings. Those impacted by these climatic shifts encompass agricultural professionals, workers in heated indoor settings, construction personnel, emergency medical staff and other first responders, as well as those in transportation roles.²

Individuals employed in at-risk occupations may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic
in City: **1,866**
5.5%
of total population
(tracts shown)



Individuals with Possible Limited Mobility

Climate action seeks to reduce single occupant vehicles and promote public transit and alternative transport. For vulnerable populations, limited mobility from insufficient public transit and lack of vehicle access can complicate emergency evacuations, particularly in high-risk areas. This limited mobility can also hinder access to cooling stations during heatwaves or to medical facilities. Those with limited vehicle access, often under economic strain or older adults, face amplified climate vulnerabilities.^{2,9}

Individuals with limited mobility may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):





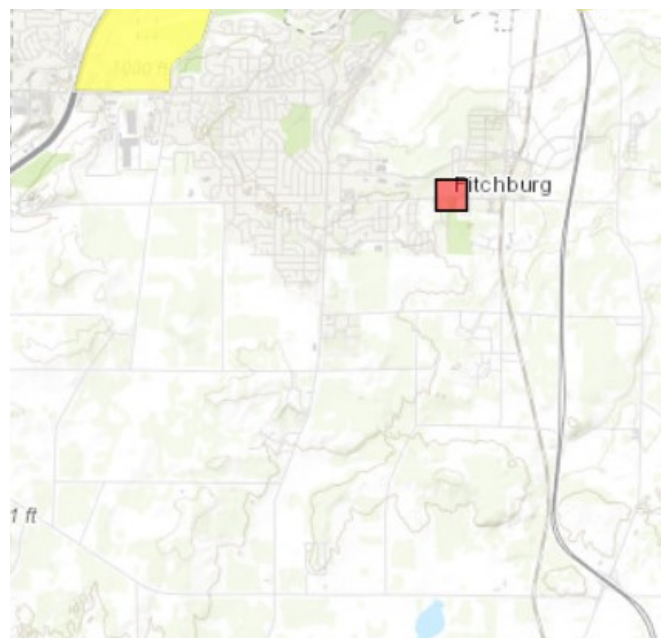
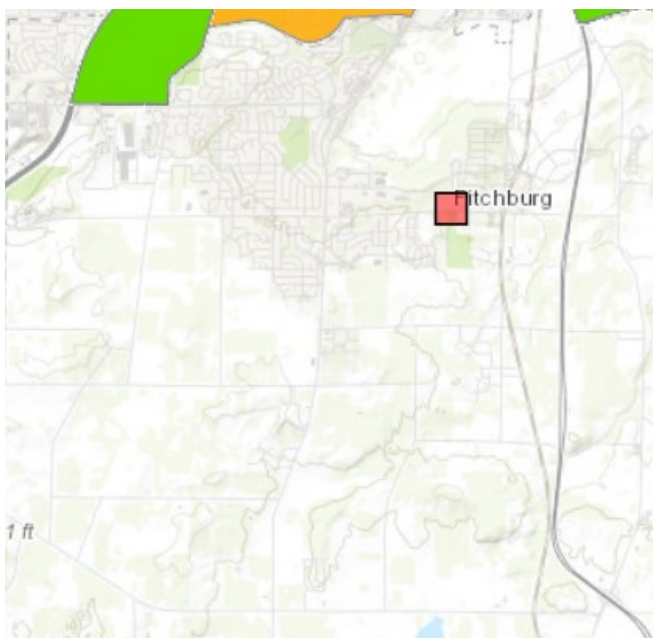
Individuals With Possible Food Insecurity

Those in economic stress are also frequently food insecure. In Wisconsin, food insecurity affects 1 in 14 individuals overall and 1 in 9 children.¹⁰ Many of the projected climate change impacts are likely to affect agricultural production and distribution, which in turn, may cause spikes in food costs and increase food and nutrition insecurity among those in economic stress. Climate change affects agriculture in a number of ways such as through changes in average temperatures, rainfall, and extreme weather events. 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 (see Section 4 for Climate Risk information):



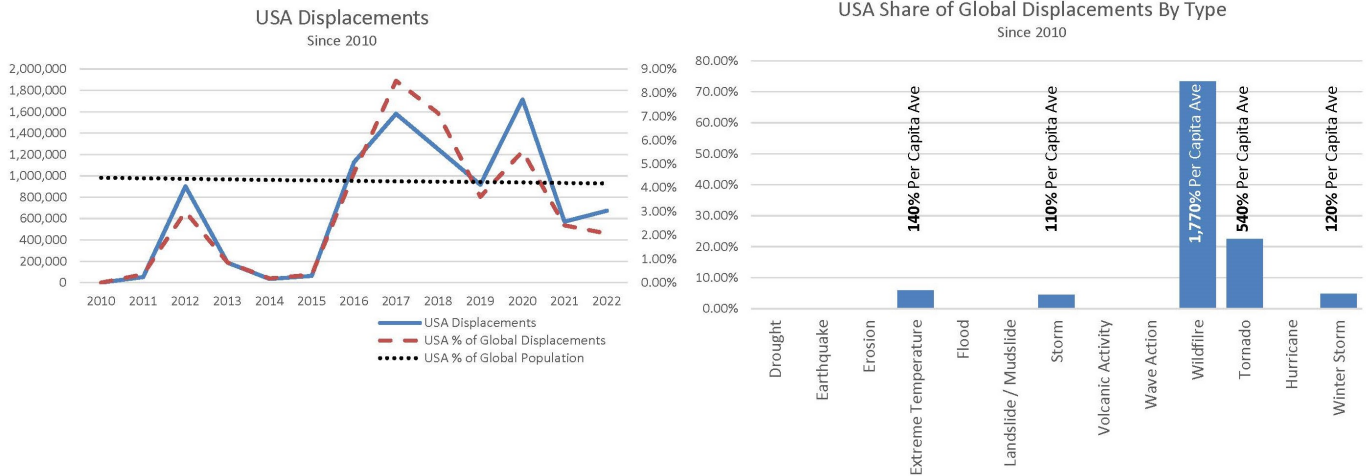
On the maps below, highlighted sections represent low-income census tracts (tracts where 20% or more of the population is at or below poverty, or where family median incomes are 80% or less of State median) where a significant number (at least 500 people) or share (at least 33 percent) of residents are distant from the nearest supermarket. In sections which are green, residents are more than 1 mile (urban) or 10 miles (rural), while in orange sections residents are more than ½ mile (urban) or 10 miles (rural) from nearest supermarket. Sections that are yellow 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. Data and graphic source: USDA Food Access Research Atlas¹¹



Climate Displacements

Since 2008, 11.1 million people in the U.S. have been displaced due to disasters, making up 2.8% of global displacements. In 2022, 675,000 U.S. residents were uprooted, ranking the U.S. second in the Americas, only behind Colombia.¹²

Over four of the past seven years since 2016, the U.S. had above its per-capita global displacement share. Especially stark is the U.S.'s impact in three categories: extreme temperatures at 140%, tornadoes at 540%, and wildfires at 1,770% of the global average. Clearly, climate-driven displacement is a pressing concern for American communities.¹²



Climate Migrant Populations

In the coming decades, US coasts will endure frequent flooding, endangering numerous homes. The Union of Concerned Scientists reports that by decade's end, 170 US communities will often face sea level floods, with many in vulnerable regions. By 2060, this could rise to 360 and surpass 670 by 2100. Areas like Oakland, Miami, St. Petersburg, and most New York City boroughs will face regular flooding. This might displace 13 million Americans by 2100. The UN anticipates 25 million to 1 billion global environmental migrants by 2050.^{13, 14}

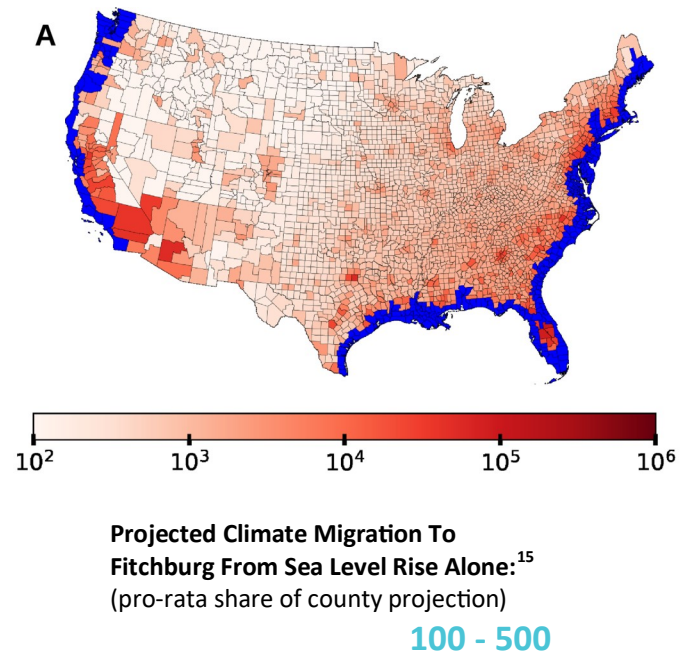
Understanding climate-driven migration, different from regular patterns, is key for informed policies, given its heightened impacts on receiving communities.

What This Means For Fitchburg

Inland regions will experience increased migration. Estimates indicate 86% of communities with populations of over 10,000 will face climate migration impacts this century. While Fitchburg isn't immune to climate change, it's poised to receive many climate migrants in the coming decades.¹⁵

This migration can strain labor and housing markets but also boost workforce diversity and human capital. Adapting to climate effects and preparing for migration are vital for community resilience while increasing the attraction of Fitchburg as a choice for households seeking to relocate to avoid worse climate impacts elsewhere.

Modeled Migration Patterns Due To Sea Level Rise¹⁵



SECTION

08

Findings

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Based on the estimated Total Instances of Potential Vulnerability by Category and considering the risks each demographic is most sensitive to, the population vulnerabilities can be considered from highest sensitivity (more likely instances of vulnerability to that risk) to lowest sensitivity (fewer likely instances of vulnerability to that risk). It should be noted that risks which appear to have lower sensitivity levels should not be considered irrelevant for the community.

The Vulnerable Population Risk Sensitivity Chart tabulates the instances of vulnerable population which are particularly sensitive to each of the Climate Risks to the Population as outlined in Section 4 and calculated in Section 7. The left side of the chart includes all of the primary climate risks while the right side includes the economic climate risks.

Vulnerable Populations Risk Sensitivity Chart

Vulnerable Demographic	Population	Primary Risks to The Population									Economic Vulnerabilities							
		Extreme Heat	Flood	Air Quality	Vector-Borne	Food	Water	Waterborne	Power	Wildfir	Crop Yield	Mortality	Energy Costs	Property Crime	Violent Crime			
Children Under 5	1,955	1,955											1,955	1,955	1,955			
Seniors Over 65	4,086	4,086	4,086	4,086	4,086	4,086				4,086	4,086		4,086	4,086	4,086			
Individuals with Disabilities	3,297	3,297	3,297	3,297		3,297				3,297	3,297			3,297	3,297			
Est Total Low Income	6,760	6,760	6,760	6,760	6,760	6,760	6,760	6,760	6,760	6,760	6,760		6,760	6,760	6,760			6,760
People of Color	9,953	9,953	9,953	9,953	9,953	9,953	9,953	9,953	9,953	9,953	9,953		9,953	9,953	9,953			9,953
Limited English	1,425	1,425	1,425	1,425	1,425	1,425	1,425	1,425	1,425	1,425	1,425		1,425	1,425	1,425			1,425
At-Risk Workers	3,833	3,833	3,833	3,833						3,833								3,833
Limited Mobility	1,866	1,866				1,866					1,866	1,866						
Total Instances of Potential Vulnerability by Category*		33,175	31,220	31,309	28,012	29,342	18,138	23,926	29,342	27,387			26,045	9,338	27,476	25,521	21,971	
Percentage of Total Instances of Potential Vulnerability		100%	94%	94%	84%	88%	55%	72%	88%	83%			79%	28%	83%	77%	66%	
Rank by Share of Total Instances of Potential Vulnerability		1	1	1	2	2	5	4	2	3			3	6	3	4	4	

* It is possible, and even likely, for individuals to be members of more than one vulnerable population. Individuals who have more than one instance of potential vulnerability (for example a person who is over 65, an individual living below 200% poverty level, and a limited english speaker) may have an increased range of potential risks to which they may be sensitive, as well as the potential for increased sensitivity to a given risk when compared to others.

To account for these considerations, the "Total Instances of Potential Vulnerabilities by Category" is not intended to represent the number of vulnerable individuals, but instead estimates the total number of potential instances of vulnerability within the community to each risk. The "Percentage of Total Instances of Potential Vulnerability" then divides that category's total by the sum of all "Instances of Potential Vulnerability by Category" to create a weighted comparison of each risk against all others. The resulting "Rank by Share of Total Instances of Potential Vulnerability" establishes a ranking based on the order of magnitude within the community's total population of likely instances of vulnerability to each risk.



Prioritizing Risk and Vulnerabilities

Climate change impacts 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.

Based on these reviews, the City’s adaptive efforts may be most effective by prioritizing strategies which address the climate risks as follows:

Primary Prioritization:

Extreme Heat and Weather, Air Quality, Flooding, Power/Infrastructure Failure, and Food Insecurity

Secondary Prioritization:

Vector-Borne Disease, Wildfire, Crop Yield, and Energy Costs

Tertiary Prioritization:

All Other Risks

With all adaptation measures, particular attention should be paid to strategies which are most effective for **People of Color, those in Economic Stress, Seniors over 65, and At-Risk Workers.**

City of Fitchburg Climate Risk Sensitivity Ranking Summary

Highest Sensitivity



Extreme Weather / Temp



Flood



Air Quality



Food Insecurity



Power Failure



Vector-Borne



Wildfire



Crop Yield



Energy Costs



Waterborne



Violent Crime



Property Crime



Water Quality



Mortality

Lowest Sensitivity



Anticipating Economic Impacts of Climate Change

A 2017 study from the University of California at Berkeley assessed the economic impact of current climate projections throughout the United States on a county-by-county basis.¹ The sectors assessed, and the findings for Dane County and the City of Fitchburg is below:

Crop Yield: Agricultural output is anticipated to decrease as Global Mean Surface Temperature rises, compounded by changes in precipitation patterns. While elevated CO2 levels might counterbalance some of these losses, the overarching effect across much of the U.S. is expected to be negative.

Energy Costs: With the rise in average annual temperatures, there will be a heightened demand for energy, leading to greater energy costs.

Labor Productivity: Labor productivity is negatively affected by rising temperatures. The extent of this impact varies; "low-risk" workers, primarily those working indoors, face different challenges compared to "high-risk" workers, who are identified as "At Risk Workers" in Section 4 and are more exposed to external conditions.

Crime: Research suggests that as cold days become less frequent, property crime may see an increase due to the crime-deterrent effect of cold days. Violent crime rates seem to have a direct relationship with temperature, increasing by a consistent 0.88% for every 1°C rise.

Projected Economic Impacts Through 2100¹

According to research from the University of California at Berkeley, the total annual economic costs for the county and Fitchburg's pro rata share by 2100 will be (2019 dollars)*:

County: \$132,753,000 annually

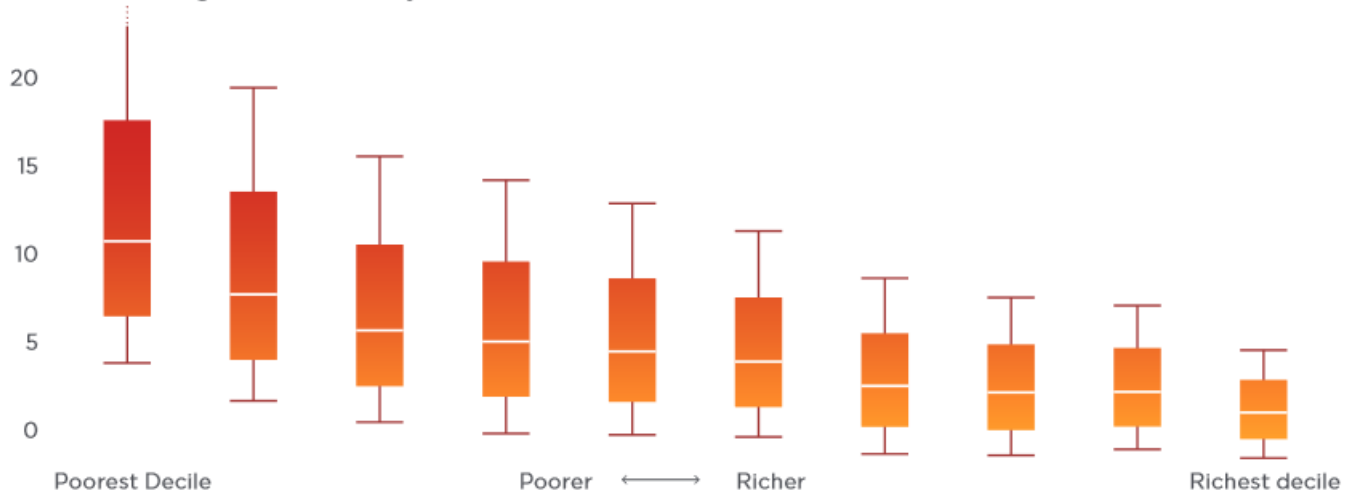
Fitchburg: \$6,903,000 annually

* Value does not include potential increased property damage nor increased healthcare costs due to extreme weather events.

Inequity of Economic Impacts Through 2100^{1,2}

Climate change will amplify the uncertainty and disparity of upcoming economic results. The anticipated economic consequences are not evenly distributed. As depicted in the graphic below, the economic burdens on the poorest 10% could be 5 to 10 times greater than those faced by the wealthiest 10% in the community.

25 Percent damage relative to county income



Note: Counties are arranged into deciles of county-level production/income and aggregate impacts as a percent of income are averaged across deciles. Boxplots denote median (white line), "likely" range (17 percentile-83 percentile, box), and 5 percentile-95 percentile (whiskers).

Graphic source: Amir Jina, Assistant Professor, Harris School of Public Policy, "Climate Change & the U.S. Economic Future"

Estimating Social Cost of Carbon

The "Social Cost of Carbon," also known as the "Avoided Cost of Carbon," aims to measure the detrimental effects of greenhouse gas emissions and the ensuing climate change repercussions. When this cost is factored into strategic planning, it enables organizations and businesses to more effectively evaluate their policies and decisions concerning greenhouse gas emissions. In essence, the "Social Cost of Carbon" quantifies the economic repercussions stemming from the emission of one ton of carbon dioxide into the atmosphere.

The "Projected Economic Impacts" illustrated on the previous page can be used to establish a reasonable localized social cost of carbon for the City. The methodology is to simply take the projected annual climate impact value and divide by the current City-Wide GHG emissions:

$$\text{Estimating the total annual economic impact for City of Fitchburg} \div \text{Current Total City-Wide GHG Emissions} = \text{Localized Social Cost of Carbon}$$



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

Mahatma Gandhi







The vulnerability assessment for City of Fitchburg was conducted through a process that included a review of relevant scientific literature, regional planning documents, and local, regional, and national climate assessments.

During the first step of the process, paleBLUEdot compiled a list of climate vulnerabilities for nine different sectors of interest based on existing resources and our experience with other communities as well as regional planning documents and studies. The list of vulnerabilities generated for each sector included both direct impacts of climate change (e.g., increased risk of illness or injury as a result of heat stress) as well as ways that existing stressors in the community might interact with climate changes, either by exacerbating the impacts of climate change (e.g., greater risk of flood damage where aging infrastructure is inadequate to deal with increased stormwater volume) or being exacerbated by climate change (e.g., loss of usable riverfront area due to frequent flooding is likely to magnify existing challenges related to the limited supply of vacant land for development in the region).

The likelihood, consequence, and adaptive capacity was ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for each sector.

Likelihood is the degree to which a sector is exposed to significant changes in climate. For this ranking, likelihood was assigned based on whether effects/impacts are anticipated to occur within a 30–80-year time frame (i.e., between 2050 and 2100).

The following scale was used:

Very High: >75% probability

High: 25-75% probability

Moderate: <25% probability

Low: Probability zero or close to it

Consequence is the degree to which a sector is affected by exposure to a changing climate. Consequence rankings were assigned based on the degree of consequence that the anticipated effect/impact would have on the functioning of that sector in the community as a whole rather than on the individuals directly experiencing the impact (e.g., the scale of flood damage or heat-related illnesses was considered at the community level rather than the severity of consequences for a given individual who might have suffered damage or illness).

The following scale was used:

Very High: Service to community ceases to exist

High: Service significantly impacted

Moderate: Service diminished

Low: Service not visibly or functionally affected

Adaptive capacity is the degree to which a sector may be able to cope with or respond to a given impact of climate change. Adaptive capacity rankings were assigned based on likely ability to establish policies or regulations that would support climate-informed actions, likely availability of partnerships and stakeholder relationships that would support robust collaborative action, ability to be flexible or respond quickly to changing conditions, and likely community willingness/desire to make changes, among other considerations.

A scale of Low/Moderate/High was used for this ranking.





Buildings and Energy

This sector focuses specifically on climate change vulnerability of publicly- and privately-owned **buildings** within the community, including those that provide critical services such as health care facilities, police/fire/rescue facilities, libraries, schools, community centers, and other governmental and public facilities. It also includes factors related to **energy** production and maintenance, energy demand, and diversification of energy services.

Vulnerability: Energy Cost and Power Outages

	Likelihood	Consequence	Capacity	Vulnerability
High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress)	Very High	High	Moderate	High

Vulnerability: Flood Damage

	Likelihood	Consequence	Capacity	Vulnerability
Increased damage or loss of buildings due to flooding or related impacts	Very High	High	Moderate	High

Vulnerability: Infrastructure Damage

	Likelihood	Consequence	Capacity	Vulnerability
Increased damage or loss of buildings and infrastructure due to extreme weather events or related impacts	High	High	Moderate	Moderate

Vulnerability: Energy Cost and Power Outages

	Likelihood	Consequence	Capacity	Vulnerability
High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress)	Very High	Moderate	High	High

Vulnerability: Isolation Due to Flooding

	Likelihood	Consequence	Capacity	Vulnerability
Reduced access to more isolated residential areas due to road flooding (e.g., mobile home parks with only one road in and out), potentially hindering evacuation efforts or emergency response	Moderate	Very High	Low	Moderate

Vulnerability: Housing Damage

	Likelihood	Consequence	Capacity	Vulnerability
Increased risk of flood and extreme weather damage along waterways, floodplains and areas susceptible to extreme weather (naturally or due to built conditions), with disproportionate impacts on vulnerable communities more likely to reside in those areas	High	Very High	Moderate	Moderate



Land Use & Housing

Land use refers to the pattern of development and redevelopment of public and private property within a community for all uses. This includes factors related to the supply and demand of land, price of land, costs associated with development, opportunities redevelopment, and existing or potential land-use conflicts. **Housing** refers more specifically to the availability of residential units within the community (including affordability), as well as the quality and condition of housing units, access, and maintenance of necessary utilities and conditions in and around housing units.

Potential Climate Change Impacts by Sector



Transportation, Equipment & Mobility

Transportation and mobility focuses on motorized and non-motorized modes of transportation and associated infrastructure. This includes consideration of public transportation systems, bicycle and pedestrian routes, and parking infrastructure. **Equipment** refers to off-road equipment which consume fuels (like lawn and construction equipment) as well as alternative fuel equipment (like electric vehicle charging).

Vulnerability: Increased Car Use

Reduced interest in walking/biking or using public transportation on hot days, increasing dependence on cars with air conditioning.

Likelihood	Consequence	Capacity	Vulnerability
High	Moderate	High	Moderate

Vulnerability: Flood Damage to Infrastructure

Increased flooding and associated damage to streets, sidewalks/trails, and parking lots during heavy rain events, particularly in low-lying areas or where stormwater infrastructure is inadequate

Likelihood	Consequence	Capacity	Vulnerability
Moderate	Very High	Moderate	High

Vulnerability: Resistance to Change

Historical investment in car-focused and lower density development resulting in reduced walkability, complicating future changes to increase the use of public and alternative mobility.

Likelihood	Consequence	Capacity	Vulnerability
Moderate	High	Moderate	Moderate



Open Space & Ecosystems

This topic area includes community **open space**, including parks, conservation lands, and other open space resources, as well as the **ecosystems** including urban tree canopy, grasses and land cover plants and the species that depend on them. Important aspects include the condition and management needs of these natural systems, which are associated with groundwater and surface water resources, recreation, native plants and wildlife .

Vulnerability: Invasive Species

Expansion of non-native invasive plants and insect pests as temperatures increase (particularly winter temperatures), likely resulting in the introduction of new invasive species into the area.

Likelihood	Consequence	Capacity	Vulnerability
Very High	Moderate	Moderate	Moderate

Vulnerability: Flooding Impacts

Increased flooding and erosion, impacting native plant communities (e.g., can result in loss of species such as ash) as well as access to and condition of parks and conservation.

Likelihood	Consequence	Capacity	Vulnerability
Very High	High	Moderate	Moderate

Vulnerability: Tree Canopy Stress

Increased stress and potential loss of tree canopy due to invasive pests (i.e. Emerald Ash Borer), changing temperature and precipitation patterns, extreme weather events, and invasive species impacts.

Likelihood	Consequence	Capacity	Vulnerability
Very High	Very High	Moderate	High



Potential Climate Change Impacts by Sector



Waste Management

Waste management refers to both municipal solid waste, recycling, and organics recycling (composting, etc). This sector includes consideration of volume, demand and service capacity, and infrastructure associated with collection and disposal.

Vulnerability: Increased Water Pollution

Increased leakage and run-off due to extreme weather events, potentially impacting local water quality.	Likelihood	Consequence	Capacity	Vulnerability
	Moderate	High	High	Moderate

Vulnerability: Increased Waste Generation

Increased waste generation due to debris and other damage (including organic debris from vegetation damage), which is likely to be exacerbated by illegal dumping.	Likelihood	Consequence	Capacity	Vulnerability
	Very High	High	Moderate	High

Vulnerability: Resistance to Change

Historical precedence for solid waste collection frequency, complexity of encouraging behavior change required to reduce solid waste generated and/or increase effective diversion to recycling and organics composting results in complications in reducing solid waste impacts.	Likelihood	Consequence	Capacity	Vulnerability
	Very High	High	Moderate	High

Vulnerability: Increased Flooding

Increased flooding during periods of heavy rain, particularly where the City's stormwater infrastructure is inadequate for increased volumes or impermeable surfaces prevent infiltration.	Likelihood	Consequence	Capacity	Vulnerability
	Very High	Very High	Moderate	High

Vulnerability: Groundwater Infiltration

Elevated groundwater tables due to frequent large storms, infiltrating the sanitary sewer system and increasing the cost of treatment.	Likelihood	Consequence	Capacity	Vulnerability
	Very High	Moderate	High	Moderate

Vulnerability: Resistance to Change

Water consumption behaviors and infrastructure investments (i.e. landscape sprinklers, non-native plantings, etc) as well as perception of a water rich region result in complications in reducing water consumption patterns.	Likelihood	Consequence	Capacity	Vulnerability
	Very High	High	Moderate	High



Water & Wastewater

This topic area includes **drinking water**, in terms of water quality and quantity and timing of supply, and **wastewater**, including stormwater runoff as well as municipal wastewater. Both drinking water and wastewater/stormwater require infrastructure for processing and distribution, which includes source water, underground water and sewer lines, culverts and stormwater management systems. This topic area must also consider **natural water resources** that supply drinking water for the City and wetlands that provide water filtration and floodwater storage.

Potential Climate Change Impacts by Sector



Local Food and Agriculture

This topic area considers **food systems**, including food processing and distribution systems, local food production including urban agriculture, and community food security.

Vulnerability: Agricultural Production Impacts

Current crops may not be suited for new conditions, increased flooding and climate change impacts on agricultural lands result in crop failures and impact food costs, availability, or security in community.

Likelihood	Consequence	Capacity	Vulnerability
High	Very High	Low	High

Vulnerability: Local Food System Impacts

Extreme weather events such as flooding result in damage or interruption to food distribution and retail operations impacting food costs availability, or security in community.

Likelihood	Consequence	Capacity	Vulnerability
Moderate	Very High	Moderate	Moderate

Vulnerability: Extreme Temperature Health Impacts

Increase in heat- or cold-related illness and death, which may be exacerbated by pre-existing medical conditions, age, occupation, and/or socioeconomic variables (e.g., access to a vehicle or regular health care).

Likelihood	Consequence	Capacity	Vulnerability
Very High	High	High	Moderate

Vulnerability: Emergency Shelter Demand

Increased demand for public shelter, emergency, and medical services.

Likelihood	Consequence	Capacity	Vulnerability
Very High	High	High	Moderate

Vulnerability: Interruption to Services

Increased flooding and extreme weather events causing associated damage or interruption to health and emergency services.

Likelihood	Consequence	Capacity	Vulnerability
High	Very High	Moderate	High



Public Health & Wellness

Public health and wellness include potential hazards that directly or indirectly impact public health by exacerbating chronic health conditions, causing illness or disease, and increasing the risk of injury or death. This topic also considers emergency services (e.g., fire, rescue), social services, and public health programming.



Potential Climate Change Impacts by Sector



Sustainable Economy

This topic area includes various indicators of **economic activity and opportunities** within the community, including employment, ability to attract and retain businesses and local industries, and community support for the local economy. This sector also represents the overall supportiveness of the local economy for the goals and objectives of increasing overall **community sustainability**.

Vulnerability: Utility Interruptions due to Extreme Weather

Increased demand and extreme weather impacts on utilities (electric, natural gas) and communications infrastructure which increase costs or potential for service interruption impacting local businesses and industry.

Likelihood	Consequence	Capacity	Vulnerability
Very High	Moderate	Moderate	Moderate

Vulnerability: Local Business Damage due to Extreme Weather

Extreme weather events, flooding, and other climate change impacts result in service interruption or economic damage for local businesses and industry.

Likelihood	Consequence	Capacity	Vulnerability
High	Very High	High	High

Vulnerability: Impacts on At-Risk Workers

Increased risks for outdoor and other at-risk workers who are more exposed to heat, potentially reducing labor productivity.

Likelihood	Consequence	Capacity	Vulnerability
Very High	High	Moderate	High



Section A1

Appendix 1 Local Climate Risks to the Environment



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Local Climate Risks To The Environment

Climate change projections for the Community 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:

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



Local 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 Glossary of Climate Adaptation and Vul- nerability Terms



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Abbreviations

BAU	Business as usual	PUB	Public Utilities Board
BEV	Battery electric vehicle	PV	Photovoltaic (solar photovoltaic)
BIPOC	Black, Indigenous, People of Color	REC	Renewable Energy Credit
C&D	Construction and demolition	SO ₂	Sulfur Dioxide
CAP	Climate Action Plan	SF ₆	Sulfur Hexafluoride
CE	Carbon Equivalent	SULEV	Super ultra-low emission vehicle
CDP	Carbon Disclosure Project	t	Ton equivalent to 2,000 lbs (United States)
CFC	Chlorofluorocarbons	TOG	Total Organic Gasses
CH ₄	Methane	USGS	U.S. Geological Survey
CHP	Combined Heat and Power	VMT	Vehicle miles traveled
CO ₂	Carbon dioxide	VHT	Vehicle hours traveled
CO ₂ e	Carbon dioxide equivalent	ZEV	Zero emission vehicle
CSG	Community Solar Garden		
DOE	U.S. Department of Energy		
EMS	Emergency medical services		
EPA	U.S. Environmental Protection Agency		
EV	Electric vehicle		
EVSE	Electric vehicle supply equipment		
FEMA	Federal Emergency Management Agency		
FTE	Full-time equivalent		
GCoM	Global Covenant of Mayors		
GDP	Gross Domestic Product		
GHG	Greenhouse gas		
GWP	Global warming potential		
HFC	Hydrofluorocarbons		
IPCC	Intergovernmental Panel on Climate Change		
kWh	Kilowatt-hour		
LEV	Low emission vehicle		
MWH	Megawatt hour – 1,000 Kilowatt-hours		
MSW	Municipal Solid Waste		
MT	Metric ton equivalent to 1,000 kg (also known as Metric Tonne)		
MMT	Million Metric tons		
MMBTU	Million British Thermal Units		
MTCO ₂ e	Metric tons of carbon dioxide equivalent		
N ₂ O	Nitrous Oxide		
NO _x	Nitrogen Oxides		
NZE	Net-Zero Emissions		
O ₃	Ozone		
ODS	Ozone Depleting Substances		
PACE	Property Assessed Clean Energy		
PFC	Perfluorocarbons		
PHEV	Plug-in hybrid electric vehicle		
PM _{2.5}	Particulate matter of 2.5 micrometer diameter or less		
POC	People of Color		
PPA	Power Purchase Agreement		



A

Action

Actions are detailed items that should be completed to carry out the vision and strategies identified in the plan.

Activity Data

Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on energy use, metal production, land areas, management systems, lime and fertilizer use and waste arisings are examples of activity data. ([IPCC](#))

Adaptation

See "Climate Adaptation or Resilience"

Adaptive Capacity

The social, technical skills, and financial capacities of individuals and groups to implement and maintain climate actions.

Aerosols

A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 micrometer that reside in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. Aerosols may influence climate in several ways: directly through scattering and absorbing radiation, and indirectly by acting as cloud condensation nuclei or modifying the optical properties and lifetime of clouds. ([IPCC2](#))

Afforestation

Planting of new forests on lands that historically have not contained forests. ([IPCC2](#))

Air Pollutant

Any man-made and/or natural substance occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, and/or materials. ([CARB](#))

Anthropogenic

The term "anthropogenic", in the context of greenhouse gas inventories, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities. ([USEPA2](#))

Atmosphere

The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium and radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio) and ozone. In addition, the atmosphere contains the greenhouse gas water vapor, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols. ([IPCC2](#))

B

Baseline Emissions

A baseline is a measurement, calculation, or time used as a basis for comparison. Baseline emissions are the level of emissions that would occur without policy intervention or without implementation of a project. Baseline estimates are needed to determine the effectiveness of emission reduction programs (also called mitigation strategies).

Base Year

The starting year for the inventory. Targets for reducing GHG emissions are often defined in relation to the base year.

BAU

See "Business As Usual Forecast"

Beneficial Electrification (see "Fuel Switching")

Biogenic

Produced by the biological processes of living organisms. Note that we use the term "biogenic" to refer only to recently produced (that is non-fossil) material of biological origin. IPCC guidelines recommend that peat be treated as a fossil carbon because it takes a long time to replace harvested peat.

Biogeochemical Cycle

Movements through the Earth system of key chemical constituents essential to life, such as carbon, nitrogen, oxygen, and phosphorus. ([NASA](#))

Biomass

Either (1) the total mass of living organisms in a given area or of a given species usually expressed as



dry weight; or (2) Organic matter consisting of or recently derived from living organisms (especially regarded as fuel) excluding peat. Includes products, by-products and waste derived from such material. (IPCC1)

Biomass Waste

Organic non-fossil material of biological origin that is a byproduct or a discarded product. "Biomass waste" includes municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural crop byproducts, straw, and other biomass solids, liquids, and gases; but excludes wood and wood-derived fuels (including black liquor), biofuels feedstock, biodiesel, and fuel ethanol. Note: EIA "biomass waste" data also include energy crops grown specifically for energy production, which would not normally constitute waste. ([EIA](#))

BIPOC

"Black, Indigenous, and People of Color" this is a term specific to the United States, intended to center the experiences of Black and Indigenous groups as representative of or shaping the socio-economic dynamics experienced by all people of color.

Black Carbon

Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability; consists of soot, charcoal and/or possible light absorbing refractory organic matter (Charlson and Heintzenberg, 1995, p. 401). ([IPCC2](#))

Blue Carbon

Carbon sequestered and stored by wetlands and other coastal ecosystems helping to mitigate the effects of climate change.

British Thermal Unit (BTU)

A traditional unit of heat energy. It's defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

Business As Usual Forecast

The Intergovernmental Panel on Climate Change (IPCC) defines a "business-as-usual" forecast as the level of emissions that would result if future development trends follow those of the past and no changes in policies

take place. A BAU forecast assumes that no emission-reduction actions will be undertaken beyond those already in place, mandated by State or Federal policy, or committed to in the base year.

C

Carbon Cycle

All parts (reservoirs) and fluxes of carbon. The cycle is usually thought of as four main reservoirs of carbon interconnected by pathways of exchange. The reservoirs are the atmosphere, terrestrial biosphere (usually includes freshwater systems), oceans, and sediments (includes fossil fuels). The annual movements of carbon, the carbon exchanges between reservoirs, occur because of various chemical, physical, geological, and biological processes. The ocean contains the largest pool of carbon near the surface of the Earth, but most of that pool is not involved with rapid exchange with the atmosphere. ([NASA](#))

Carbon Dioxide (CO₂)

A naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. ([IPCC2](#))

Carbon Dioxide Equivalent (CO₂e)

A metric used to compare emissions of various greenhouse gases. It is the mass of carbon dioxide that would produce the same estimated radiative forcing as a given mass of another greenhouse gas. Carbon dioxide equivalents are computed by multiplying the mass of the gas emitted by its global warming potential.

Carbon Disclosure Project (CDP)

An international organization that administers a platform for organizations and cities to publicly disclose their environmental impacts, such as climate risk. CDP is one of the approved disclosure platforms utilized by GCoM.

Carbon Emissions

The release of carbon dioxide into the atmosphere. Primary human sources of the release of carbon



dioxide occur from burning oil, coal, and gas for energy use.

Carbon Equivalent (CE)

A metric measure used to compare the emissions of the different greenhouse gases based upon their global warming potential. Carbon equivalents can be calculated from to carbon dioxide equivalents by multiplying the carbon dioxide equivalents by 12/44 (the ratio of the molecular weight of carbon to that of carbon dioxide). The use of carbon equivalent is declining in GHG inventories.

Carbon Free

Processes, systems, or products that do not release carbon dioxide (CO₂) or other greenhouse gases into the atmosphere. This term is often used in discussions about clean, sustainable, or renewable energy sources – however, not all “carbon free” energy sources are renewable. Wind, solar and nuclear energy are all carbon-free sources but only wind and solar are renewable.

Carbon Intensity

The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. ([EIA](#))

Carbon Neutrality

“Carbon neutrality” means annual zero net anthropogenic (human caused or influenced) CO₂ emissions by a certain date. By definition, carbon neutrality means every ton of anthropogenic CO₂ emitted is compensated with an equivalent amount of CO₂ removed (e.g. via carbon sequestration).

Carbon Offsets

A carbon offset is a reduction or removal of emissions of carbon dioxide or other greenhouse gases made to compensate for emissions made elsewhere. Offsets are measured in metric tonnes of carbon dioxide-equivalent. Offsets are bought and sold to address direct and indirect emissions associated with an organization’s operations.

Climate and Sustainability Glossary of Terms

Carbon Sinks

A forest, ocean, or other natural environment viewed in terms of its ability to absorb carbon dioxide from the atmosphere.

Carbon Sequestration

This refers to the capture of CO₂ from the atmosphere and its long term storage in oceans (oceanic carbon sequestration), in biomass and soils (terrestrial carbon sequestration) or in underground reservoirs (geologic carbon sequestration).

Chlorofluorocarbons (CFCs)

Greenhouse gases covered under the 1987 Montreal Protocol and used for refrigeration, air conditioning, packaging, insulation, solvents, or aerosol propellants. Because they are not destroyed in the lower atmosphere, CFCs drift into the upper atmosphere where, given suitable conditions, they break down ozone. These gases are being replaced by other compounds, including hydrochlorofluorocarbons and hydrofluorocarbons, which are greenhouse gases covered under the Kyoto Protocol. ([IPCC3](#))

Circular Economy

An alternative to a traditional linear economy (make, use, dispose) in which an economy is a regenerative system where resource input and waste are minimized. This is achieved through long-lasting product design, repair, reuse, remanufacturing, and recycling. Circular economy strategies are often cited as systems level approaches to reducing waste generation through product and system design.

Climate

Climate, in a narrow sense, is usually defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. ([IPCC2](#))

Climate Adaptation or Resilience



The capacity of a natural environment or community to prevent, withstand, respond to, and recover from a disruption. The process of adjusting to new climate conditions to reduce risks to valued assets. Adaptation is achieved through actions taken to increase resilience to climate change impacts by reducing vulnerability.

Climate Action Plan

A detailed strategy outlining measures a community, business, or government will take to reduce greenhouse gas emissions and adapt to climate change impacts, promoting sustainable and resilient development.

Climate Change

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. ([IPCC2](#))

Climate Hazard

An extreme climate event or condition that can harm human health, livelihoods, or natural resources. It can include abrupt changes to the climate system such as extreme precipitation, storms, droughts, and heat waves.

Climate Migration

Movement of people due to the impacts of climate change on their livelihoods or erosion of quality of life, such as shifts in water availability and crop productivity, or to factors such as sea level rise or storm surge.

Climate Model

A quantitative method to simulate interactions of the important drivers of climate—including atmosphere, oceans, land, and ice—to develop projections of future climate.

Climate Scenario

A coherent, internally consistent, plausible description of possible climatic conditions

Climate Risk

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability and hazard. (IPCC):

Climate Vulnerability

Is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its capacity to adapt.

Vulnerability = potential impact (sensitivity x exposure) – adaptive capacity (IPCC):

Climate Vulnerability Assessment

A report used to identify and define the risks posed by climate change and inform adaptation measures needed to combat climate change. Reports can be about a wide range of fields including food security, poverty analysis, and extreme weather events.

Co-Benefit

Indirect benefits to the community (e.g., public health, economic, equity) caused by climate adaptation and mitigation strategies, actions, and policies.

Co-generation

Co-generation is an industrial structure, installation, plant, building, or self-generating facility that has sequential or simultaneous generation of multiple forms of useful energy (usually mechanical and thermal) in a single, integrated system. ([CARB](#))

Community Choice Aggregation (CCA)

CCA programs, also known as “Municipal Power Aggregation” or “Community Power Aggregation”, allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider. Typically, enabling legislation at the State level is required in order to assemble a CCA program for a community. See EPA’s CCA webpage for more:



<https://www.epa.gov/green-power-markets/community-choice-aggregation>

Combined Heat and Power (CHP)

Combined heat and power is the simultaneous production of both electricity and useful heat for application by the producer or to be sold to other users with the aim of better utilization of the energy used. Public utilities may utilize part of the heat produced in power plants and sell it for public heating purposes. Industries as auto-producers may sell part of the excess electricity produced to other industries or to electric utilities. ([IPCC](#))

Community Power Aggregation

See "Community Choice Aggregation"

Community Solar / Community Solar Garden (CSG)

Solar facilities shared by multiple community subscribers who receive credit on their electricity bills for their share of the power produced. Community solar allows members of a community to share the benefits of solar power on their property without installing it on their own property. Electricity generated by the community solar farm typically costs less than the price from utility companies.

Complete Streets

A "complete street" is a design approach that requires streets to be designed to support safe, convenient and comfortable travel and access for users of all ages and abilities regardless of their mode of transportation.

Consistency

Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. ([IPCC](#))

Continuous Emission Monitor (CEM)

A type of air emission monitoring system installed to operate continuously inside of a smokestack or other emission source. ([CARB](#))

Cool Roof

Roof surfaces designed to reflect radiation from the sun, reducing heat transfer into the building or the building's surrounding area.

Cool Pavement

Pavement surfaces designed to reflect radiation from the sun, reducing heat transfer into the road's surrounding area.

Criteria Air Pollutant

An air pollutant for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set. Examples include: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and PM10 and PM2.5. The term "criteria air pollutants" derives from the requirement that the U.S. EPA must describe the characteristics and potential health and welfare effects of these pollutants. The U.S. EPA and CARB periodically review new scientific data and may propose revisions to the standards as a result. ([CARB](#))

D

Decarbonization

The process of reducing carbon emissions by transitioning to cleaner energy sources, improving energy efficiency, and/or capturing and storing carbon emissions. The goal is to minimize impact on climate change and achieve a carbon-neutral economy.

Deforestation

Those practices or processes that result in the change of forested lands to non-forest uses. This is often cited as one of the major causes of the enhanced greenhouse effect for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present and contributing to carbon storage. ([UNFCCC](#))

Demand Side Management (DSM)

Strategies to alter consumer energy usage through strategies like education and monetary incentives. Its goal is to lower overall energy use, specifically during high-demand times, and move usage to off-peak hours like nights or weekends.



Distillate Fuel Oil

A general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation. ([EIA](#))

District Heating

District heating is a system for distributing heat generated in a centralized location through a system of pipes for residential and/or commercial heating within a district of a community.

E

Eco-System Services

Contributions of ecosystems to human well-being. For example, ecosystems produce resources used by humans such as clean air, water, food, open space, flood control, climate mitigation, and other benefits.

Emissions

The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere. ([USEPA1](#))

Emission Factor

A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions. ([IPCC](#))

Emission Inventory

An estimate of the amount of pollutants emitted into the atmosphere from major mobile, stationary, area-wide, and natural source categories over a specific period of time such as a day or a year. ([CARB](#))

Emission Rate

The weight of a pollutant emitted per unit of time (e.g., tons / year). ([CARB](#))

Energy Burden

Percentage of gross household income spent on energy costs. A household's energy burden is considered to be "high" if it is 6% or more of household income while a severe energy burden is above 10%. ([ACEEE](#))

Energy Savings / Energy Efficiency

Energy savings refer to a long-term reduction in energy use while maintaining the same outcomes. For instance, a new furnace that uses X% less energy to heat your home results in X% energy savings or X% increase in energy efficiency.

Energy Tariff

An Energy Tariff, or utility tariff, governs how an energy provider (electric or natural gas) charges the customer for their energy and natural gas usage. Electric and natural gas vendors must submit their tariffs to the government for approval.

Environmental Justice

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies

Equity

The state or quality of being just and fair in the way people are treated. Equity recognizes that each person has different circumstances and allocates the exact resources and opportunities needed to reach an equal outcome. According to the World Health Organization, Equity is "the absence of avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically or geographically" while the US Center for Disease Control defines Equity as "when everyone has the opportunity to be as healthy as possible." Within the context of climate change, climate equity means both protection from climate change and environmental hazards as well as access to climate resilience and environmental benefits for all, regardless of income, race, and other characteristics.

Estimation

Estimation is the assessment of the value of an unmeasurable quantity using available data and knowledge within stated computational formulas or mathematical models.



F

Fluorocarbons

Carbon-fluorine compounds that often contain other elements such as hydrogen, chlorine, or bromine. Common fluorocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). ([UNFCC](#))

Flux

Either (1) Raw materials, such as limestone, dolomite, lime, and silica sand, which are used to reduce the heat or other energy requirements of thermal processing of minerals (such as the smelting of metals). Fluxes also may serve a dual function as a slagging agent. (2) The rate of flow of any liquid or gas, across a given area; the amount of this crossing a given area in a given time. (e.g., "Flux of CO₂ absorbed by forests"). ([IPCC](#))

Fossil Fuel

Geologic deposits of hydrocarbons from ancient biological origin, such as coal, petroleum and natural gas.

Fuel Combustion

Fuel combustion is the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus. ([IPCC](#))

Fuel Switch (see also "Beneficial Electrification")

Fuel switching involves transitioning from one energy source to another, often from fossil fuels to renewable sources like wind, solar, or hydroelectric power. It aims to reduce costs and emissions, contributing significantly to climate change mitigation efforts.

Fugitive Emissions

Fugitive emissions are unintentional leaks emitted from sealed surfaces, such as packings and gaskets, or leaks from underground pipelines resulting from corrosion or faulty connections.

G

Geologic Carbon Sequestration

It is the process of injecting CO₂ from a source, such as coal-fired electric generating power plant, through a well into the deep subsurface. With

proper site selection and management, geologic sequestration could play a major role in reducing emissions of CO₂. Research efforts to evaluate the technical aspects of CO₂ geologic sequestration are underway. ([USEPA4](#))

GHG

See "Greenhouse Gas"

Global Environmental Change

Pervasive, accelerating changes and disruptions of Earth's natural systems including climate change, biodiversity loss, changes in land use and land cover, resource scarcity, global pollution, and altered biogeochemical cycles. (source: Planetary Health Alliance)

Global Warming

Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. Also see Climate Change ([USEPA1](#))

Global Warming Potential (GWP)

An index, based upon radiative properties of well-mixed greenhouse gases, measuring the radiative forcing of a unit mass of a given well-mixed greenhouse gas in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing thermal infrared radiation. The Kyoto Protocol is based on GWPs from pulse emissions over a 100-year time frame. ([IPCC2](#))

GCoM Global Covenant of Mayors:

GCoM is the largest global alliance for city climate leadership, built upon the commitment of over 10,000 cities and local governments. The alliance's mission is to mobilize and support climate and energy action in communities across the world.

Green Streets



A “green street” is a stormwater management approach that incorporates vegetation, soil, and engineered systems to slow, filter, and cleanse stormwater runoff from impervious surfaces.

Greenhouse Effect

Trapping and build-up of heat in the atmosphere (troposphere) near the earth's surface. Some of the heat flowing back toward space from the earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase.

([UNFCC](#))

Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories:

A robust, transparent and globally-accepted framework that cities and local governments can use to consistently identify, calculate and report on city greenhouse gas emissions.

Greenhouse Gas

Greenhouse Gas (GHG) is any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrochlorofluorocarbons (HCFCs), ozone (O₃), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). ([UNFCC](#))

Greenhouse Gas Reduction

Actions taken to reduce the number and severity of potential future climate impacts compared to unchecked greenhouse gas emissions.

Green Infrastructure

An approach to managing precipitation by reducing and treating stormwater at its source while delivering environmental, social, and economic benefits. Stormwater runoff can carry trash, bacteria, and other pollutants and is a major cause of water pollution in urban areas.

Green Roof

A green roof is a layer of vegetation planted over a waterproofing system that is installed on top of a flat or slightly-sloped roof. Green roofs are also known

as vegetative or eco-roofs. They fall into three main categories—extensive, intensive, and semi-intensive. Green roofs have been shown to decrease heat island contributions of buildings and decrease stormwater runoff while increasing overall vegetative land coverage.

Green wall

A green wall is similar to a green roof but applied to exterior wall surfaces.

Gross Domestic Product (GDP)

The sum of gross value added, at purchasers' prices, by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products in a country or a geographic region for a given period, normally one year. It is calculated without deducting for depreciation of fabricated assets or depletion and degradation of natural resources. ([IPCC3](#))

Groundwater

Water that occurs beneath the water table in soils and geologic formations that are fully saturated.

H

Halocarbons

A collective term for the group of partially halogenated organic species, including the chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), halons, methyl chloride, methyl bromide, etc. Many of the halocarbons have large Global Warming Potentials. The chlorine and bromine-containing halocarbons are also involved in the depletion of the ozone layer. ([IPCC2](#))

Hazard

The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Heat Island

A heat island is an urban or large-scale area characterized by temperatures higher than those of the surrounding due to human activities. The difference in temperature between urban and less-developed rural areas has to do with how well the



surfaces in each environment absorb and hold heat. See also “Micro Heat Island”

Hydrocarbons

Strictly defined as molecules containing only hydrogen and carbon. The term is often used more broadly to include any molecules in petroleum which also contains molecules with S, N, or O. An unsaturated hydrocarbon is any hydrocarbon containing olefinic or aromatic structures. ([IPCC](#))

Hydrofluorocarbons (HFCs)

Compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer, but they are powerful greenhouse gases with global warming potentials ranging from 140 (HFC-152a) to 11,700 (HFC-23). ([USEPA1](#))

I

ICLEI Local Governments for Sustainability:

A membership organization for local governments to pursue reductions in carbon pollution and improvements in advancing sustainable urban development. ICLEI’s members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

Impact

An effect of climate change on the structure or function of a system: for example, environmental consequences of climate change, such as extreme heat waves, rising sea levels, or changes in precipitation resulting in flooding and droughts.

Indicator: A quantitative measure of one aspect of climate-change vulnerability. Examples include projected change in mean annual temperature or number of at-risk species

Intergovernmental Panel on Climate Change

The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant

components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories. ([USEPA1](#))

K

Kilowatt Hour (kWh):

A measure of electrical energy equivalent to a power consumption of 1,000 watts for one hour.

Kyoto Protocol

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most Organisation for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005. ([IPCC2](#))

L

Land Use and Land Use Change

Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction and conservation). Land use change refers to a change in the use or



management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have a radiative forcing and/or other impacts on climate, locally or globally. ([IPCC2](#))

Living Streets

A “living street” combines the concepts of complete streets and green streets while putting additional focus on quality of life aspects for City residents.

LULUCF

Acronym for "Land Use, Land Use Change and Forestry", a category of activities in GHG inventories.

M

Megawatt Hour (MWH):

A measure of electrical energy equivalent to a power consumption of 1,000,000 watts for one hour.

Methane (CH₄)

A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 25 times that of carbon dioxide (CO₂). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, flooded rice fields, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The GWP is from the IPCC's Fourth Assessment Report (AR4).

Metric Ton

The tonne (t) or metric ton (MT), sometimes referred to as a metric tonne, is an international unit of mass. A metric ton is equal to a Megagram (Mg), 1000 kilograms, 2204.6 pounds, or 1.1023 short tons.

Micro Heat Island

Micro heat islands are smaller scale hot spots within developed areas which experience higher temperatures than surrounding areas due to how well the surfaces in the location absorb, reflect, and hold heat. These occur in areas such as poorly vegetated parking lots, non-reflective roofs and asphalt roads. Micro urban heat islands are strongly

Climate and Sustainability Glossary of Terms

affected by micro climate factors and localized conditions of the built environment. See also “Heat Island”

Million Metric Tons (MMT)

Common measurement used in GHG inventories. It is equal to a Teragram (Tg).

Mitigation:

Actions taken to limit the magnitude or rate of long-term global warming and its related effects. Climate change mitigation generally involves reductions in human emissions of greenhouse gases.

Mobile Sources

Sources of air pollution such as automobiles, motorcycles, trucks, off-road vehicles, boats, and airplanes. ([CARB](#))

Mode Share

The percentage of travelers using a particular type of transportation. Modal share is an important component in developing sustainable transport within a city or region because it reveals the level of utilization of various transportation methods. The percentage reflects how well infrastructure, policies, investments, and land-use patterns support different types of travel.

Model

A model is a quantitatively-based abstraction of a real-world situation which may simplify or neglect certain features to better focus on its more important elements. ([IPCC](#))

Municipal Power Aggregation

See “Community Choice Aggregation”

Municipal Solid Waste (MSW)

Residential solid waste and some non-hazardous commercial, institutional, and industrial wastes. This material is generally sent to municipal landfills for disposal. ([USEPA1](#))

N

Natural Sources

Non-manmade emission sources, including biological and geological sources, wildfires, and windblown dust. ([CARB](#))

Net Energy Metering, (NEM)



Net Energy Metering (NEM), also known as Net Metering, allows residential and commercial customers who generate their own electricity from solar power to sell the electricity they aren't using back into the grid. The NEM rate schedule (energy tariff) determines how much you are paid for the electricity you sold to the grid. Many states have passed net metering laws. In other states, utilities may offer net metering programs voluntarily or as a result of regulatory decisions. Differences between state legislation, regulatory decisions and implementation policies mean that the mechanism for compensating solar customers varies widely across the country.

Net Zero Emissions (NZE)

Refers to a community, business, institution, or building for which, on an annual basis, all greenhouse gas emissions resulting from operations are offset by carbon-free energy production. An NZE building or property is one which generates or offsets all energy consumed. If a City develops a NZE building code, this definition will have to be refined to provide additional guidance on calculating emissions and offsets to achieve net-zero emissions.

Nitrogen Fixation

Conversion of atmospheric nitrogen gas into forms useful to plants and other organisms by lightning, bacteria, and blue-green algae; it is part of the nitrogen cycle. ([UNFCCC](#))

Nitrogen Oxides (NO_x)

Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced in the emissions of vehicle exhausts and from power stations. In the atmosphere, nitrogen oxides can contribute to formation of photochemical ozone (smog), can impair visibility, and have health consequences; they are thus considered pollutants. ([NASA](#))

Nitrous Oxide (N₂O)

A powerful greenhouse gas with a global warming potential of 298 times that of carbon dioxide (CO₂). Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, manure management, fossil fuel combustion, nitric acid production, and biomass burning. The GWP is from the IPCC's Fourth Assessment Report (AR4).

O

Ozone (O₃)

Ozone, the triatomic form of oxygen (O₃), is a gaseous atmospheric constituent. In the troposphere, it is created both naturally and by photochemical reactions involving gases resulting from human activities (smog). Tropospheric ozone acts as a greenhouse gas. In the stratosphere, it is created by the interaction between solar ultraviolet radiation and molecular oxygen (O₂). Stratospheric ozone plays a dominant role in the stratospheric radiative balance. Its concentration is highest in the ozone layer. ([IPCC2](#))

Ozone Depleting Substances (ODS)

A compound that contributes to stratospheric ozone depletion. Ozone-depleting substances (ODS) include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone. ([IPCC](#))

P

Perfluorocarbons (PFCs)

A group of human-made chemicals composed of carbon and fluorine only. These chemicals (predominantly CF₄ and C₂F₆) were introduced as alternatives, along with hydrofluorocarbons, to the ozone depleting substances. In addition, PFCs are emitted as by-products of industrial processes and are also used in manufacturing. PFCs do not harm the stratospheric ozone layer, but they are powerful greenhouse gases: CF₄ has a global warming potential (GWP) of 7,390 and C₂F₆ has a GWP of 12,200. The GWP is from the IPCC's Fourth Assessment Report (AR4).

Phantom Load

Phantom load refers to the energy used by any appliance or electronic device (such as televisions, DVD players, microwaves and personal computers) that still uses electricity or "standby power" when turned off. An appliances that draws "phantom loads" means it is constantly drawing electricity.



Photosynthesis

The process by which plants take carbon dioxide from the air (or bicarbonate in water) to build carbohydrates, releasing oxygen in the process. There are several pathways of photosynthesis with different responses to atmospheric carbon dioxide concentrations. ([IPCC2](#))

Plug Load

Plug loads refer to energy used by equipment that is plugged into an outlet. In an office, key plug loads include computer and monitors, printers, and copiers. Plug loads as a share of overall building energy use is higher in energy efficient buildings.

POC

“People of Color” or “Person of Color” is a general umbrella term that collectively refers to all non-white demographic groups.

Point Sources

Specific points of origin where pollutants are emitted into the atmosphere such as factory smokestacks. ([CARB](#))

Power Purchase Agreement (PPA)

A power purchase agreement (PPA), or electricity power agreement, is a contract between two parties; one party generates electricity (the seller) and the other party looks to purchase electricity (the buyer). Individual customers and organizations may enter into PPAs with individual developers or may join together to seek better prices as a group. PPAs can allow longer term commitments to renewable energy as well as a form of “direct” investing in new renewable energy generation.

Property-Assessed Clean Energy (PACE)

A program created for financing energy efficiency and renewable improvements on private property. Private property can include residential, commercial or industrial properties. Improvements can include energy efficiency, renewable energy and water conservation upgrades to a building.

Process Emissions

Emissions from industrial processes involving chemical transformations other than combustion. ([IPCC](#))

R

Radiative Forcing

A change in the balance between incoming solar radiation and outgoing infrared (i.e., thermal) radiation. Without any radiative forcing, solar radiation coming to the Earth would continue to be approximately equal to the infrared radiation emitted from the Earth. The addition of greenhouse gases to the atmosphere traps an increased fraction of the infrared radiation, reradiating it back toward the surface of the Earth and thereby creates a warming influence. ([UNFCCC](#))

Reforestation

Planting of forests on lands that have previously contained forests but that have been converted to some other use. ([IPCC2](#))

Regeneration

The act of renewing tree cover by establishing young trees, naturally or artificially - note regeneration usually maintains the same forest type and is done promptly after the previous stand or forest was removed. ([CSU](#))

Renewable Energy

Energy resources that are naturally replenishing such as solar, wind, hydro and geothermal energy.

Renewable Energy Credits (RECs)

A market-based instrument that represents the property rights to the environmental, social and other non-power attributes of renewable electricity generation. RECs are issued when one megawatt-hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy resource. The single largest category of reductions in Evanston’s emissions has been through the purchase of RECs.

Residence Time

Average time spent in a reservoir by an individual atom or molecule. Also, this term is used to define the age of a molecule when it leaves the reservoir. With respect to greenhouse gases, residence time usually refers to how long a particular molecule remains in the atmosphere. ([UNFCCC](#))

Resilience

The ability to anticipate, prepare for, respond to, and recover quickly from climate change hazards with



minimum damage to social well-being, the economy, and the environment.

Reservoir

Either (1) a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored; or (2) Water bodies regulated for human activities (energy production, irrigation, navigation, recreation etc.) where substantial changes in water area due to water level regulation may occur. ([IPCC](#))

Respiration

The process whereby living organisms convert organic matter to carbon dioxide, releasing energy and consuming molecular oxygen. ([IPCC2](#))

Retro-commissioning

The systematic process to improve an existing building's performance ensuring the building controls are running efficiently and balancing the designed use and the actual use of the building.

Ride-share

The practice of sharing transportation in the form of carpooling or vanpooling. It is typically an arrangement made through a ride-matching service that connects drivers with riders.

S

Scope 1:

Scope 1 includes emissions being released within the city limits resulting from combustion of fossil fuels and from waste decomposition in the landfill and wastewater treatment plant.

Scope 2:

Scope 2 includes emissions produced outside the city that are induced by consumption of electrical energy within the city limits.

Scope 3:

Scope 3 includes emissions of potential policy relevance to local government operations that can be measured and reported but do not qualify as Scope 1 or 2. This includes, but is not limited to, outsourced operations and employee commute.

Short Ton

Common measurement for a ton in the United

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States. A short ton is equal to 2,000 lbs or 0.907 metric tons. ([USEPA1](#))

Sink

Any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere. ([IPCC2](#))

Social Cost of Carbon

The social cost of carbon is a measure of the economic harm from climate change impacts, expressed as the dollar value of the total damages from emitting one ton of carbon dioxide into the atmosphere.

Solar Radiation

Electromagnetic radiation emitted by the Sun. It is also referred to as shortwave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the Sun, peaking in visible wavelengths. ([IPCC2](#))

Solar Photovoltaic (PV)

Solar photovoltaic (PV) is a technology that converts sunlight directly into electricity using semiconducting materials, usually silicon. Solar PV can be used for homes, businesses, or at utility scale and fed into the electrical grid. Solar PV can be installed on rooftops, open land, or integrated into building materials for renewable energy production. ([NREL](#))

Source

Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere. ([IPCC2](#))

Stationary Sources

Non-mobile sources such as power plants, refineries, and manufacturing facilities which emit air pollutants. ([CARB](#))

Strategy / Strategic Goal

Specific statements of direction that expand on the sustainability vision and GHG reduction goals and guide decisions about future public policy, community investment, and actions.



Sulfur Dioxide (SO₂)

A compound composed of one sulfur and two oxygen molecules. Sulfur dioxide emitted into the atmosphere through natural and anthropogenic processes is changed in a complex series of chemical reactions in the atmosphere to sulfate aerosols. These aerosols are believed to result in negative radiative forcing (i.e., tending to cool the Earth's surface) and do result in acid deposition (e.g., acid rain). ([UNFCC](#))

Sulfur Hexafluoride (SF₆)

A colorless gas soluble in alcohol and ether, slightly soluble in water. A very powerful greenhouse gas with a global warming potential most recently estimated at 22,800 times that of carbon dioxide (CO₂). SF₆ is used primarily in electrical transmission and distribution systems and as a dielectric in electronics. This GWP is from the IPCC's Fourth Assessment Report (AR4).

T

Terrestrial Carbon Sequestration

It is the process through which carbon dioxide (CO₂) from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils. The term "sinks" is also used to refer to forests, croplands, and grazing lands, and their ability to sequester carbon. Agriculture and forestry activities can also release CO₂ to the atmosphere. Therefore, a carbon sink occurs when carbon sequestration is greater than carbon releases over some time period. ([USEPA3](#))

Therm:

A unit of measure for energy that is equivalent to 100,000 British Thermal units, or roughly the energy in 100 cubic feet of natural gas. Often used for measuring natural gas usage for billing purposes.

Total Organic Gases (TOG)

Gaseous organic compounds, including reactive organic gases and the relatively unreactive organic gases such as methane. ([CARB](#))

Transparency

Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported

information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information. ([IPCC](#))

Trend

The trend of a quantity measures its change over a time period, with a positive trend value indicating growth in the quantity, and a negative value indicating a decrease. It is defined as the ratio of the change in the quantity over the time period, divided by the initial value of the quantity, and is usually expressed either as a percentage or a fraction. ([IPCC](#))

U

Urban Tree Canopy

Describes the makeup and characteristics of trees within the urban environment.

V

VMT Vehicle Miles Traveled:

A unit used to measure vehicle travel made by private vehicles, including passenger vehicles, truck, vans and motorcycles. Each mile traveled is counted as one vehicle mile regardless of the number of persons in the vehicle.

Vision Zero:

Vision Zero is a strategy to eliminate all traffic fatalities and severe injuries, while increasing safe, healthy, equitable mobility for all. <https://visionzeronetwork.org/>

Vulnerability

The degree to which a system is susceptible to or unable to cope with, adverse effects of climate change. Vulnerability consists of the following:

- Exposure: The presence of people, ecosystems, or assets in places and settings that could be adversely affected by climate change impacts
- Sensitivity: The degree to which people, ecosystems, or assets are affected by climate change
- Adaptive capacity: The ability of assets, systems or people to adjust to an adverse impact

W

Water Vapor

The most abundant greenhouse gas; it is the water present in the atmosphere in gaseous form. Water vapor is an important part of the natural greenhouse



effect. While humans are not significantly increasing its concentration, it contributes to the enhanced greenhouse effect because the warming influence of greenhouse gases leads to a positive water vapor feedback. In addition to its role as a natural greenhouse gas, water vapor plays an important role in regulating the temperature of the planet because clouds form when excess water vapor in the atmosphere condenses to form ice and water droplets and precipitation. ([UNFCC](#))

Weather

Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. A simple way of remembering the difference is that climate is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard). ([USEPA1](#))

Z

Zero Emission Vehicles (ZEV)

A vehicle that does not emit harmful emissions during operation. Harmful emissions can have a negative impact on human health and the environment. Electric (battery-powered) cars, electric trains, hydrogen-fueled vehicles, bicycles, and carriages are considered to produce zero emissions.

Zero Waste

The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health.

Section A3

Appendix 3 FEMA National Risk Index Report for Community



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National Risk Index



August 16, 2023

Census tract 55025010702, Dane County, Wisconsin

Summary

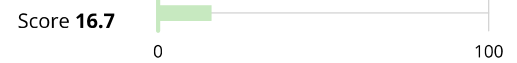
Risk Index is **Relatively Low**



Expected Annual Loss is **Relatively Moderate**



Social Vulnerability is **Very Low**



Community Resilience is **Very High**



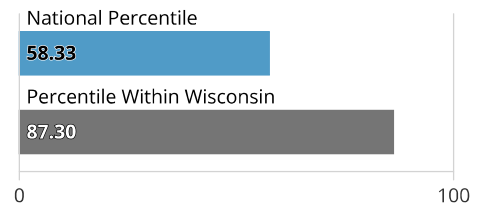
While reviewing this report, keep in mind that low risk is driven by lower loss due to natural hazards, lower social vulnerability, and higher community resilience.

For more information about the National Risk Index, its data, and how to interpret the information it provides, please review the **About the National Risk Index** and **How to Take Action** sections at the end of this report. Or, visit the National Risk Index website at hazards.fema.gov/nri/learn-more to access supporting documentation and links.

Risk Index

The Risk Index rating is **Relatively Low** for **Census tract 55025010702** when compared to the rest of the U.S.

Score **58.33**



58% of U.S. Census tracts have a lower Risk Index

87% of Census tracts in Wisconsin have a lower Risk Index

Risk Index Legend

- Very High
- Relatively High
- Relatively Moderate
- Relatively Low
- Very Low
- No Rating
- Not Applicable
- Insufficient Data

Hazard Type Risk Index

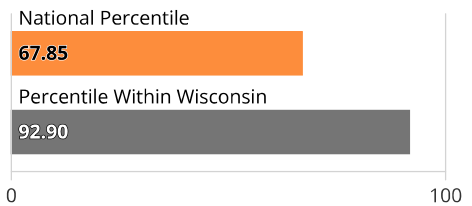
Hazard type Risk Index scores are calculated using data for only a single hazard type, and reflect a community's Expected Annual Loss value, community risk factors, and the adjustment factor used to calculate the risk value.

Hazard Type	EAL Value	Social Vulnerability	Community Resilience	CRF	Risk Value	Score
Tornado	\$343,505	Very Low	Very High	0.84	\$288,896	84.9
Hail	\$163,988	Very Low	Very High	0.84	\$137,918	94.7
Heat Wave	\$63,009	Very Low	Very High	0.84	\$52,992	83.7
Strong Wind	\$54,169	Very Low	Very High	0.84	\$45,558	82.4
Ice Storm	\$45,108	Very Low	Very High	0.84	\$37,937	92.3
Cold Wave	\$41,240	Very Low	Very High	0.84	\$34,684	91.5
Winter Weather	\$28,606	Very Low	Very High	0.84	\$24,058	94.5
Lightning	\$21,055	Very Low	Very High	0.84	\$17,708	80.3
Riverine Flooding	\$20,358	Very Low	Very High	0.84	\$17,122	61.3
Wildfire	\$9,639	Very Low	Very High	0.84	\$8,107	82.9
Earthquake	\$6,601	Very Low	Very High	0.84	\$5,552	32.4
Landslide	\$3,255	Very Low	Very High	0.84	\$2,738	81.3
Hurricane	\$1,404	Very Low	Very High	0.84	\$1,181	18.4
Drought	\$74	Very Low	Very High	0.84	\$63	75
Avalanche	--	Very Low	Very High	0.84	--	--
Coastal Flooding	--	Very Low	Very High	0.84	--	--
Tsunami	--	Very Low	Very High	0.84	--	--
Volcanic Activity	--	Very Low	Very High	0.84	--	--

Expected Annual Loss

In **Census tract 55025010702**, expected loss each year due to natural hazards is **Relatively Moderate** when compared to the rest of the U.S.

Score **67.85**



68% of U.S. Census tracts have a lower Expected Annual Loss

93% of Census tracts in Wisconsin have a lower Expected Annual Loss

Expected Annual Loss Legend

- Very High
- Relatively High
- Relatively Moderate
- Relatively Low
- Very Low

No Expected Annual Losses Not Applicable Insufficient Data

Composite Expected Annual Loss **\$802,010.92**

Composite Expected Annual Loss Rate National Percentile **21.4**

Building EAL	\$433,195.86	Population EAL	0.03 fatalities
Building EAL Rate	\$1 per \$5.63K of building value	Population EAL Rate	1 per 296.87K people
Agriculture EAL	\$14,058.90	Population Equivalence EAL	\$354,756.16
Agriculture EAL Rate	\$1 per \$872.57 of agriculture value		

Expected Annual Loss for Hazard Types

Expected Annual Loss scores for hazard types are calculated using data for only a single hazard type, and reflect a community's relative expected annual loss for only that hazard type. **14 of 18** hazard types contribute to the expected annual loss for **Census tract 55025010702**.

Hazard Type	Expected Annual Loss Rating	EAL Value	Score
Tornado	Relatively High	\$343,505	92.0
Hail	Relatively High	\$163,988	96.1
Heat Wave	Relatively High	\$63,009	89.0
Strong Wind	Relatively High	\$54,169	87.2
Ice Storm	Relatively High	\$45,108	94.3
Cold Wave	Relatively High	\$41,240	93.7
Winter Weather	Relatively High	\$28,606	96.2
Lightning	Relatively High	\$21,055	87.7
Riverine Flooding	Relatively Low	\$20,358	64.9
Wildfire	Relatively Low	\$9,639	84.1
Earthquake	Very Low	\$6,601	37.3
Landslide	Relatively Moderate	\$3,255	85.1
Hurricane	Very Low	\$1,404	20.3
Drought	Very Low	\$74	75.9
Avalanche	Not Applicable	--	--
Coastal Flooding	Not Applicable	--	--
Tsunami	Not Applicable	--	--
Volcanic Activity	Not Applicable	--	--

Expected Annual Loss Values

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Avalanche	--	--	--	--	--
Coastal Flooding	--	--	--	--	--
Cold Wave	\$41,240	\$70	\$38,601	0.00	\$2,568
Drought	\$74	n/a	n/a	n/a	\$74
Earthquake	\$6,601	\$5,701	\$901	0.00	n/a
Hail	\$163,988	\$155,145	\$8,661	0.00	\$182
Heat Wave	\$63,009	\$311	\$62,069	0.01	\$629
Hurricane	\$1,404	\$1,293	\$5	0.00	\$106
Ice Storm	\$45,108	\$4,499	\$40,609	0.00	n/a
Landslide	\$3,255	\$2,857	\$398	0.00	n/a
Lightning	\$21,055	\$4,952	\$16,103	0.00	n/a
Riverine Flooding	\$20,358	\$10,081	\$781	0.00	\$9,496
Strong Wind	\$54,169	\$25,915	\$27,672	0.00	\$582
Tornado	\$343,505	\$212,614	\$130,523	0.01	\$368
Tsunami	--	--	--	--	--
Volcanic Activity	--	--	--	--	--
Wildfire	\$9,639	\$8,994	\$645	0.00	\$0
Winter Weather	\$28,606	\$764	\$27,789	0.00	\$53

Exposure Values

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Avalanche	--	--	--	--	--
Coastal Flooding	--	--	--	--	--
Cold Wave	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380
Drought	\$3,862,659	n/a	n/a	n/a	\$3,862,659
Earthquake	\$107,753,610,000	\$2,437,210,000	\$105,316,400,000	9,079.00	n/a
Hail	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380
Heat Wave	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380
Hurricane	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380
Ice Storm	\$107,753,625,556	\$2,437,225,556	\$105,316,400,000	9,079.00	n/a
Landslide	\$40,086,415,342	\$806,766,219	\$39,279,649,123	3,386.18	n/a
Lightning	\$107,753,625,556	\$2,437,225,556	\$105,316,400,000	9,079.00	n/a
Riverine Flooding	\$162,240,770	\$3,291,429	\$158,642,442	13.68	\$306,898
Strong Wind	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380
Tornado	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380
Tsunami	--	--	--	--	--
Volcanic Activity	--	--	--	--	--
Wildfire	\$7,728,146,019	\$166,555,830	\$7,560,625,014	651.78	\$965,174
Winter Weather	\$107,765,892,936	\$2,437,225,556	\$105,316,400,000	9,079.00	\$12,267,380

Annualized Frequency Values

Hazard Type	Annualized Frequency	Events on Record	Period of Record
Avalanche	--	--	--
Coastal Flooding	--	--	--
Cold Wave	0.6 events per year	9	2005-2021 (16 years)
Drought	1.6 events per year	35	2000-2021 (22 years)
Earthquake	0.014% chance per year	n/a	2021 dataset
Hail	3.8 events per year	130	1986-2021 (34 years)
Heat Wave	0.9 events per year	15	2005-2021 (16 years)
Hurricane	0 events per year	0	East 1851-2021 (171 years) / West 1949-2021 (73 years)
Ice Storm	0.7 events per year	50	1946-2014 (67 years)
Landslide	0 events per year	0	2010-2021 (12 years)
Lightning	39.9 events per year	879	1991-2012 (22 years)
Riverine Flooding	2.3 events per year	55	1996-2019 (24 years)
Strong Wind	4.7 events per year	160	1986-2021 (34 years)
Tornado	0 events per year	3	1950-2021 (72 years)
Tsunami	--	--	--
Volcanic Activity	--	--	--
Wildfire	0.015% chance per year	n/a	2021 dataset
Winter Weather	3.7 events per year	60	2005-2021 (16 years)

Historic Loss Ratios

Hazard Type	Overall Rating
Avalanche	--
Coastal Flooding	--
Cold Wave	Relatively Low
Drought	Very Low
Earthquake	Very Low
Hail	Relatively Moderate
Heat Wave	Relatively Moderate
Hurricane	Very Low
Ice Storm	Relatively Moderate
Landslide	Very Low
Lightning	Relatively Moderate
Riverine Flooding	Relatively Moderate
Strong Wind	Relatively Low
Tornado	Very Low
Tsunami	--
Volcanic Activity	--
Wildfire	Relatively Low
Winter Weather	Relatively Moderate

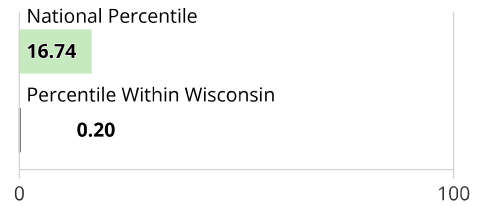
Expected Annual Loss Rate

Hazard Type	Building EAL Rate (per building value)	Population EAL Rate (per population)	Agriculture EAL Rate (per agriculture value)
Avalanche	--	--	--
Coastal Flooding	--	--	--
Cold Wave	\$1 per \$34.58M	1 per 2.73M	\$1 per \$4.78K
Drought	--	--	\$1 per \$164.98K
Earthquake	\$1 per \$427.55K	1 per 116.94M	--
Hail	\$1 per \$15.71K	1 per 12.16M	\$1 per \$67.49K
Heat Wave	\$1 per \$7.84M	1 per 1.70M	\$1 per \$19.50K
Hurricane	\$1 per \$1.88M	1 per 23.36B	\$1 per \$115.56K
Ice Storm	\$1 per \$541.79K	1 per 2.59M	--
Landslide	\$1 per \$853.00K	1 per 264.70M	--
Lightning	\$1 per \$492.18K	1 per 6.54M	--
Riverine Flooding	\$1 per \$241.76K	1 per 134.93M	\$1 per \$1.29K
Strong Wind	\$1 per \$94.05K	1 per 3.81M	\$1 per \$21.07K
Tornado	\$1 per \$11.46K	1 per 806.88K	\$1 per \$33.31K
Tsunami	--	--	--
Volcanic Activity	--	--	--
Wildfire	\$1 per \$270.98K	1 per 163.33M	\$1 per \$2.03B
Winter Weather	\$1 per \$3.19M	1 per 3.79M	\$1 per \$232.55K

Social Vulnerability

Social groups in **Census tract 55025010702** have a **Very Low** susceptibility to the adverse impacts of natural hazards when compared to the rest of the U.S.

Score **16.74**



17% of U.S. Census tracts have a lower Social Vulnerability

0% of Census tracts in Wisconsin have a lower Social Vulnerability

Social Vulnerability Legend

- Very High
- Relatively High
- Relatively Moderate
- Relatively Low
- Very Low
- Data Unavailable

Community Resilience

Communities in **Census tract 55025010702** have a **Very High** ability to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions when compared to the rest of the U.S.



Score **97.11**



3% of U.S. Census tracts have a higher Community Resilience

99% of Census tracts in Wisconsin have a higher Community Resilience

Community Resilience Legend

- Very High
- Relatively High
- Relatively Moderate
- Relatively Low
- Very Low
- Data Unavailable

About the National Risk Index

The National Risk Index is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards: Avalanche, Coastal Flooding, Cold Wave, Drought, Earthquake, Hail, Heat Wave, Hurricane, Ice Storm, Landslide, Lightning, Riverine Flooding, Strong Wind, Tornado, Tsunami, Volcanic Activity, Wildfire, and Winter Weather.

The National Risk Index leverages available source data for Expected Annual Loss due to these 18 hazard types, Social Vulnerability, and Community Resilience to develop a baseline relative risk measurement for each United States county and Census tract. These measurements are calculated using average past conditions, but they cannot be used to predict future outcomes for a community. The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

Explore the National Risk Index Map at hazards.fema.gov/nri/map.

Visit the National Risk Index website at hazards.fema.gov/nri/learn-more to access supporting documentation and links.

Calculating the Risk Index

Risk Index scores are calculated using an equation that combines scores for Expected Annual Loss due to natural hazards, Social Vulnerability and Community Resilience:

$$\text{Risk Index} = \text{Expected Annual Loss} \times \text{Social Vulnerability} \div \text{Community Resilience}$$

Risk Index scores are presented as a composite score for all 18 hazard types, as well as individual scores for each hazard type.

For more information, visit hazards.fema.gov/nri/determining-risk.

Calculating Expected Annual Loss

Expected Annual Loss scores are calculated using an equation that combines values for exposure, annualized frequency, and historic loss ratios for 18 hazard types:

$$\text{Expected Annual Loss} = \text{Exposure} \times \text{Annualized Frequency} \times \text{Historic Loss Ratio}$$

Expected Annual Loss scores are presented as a composite score for all 18 hazard types, as well as individual scores for each hazard type.

For more information, visit hazards.fema.gov/nri/expected-annual-loss.

Calculating Social Vulnerability

Social Vulnerability is measured using the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC).

For more information, visit hazards.fema.gov/nri/social-vulnerability.

Calculating Community Resilience

Community Resilience is measured using the Baseline Resilience Indicators for Communities (HVRI BRIC) published by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI).

For more information, visit hazards.fema.gov/nri/community-resilience.

How to Take Action

There are many ways to reduce natural hazard risk through mitigation. Communities with high National Risk Index scores can take action to reduce risk by decreasing Expected Annual Loss due to natural hazards, decreasing Social Vulnerability, and increasing Community Resilience.

For information about how to take action and reduce your risk, visit hazards.fema.gov/nri/take-action.

Disclaimer

The National Risk Index (the Risk Index or the Index) and its associated data are meant for planning purposes only. This tool was created for broad nationwide comparisons and is not a substitute for localized risk assessment analysis. Nationwide datasets used as inputs for the National Risk Index are, in many cases, not as accurate as available local data. Users with access to local data for each National Risk Index risk factor should consider substituting the Risk Index data with local data to recalculate a more accurate risk index. If you decide to download the National Risk Index data and substitute it with local data, you assume responsibility for the accuracy of the data and any resulting data index. Please visit the [Contact Us](#) page if you would like to discuss this process further.

The methodology used by the National Risk Index has been reviewed by subject matter experts in the fields of natural hazard risk research, risk analysis, mitigation planning, and emergency management. The processing methods used to create the National Risk Index have produced results similar to those from other natural hazard risk analyses conducted on a smaller scale. The breadth and combination of geographic information systems (GIS) and data processing techniques leveraged by the National Risk Index enable it to incorporate multiple hazard types and risk factors, manage its nationwide scope, and capture what might have been missed using other methods.

The National Risk Index does not consider the intricate economic and physical interdependencies that exist across geographic regions. Keep in mind that hazard impacts in surrounding counties or Census tracts can cause indirect losses in your community regardless of your community's risk profile.

Nationwide data available for some risk factors are rudimentary at this time. The National Risk Index will be continuously updated as new data become available and improved methodologies are identified.

The National Risk Index Contact Us page is available at hazards.fema.gov/nri/contact-us.

Section A4

Appendix 4 References



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City of Fitchburg Climate Vulnerability Assessment

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Section A5

Appendix 5 Reference Map

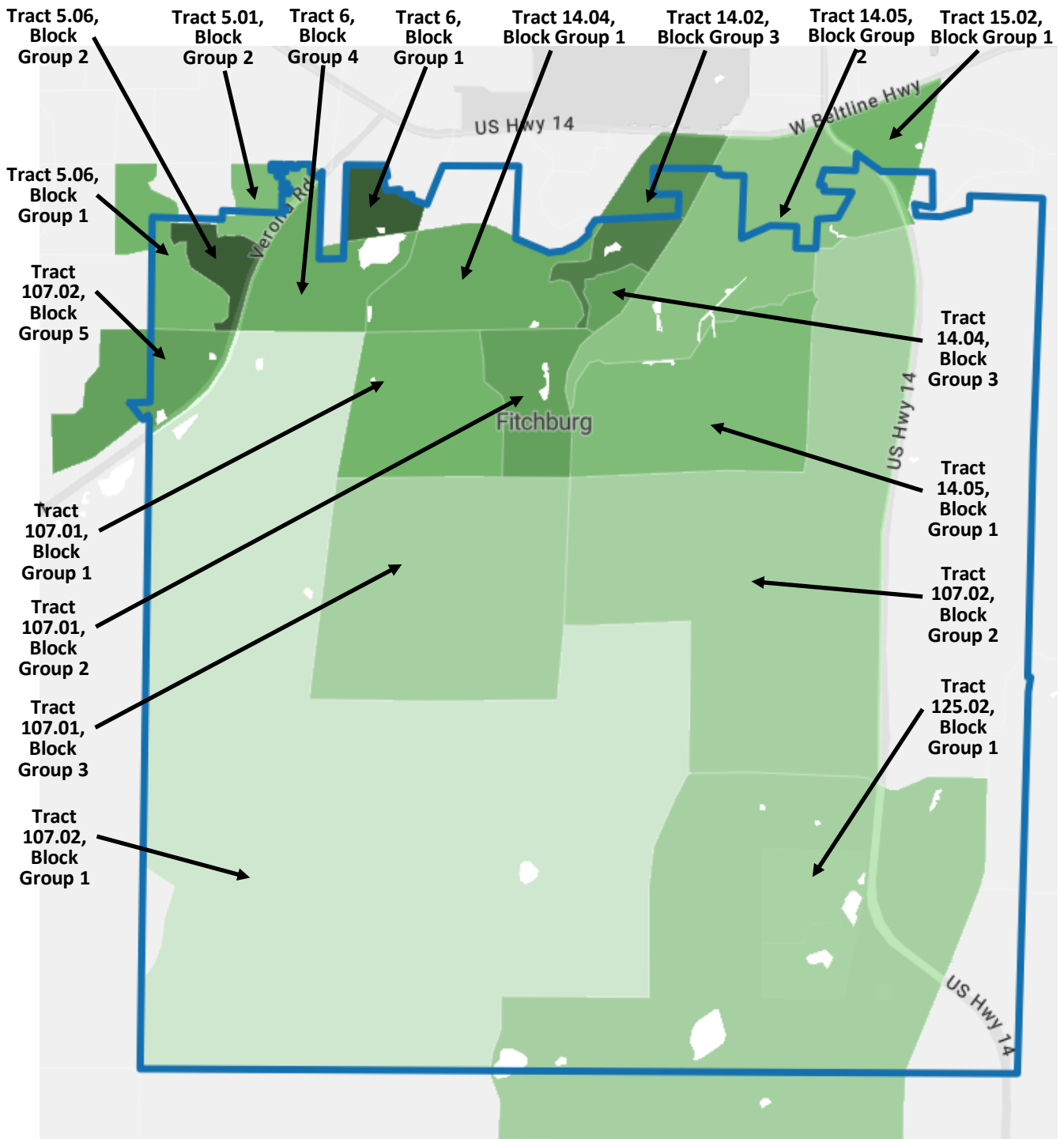


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City of Fitchburg Reference Map

This assessment includes population data or maps at the Census Tract or Block Group level, as needed to relate to relevant US Census Bureau data. Census boundaries may differ from actual community boundaries. All areas within the official community boundaries are included in the plan this Baseline Document supports, even if not shown on a map. Other assessments might use data at the Census "Place" or city boundary level, leading to differences in reported population counts due to Census boundary variations.

The map on this page indicates census areas which may be referenced in this report. City boundary and census area boundaries are based on 2020 US Census.





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