SMALL TOWN & RURAL ISSUES -

People, Trees, and Power:
Tools and Strategies for Advancing Community Resilience

paleBLUEdot LLC

Agenda

Introduction

What is Resilience

Anticipating Climate Change

Practical Ways For Planners To Advance Resilience

Case Studies

mission:

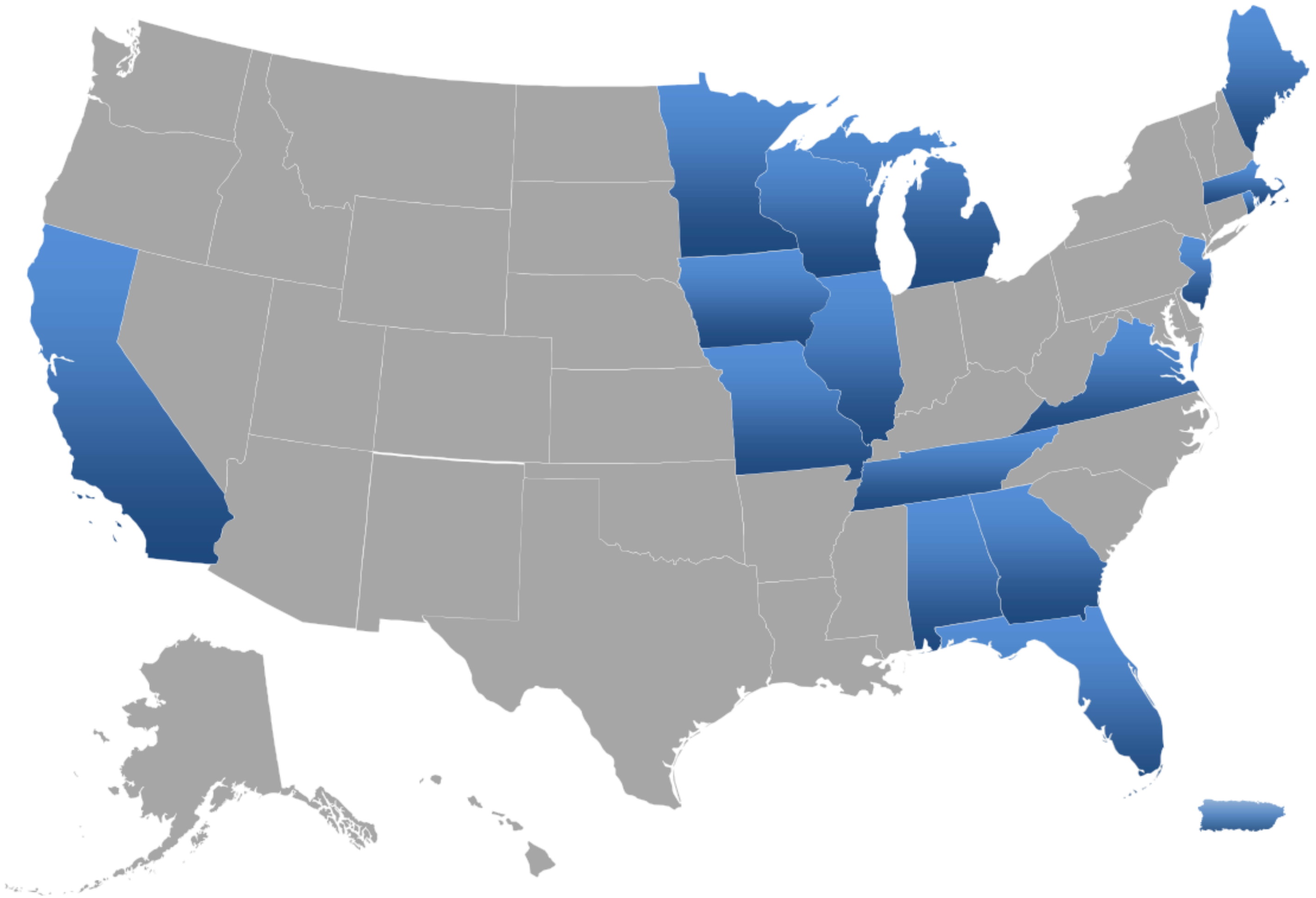
To hasten the transition to an authentically sustainable, no carbon economy and to elevate the public discourse

paleBLUEdot Certifications/Affiliations

climate

sustainability + resilience

renewable energy



What is Resilience

Resilience

…is the ability to **anticipate risk**, limit impact, and **“bounce back” rapidly** through survival, adaptation, evolution, and growth in the face of **turbulent change**.

Resilience ≠ Hazard Mitigation

Resilience planning goes beyond traditional hazard mitigation or emergency management in that it explores and addresses the **underlying causes to the vulnerabilities** to hazards

What is Resilience

Community Stressors

A community stressor is an event that negatively impacts a community physically, emotionally, or economically. Stressors differ by communities, but examples include:

Source: Department of Energy

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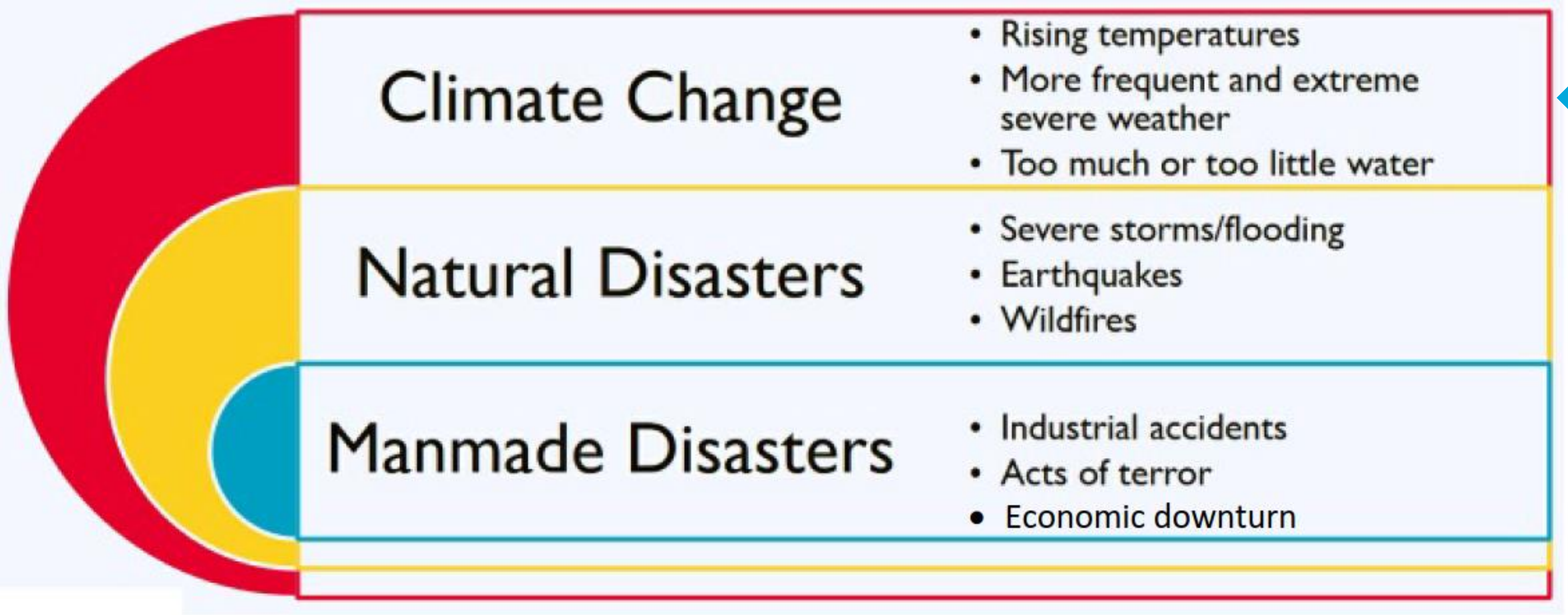
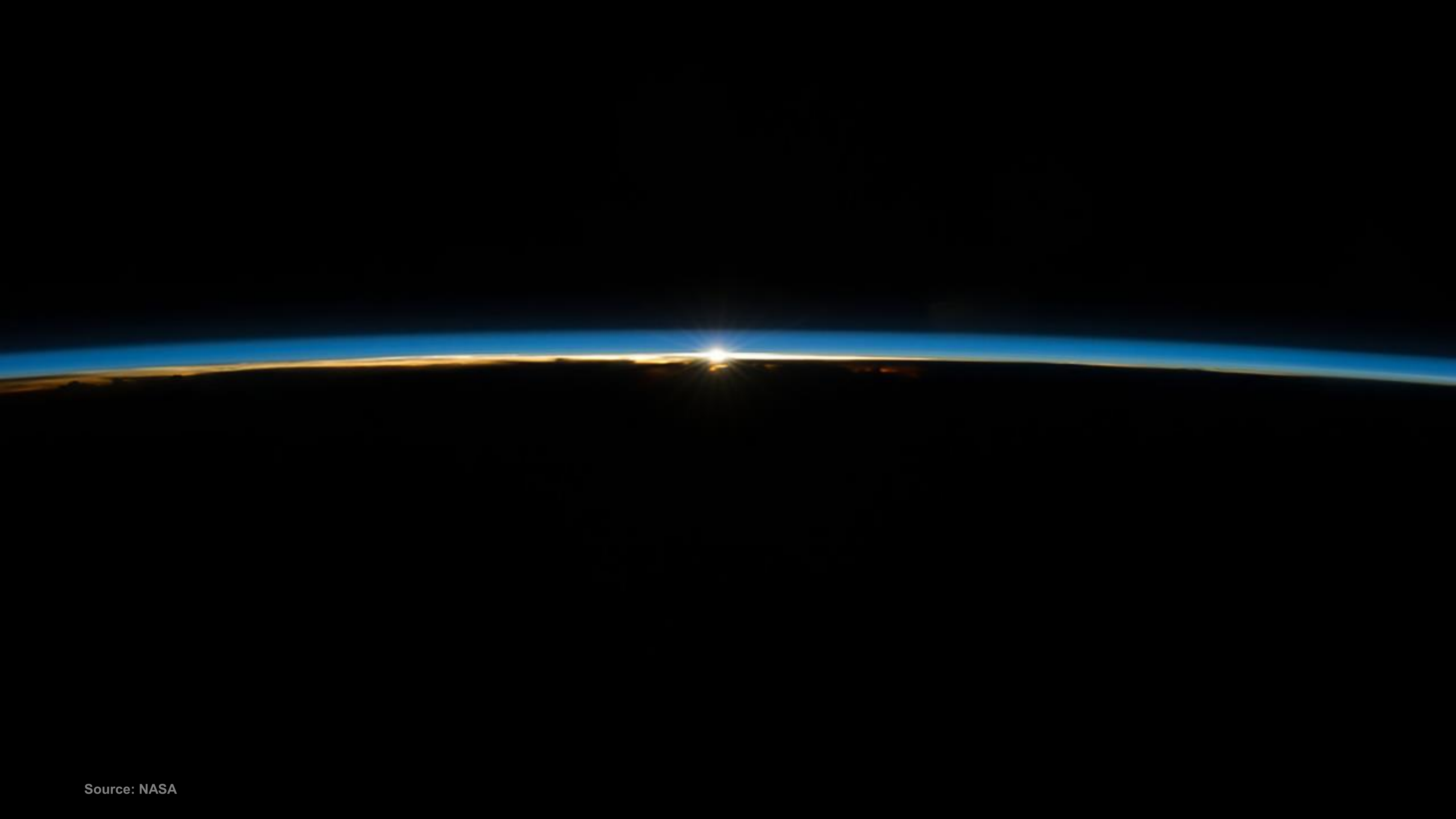


Source: Department of Energy

Typically Missing in Haz Mitigation and Comp Plans

Anticipating Climate Change



Source: NASA

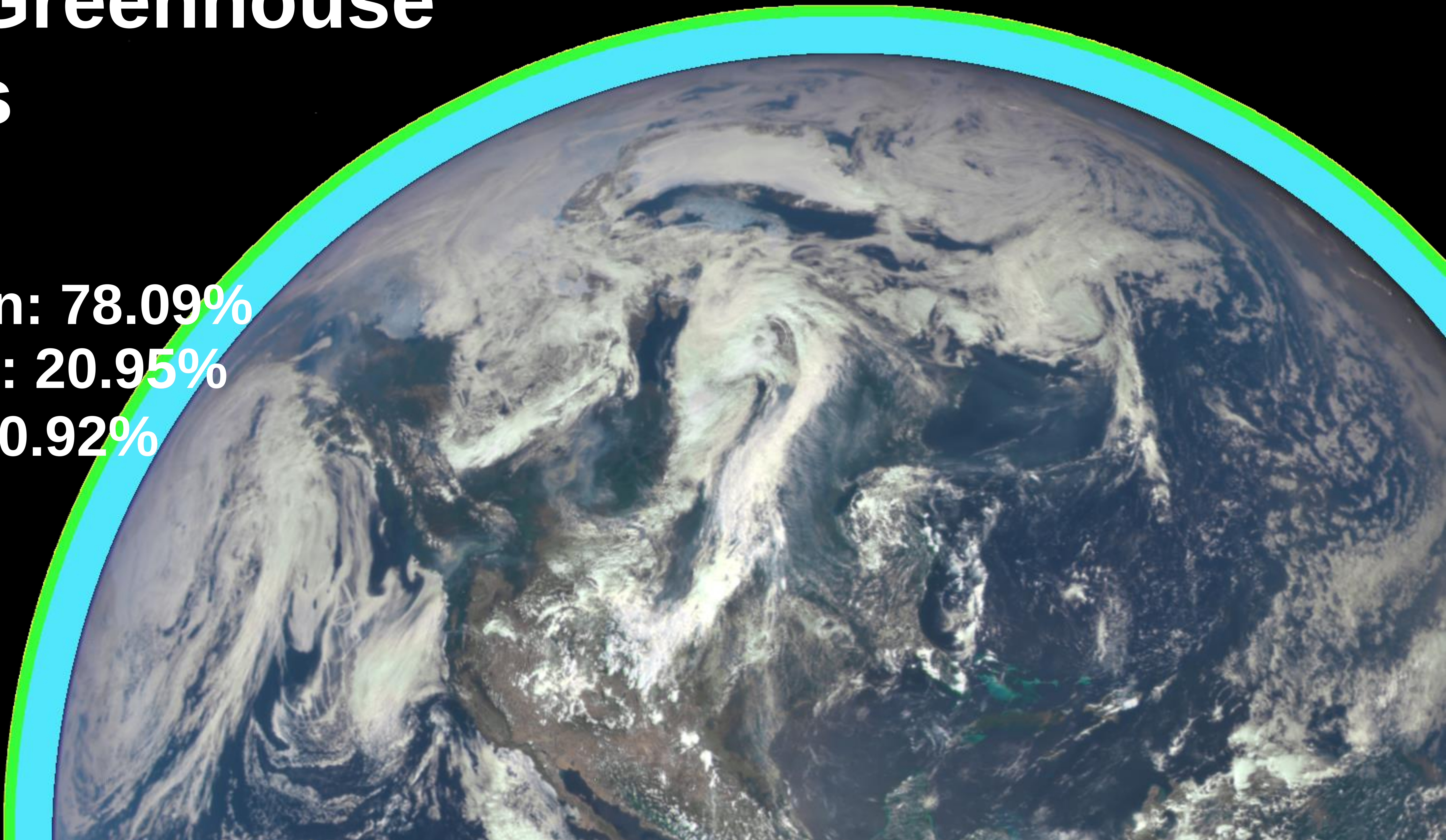
The role of “Greenhouse gases”

Our atmosphere is made up of both Greenhouse Gases and non-greenhouse gases

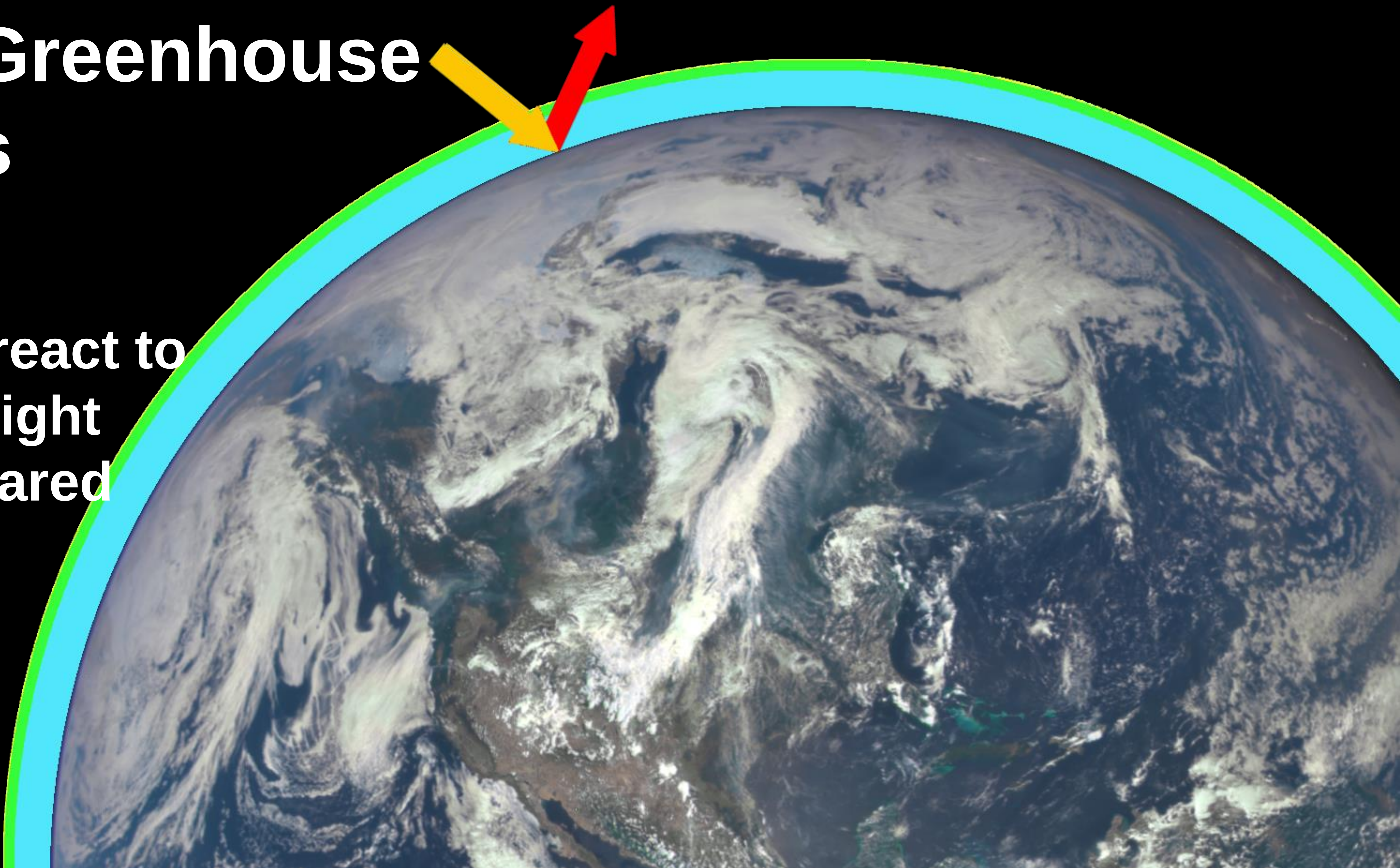
Non-Greenhouse gases

Nitrogen: 78.09%
Oxygen: 20.95%
Argon: 0.92%

99.96%

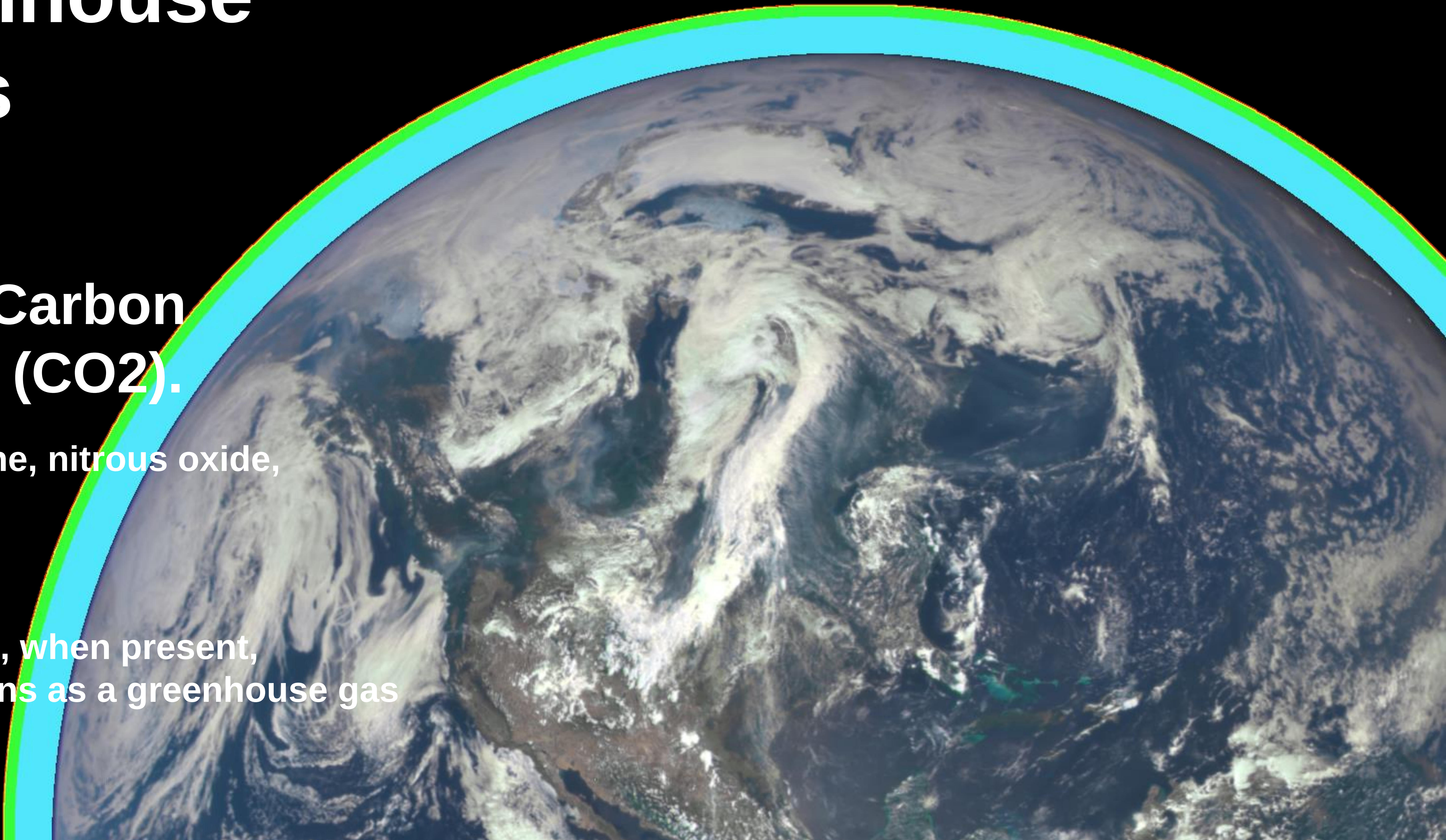


Non-Greenhouse gases



Do not react to visible light Nor Infrared energy.

Greenhouse gases



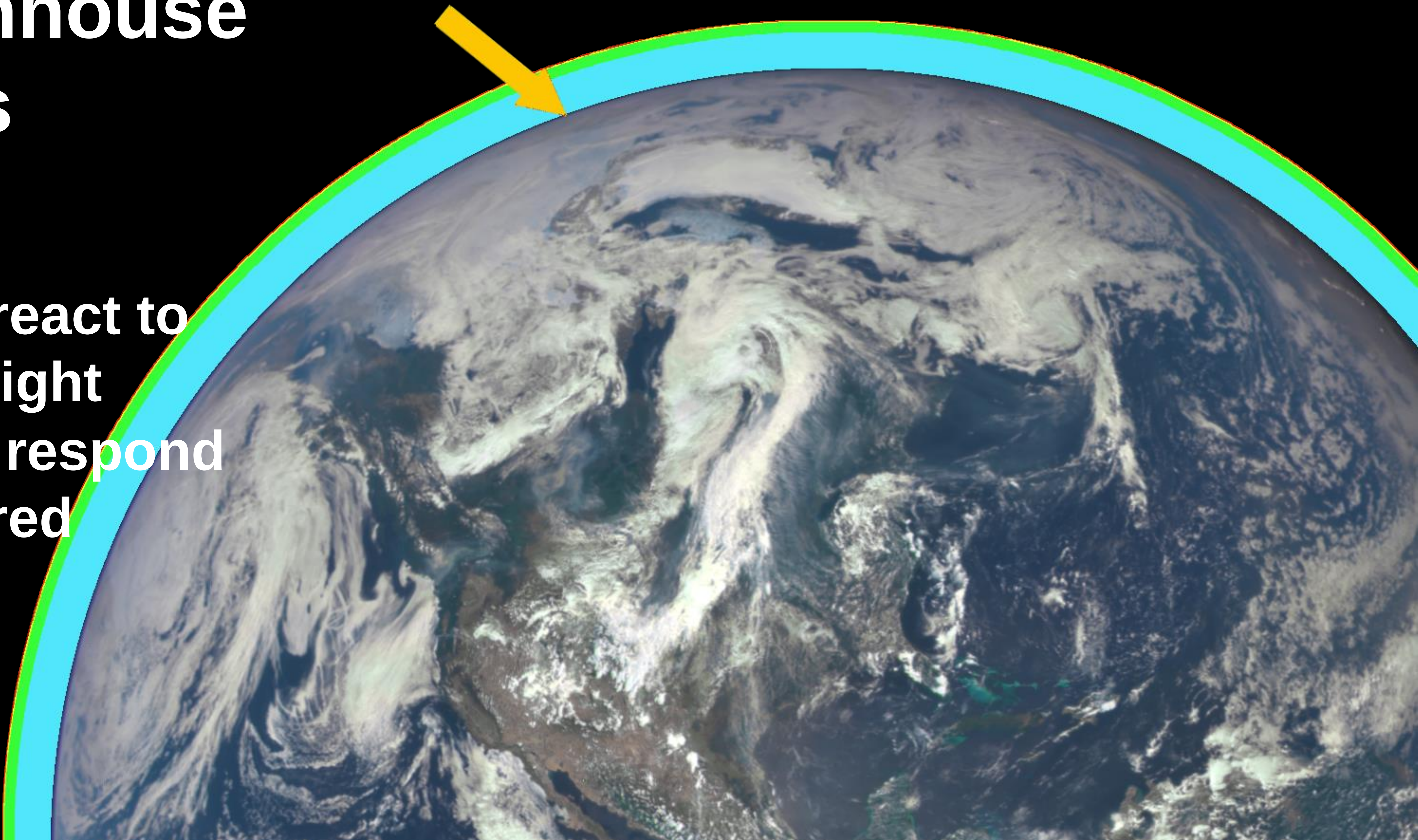
Mostly Carbon Dioxide (CO_2).

Also methane, nitrous oxide,
And Ozone.

0.04%

Water Vapor, when present,
Also functions as a greenhouse gas

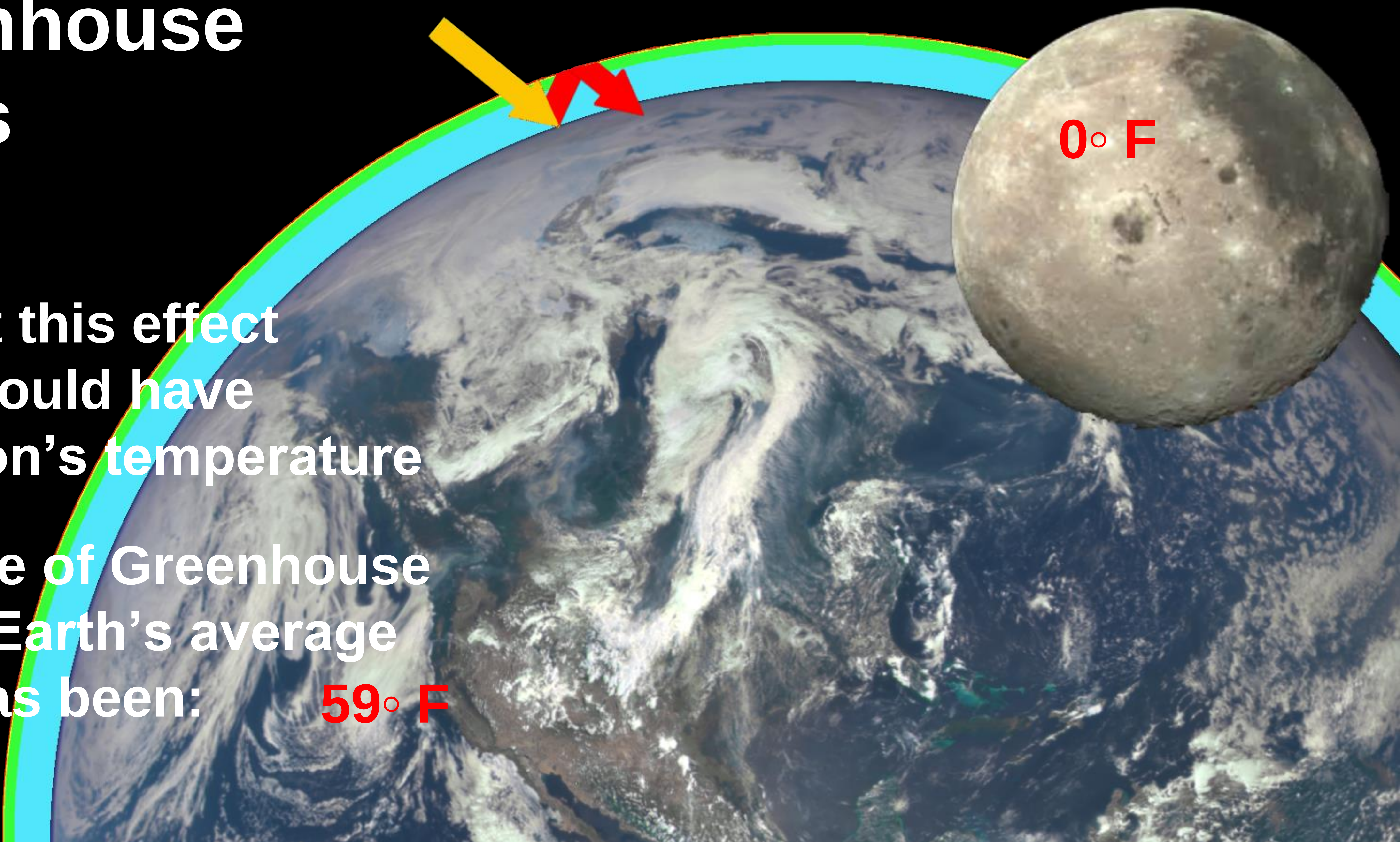
Greenhouse gases



Do not react to visible light
But DO respond to Infrared energy.

Greenhouse gases

Without this effect Earth would have the Moon's temperature



Because of Greenhouse gases, Earth's average temp has been: 59° F

How can 0.04% make a difference?

Source: NASA

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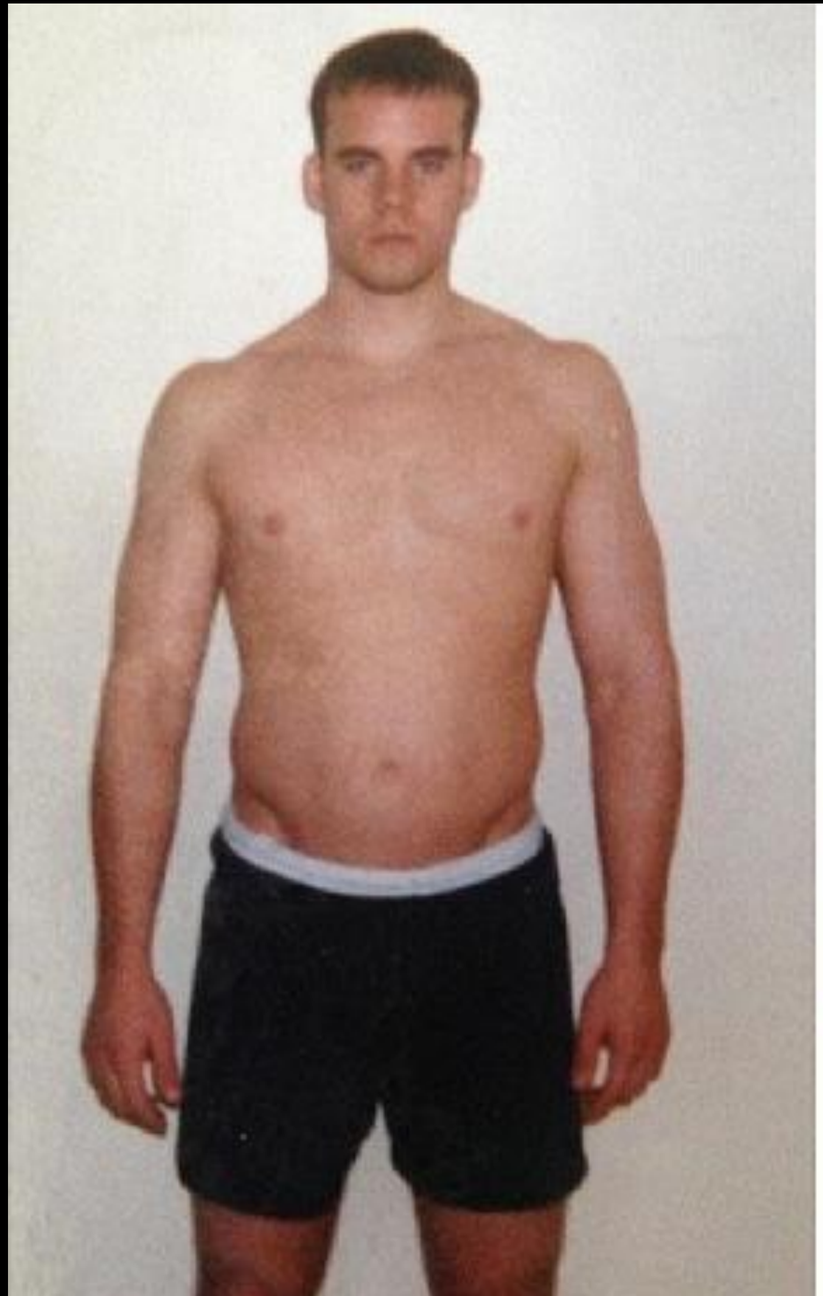


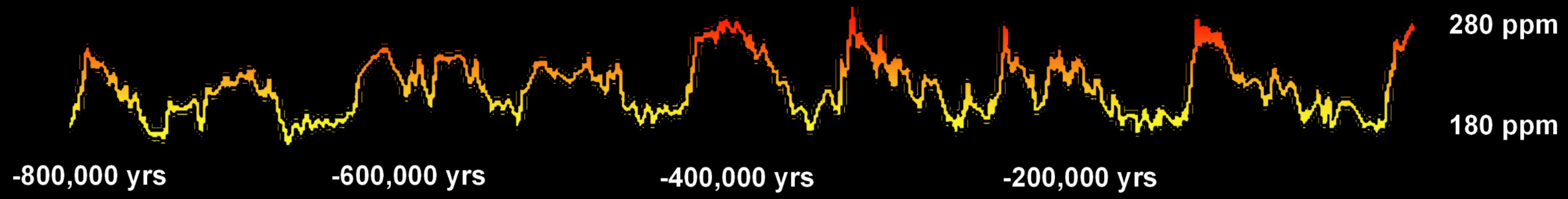
Source: NASA

CO_2 is being released into the atmosphere faster than at any time in at least the last 66 million years.

Source: RE Zeebe, et al., *Nature Geoscience*, March 2016

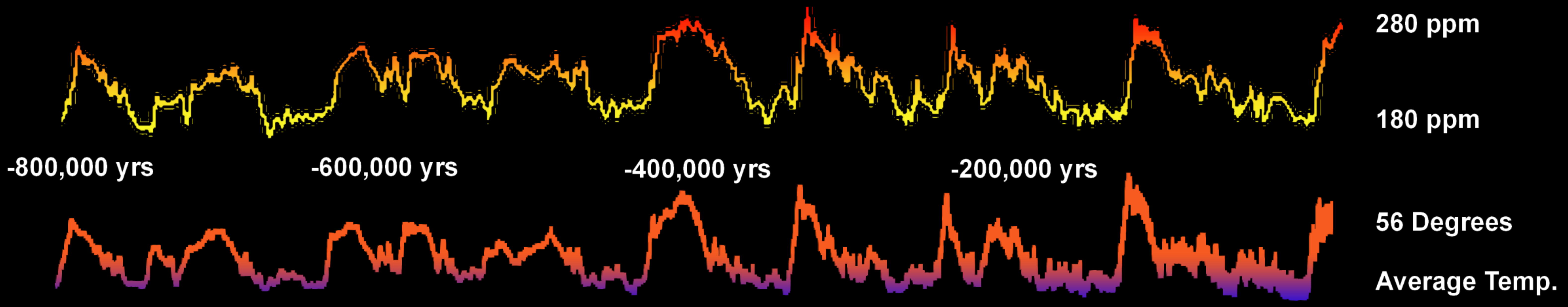
The Carbon Cycle

Though it naturally fluctuates - it has remained balanced with CO2 levels between 180 to 280 ppm



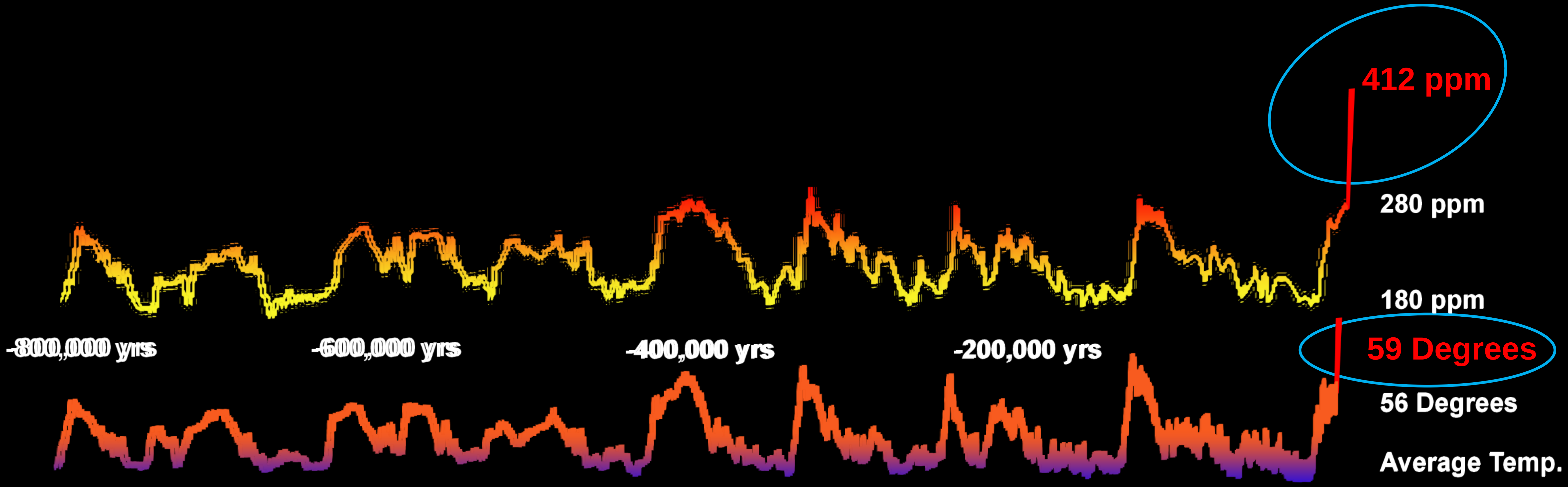
The Carbon Cycle

Global CO2 levels and temperature have been closely related for over 800,000 years.



The Carbon Cycle

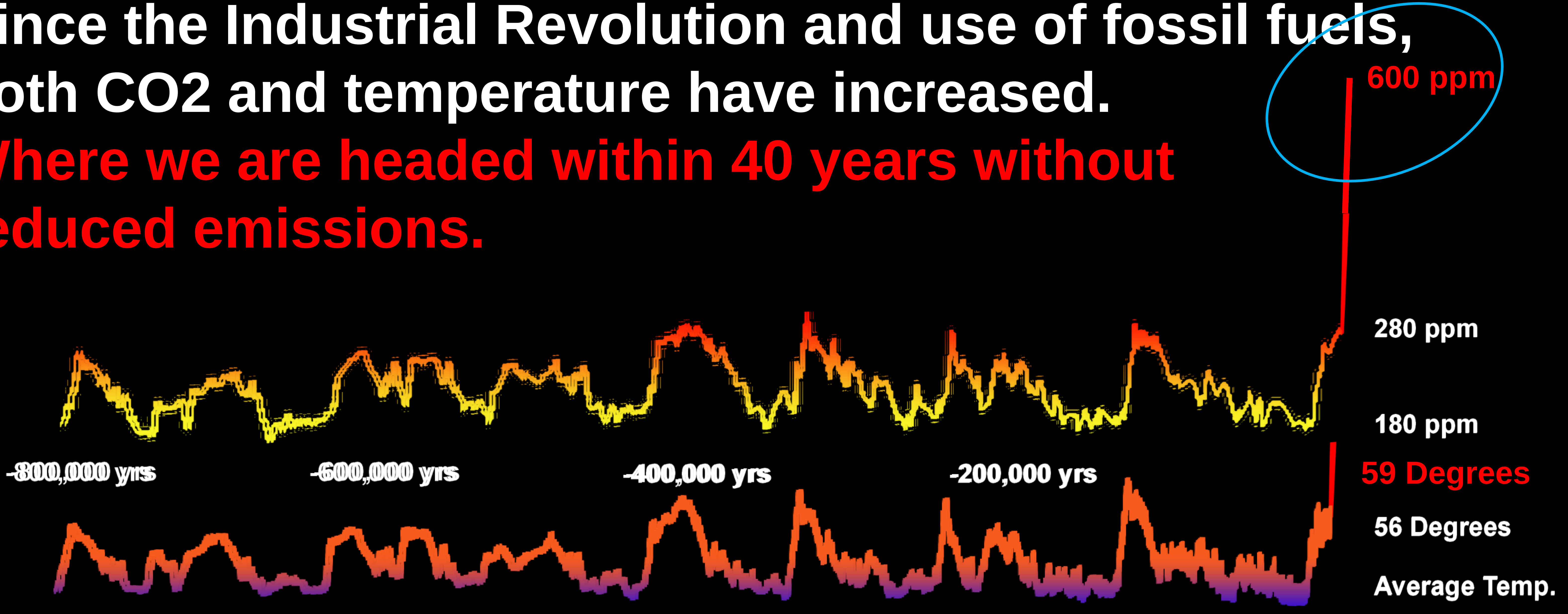
Since the Industrial Revolution and use of fossil fuels, both CO2 and temperature have increased.



The Carbon Cycle

Since the Industrial Revolution and use of fossil fuels, both CO2 and temperature have increased.

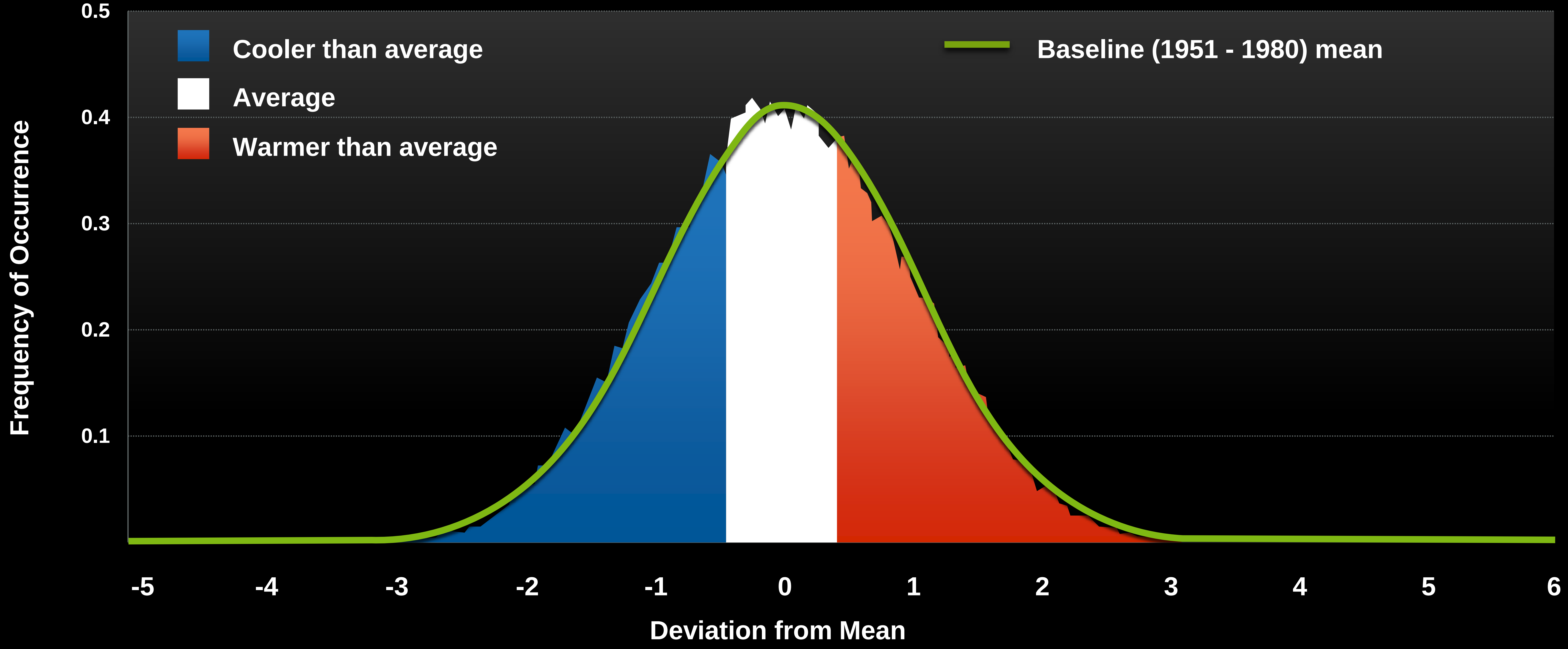
Where we are headed within 40 years without reduced emissions.




What...“Climate Change” have we already experienced?
Source: NASA

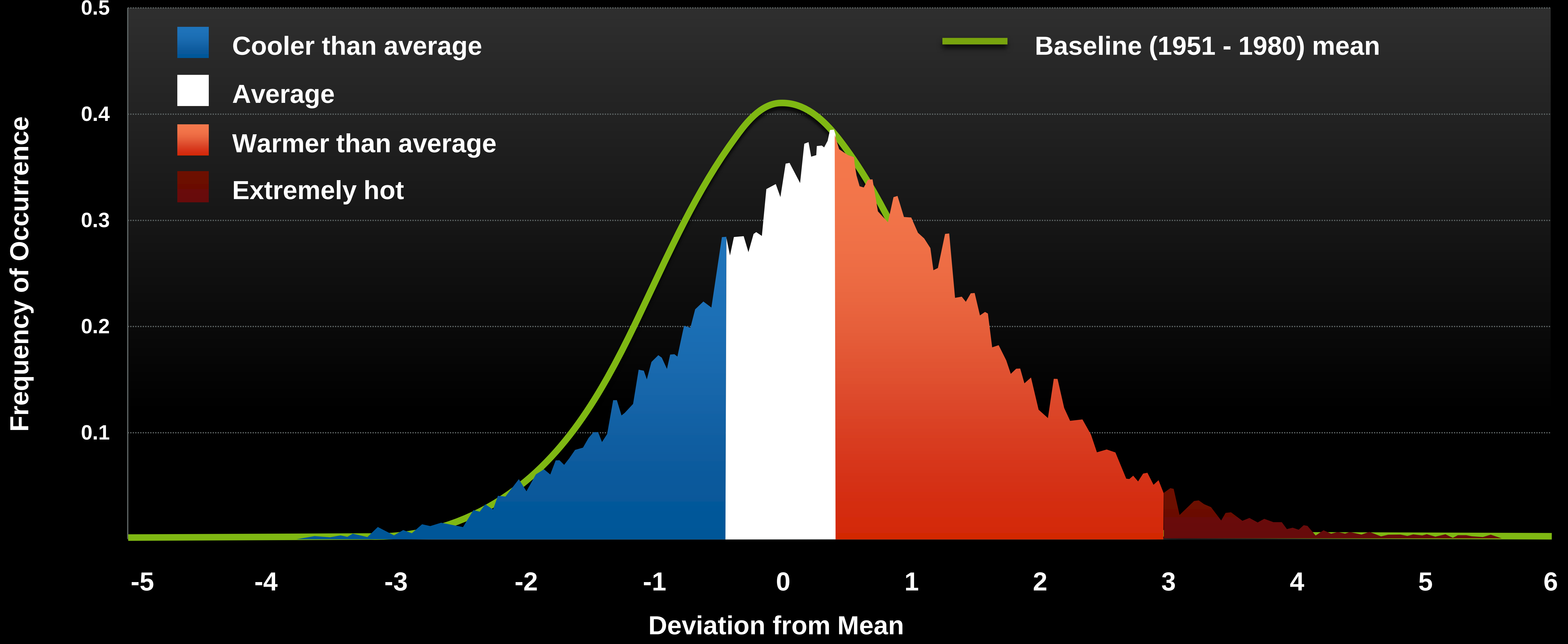
Summer Temperatures Have Shifted

1951 – 1980



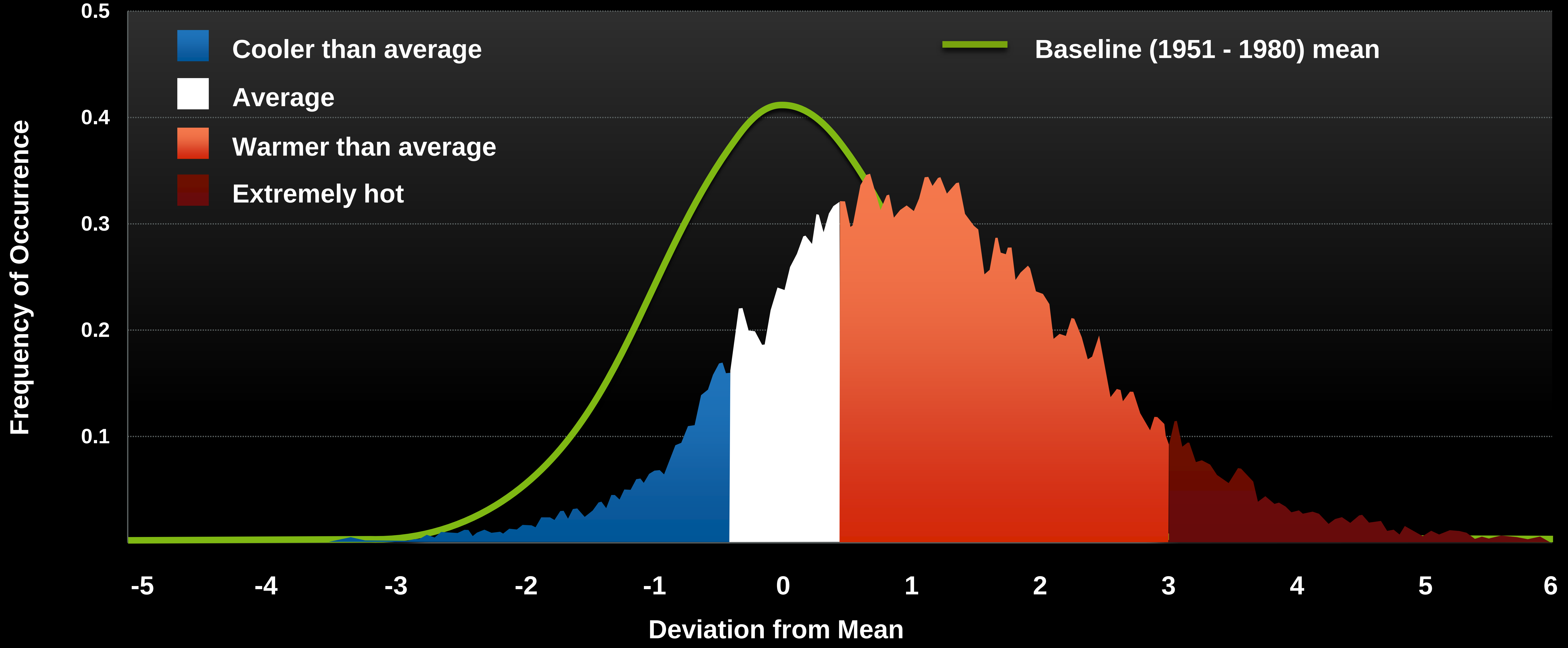
Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012 – Updated 2016

1983 – 1993



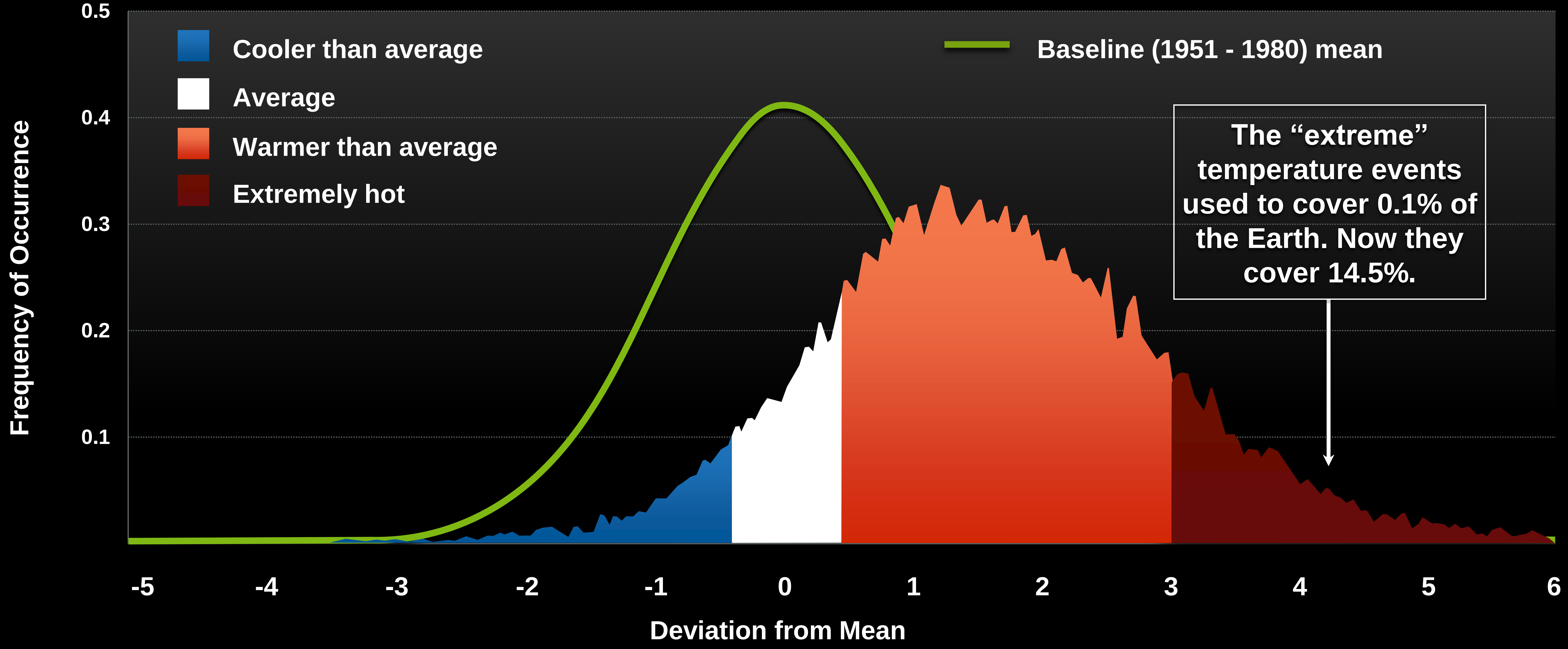
Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012 – Updated 2016

1994 – 2004



Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012 – Updated 2016

2005 – 2015



Source: NASA/GISS; Hansen, et al., “Perceptions of Climate Change,” Proc. Natl. Acad. Sci. USA 10.1073, August 2012 – Updated 2016

18 of the 19 Hottest Years on Record Have Occurred Since the Year 2001

The Hottest Years Have Been the Last Five Years

2016	2017	2015	2018	2014	2010	2005	2007	2013
2009	2012	2006	1998	2002	2003	2011	2004	2001

Data: NASA/GISS

With **each additional 1°** (C) of temperature, the atmosphere's capacity to **hold water vapor increases by 7%**

There is already **5%** more water vapor over the oceans than there was only 30 years ago

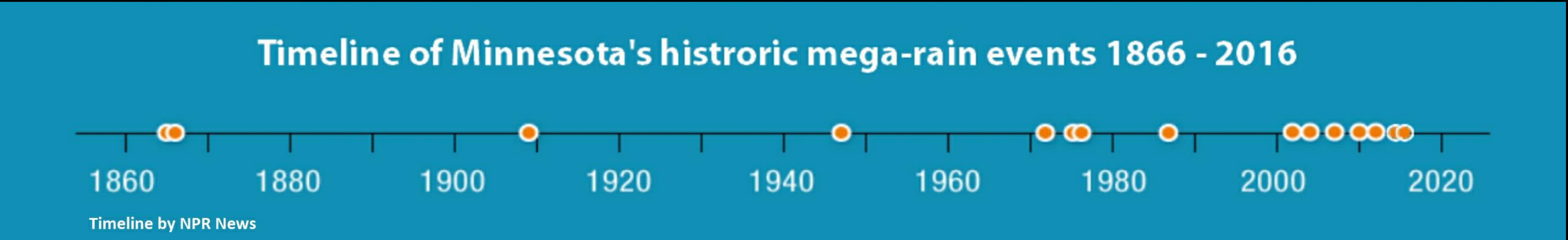
Source: K. Trenberth, "Changes in Precipitation with Climate Change," *Climate Research*, March 2011

So the downpours get bigger

© 2010 Sean R. Heavey

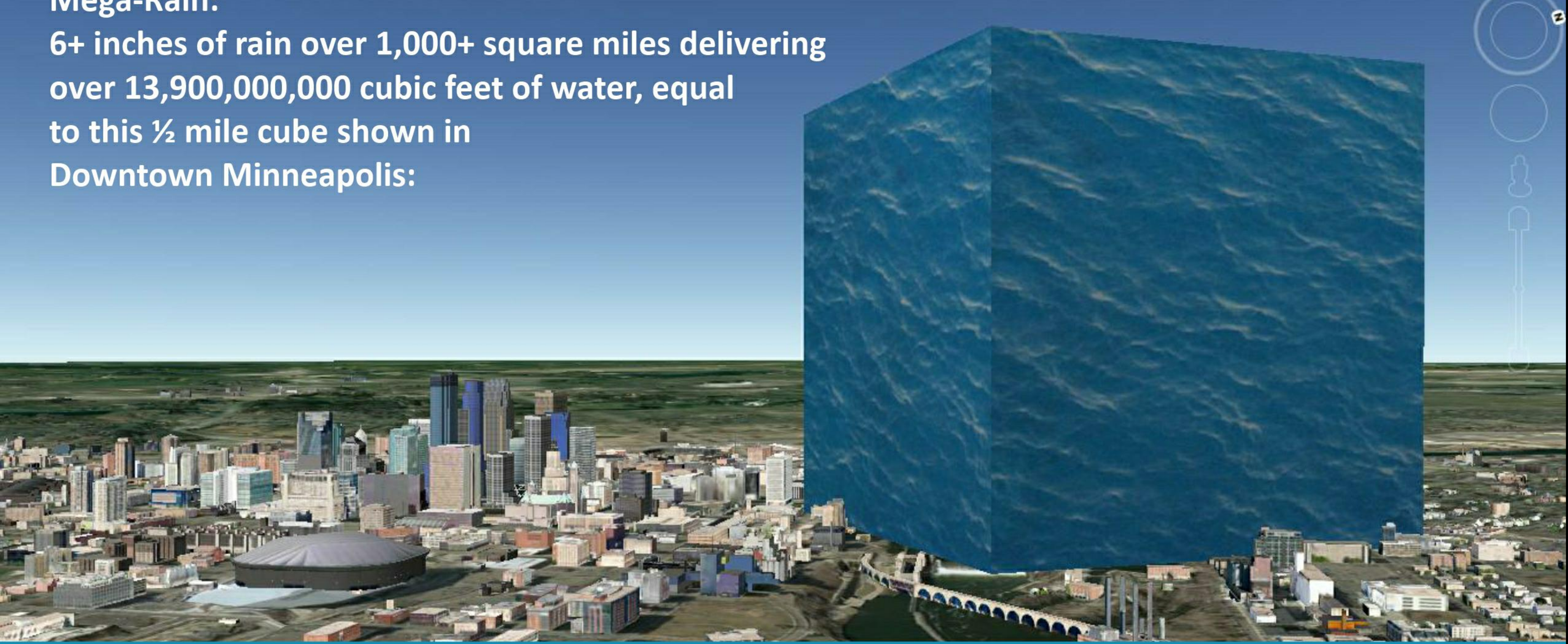
Midwest Mega-Rains:
6” of Rain
Over 1,000+ Square Miles.

Midwest Mega-Rains:
6” of Rain
Over 1,000+ Square Miles.
MN has had 15 since 1860:



Mega-Rain:

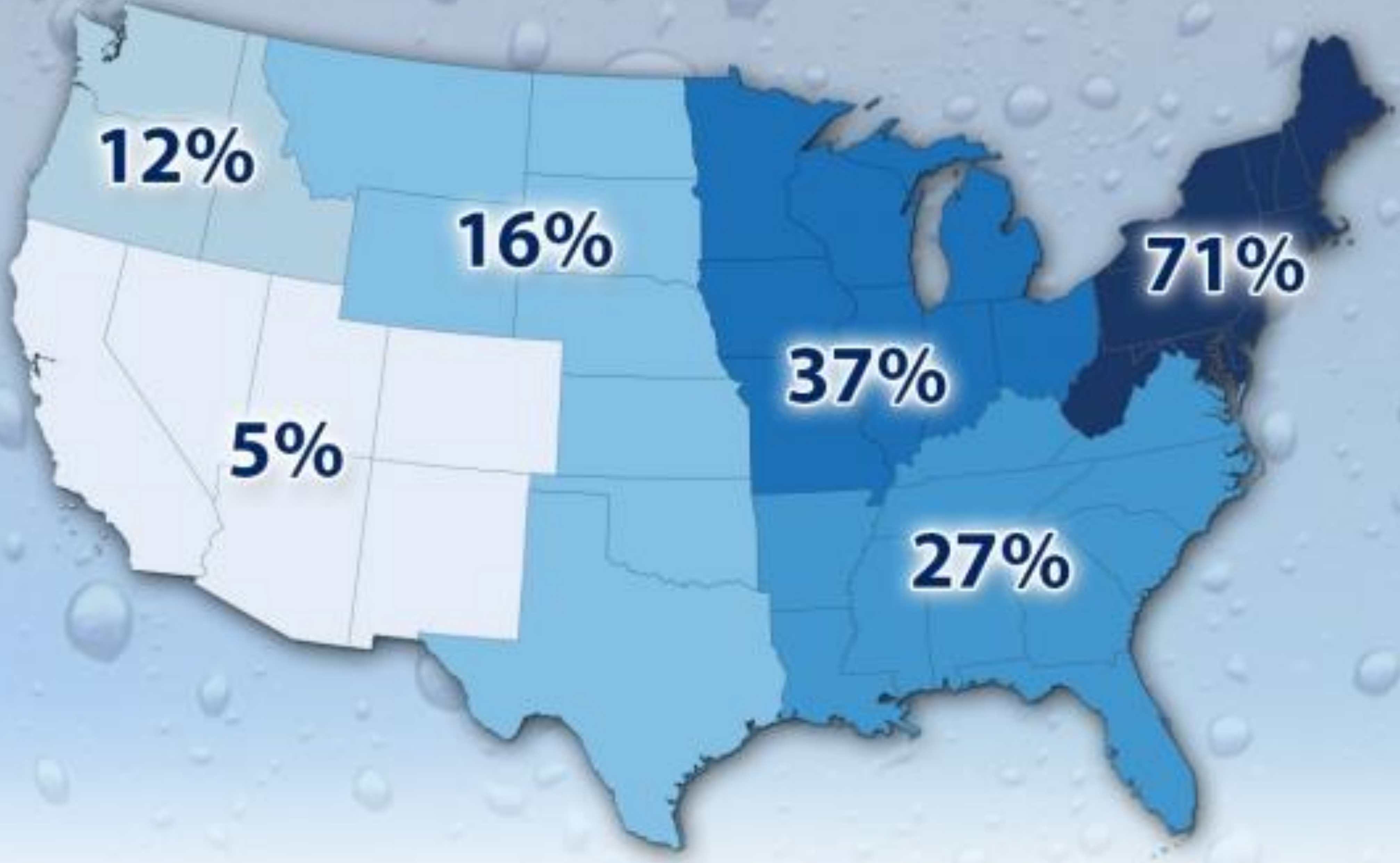
6+ inches of rain over 1,000+ square miles delivering over 13,900,000,000 cubic feet of water, equal to this ½ mile cube shown in Downtown Minneapolis:



Timeline of Minnesota's histroric mega-rain events 1866 - 2016

Timeline by NPR News

Heavy Downpours Increasing



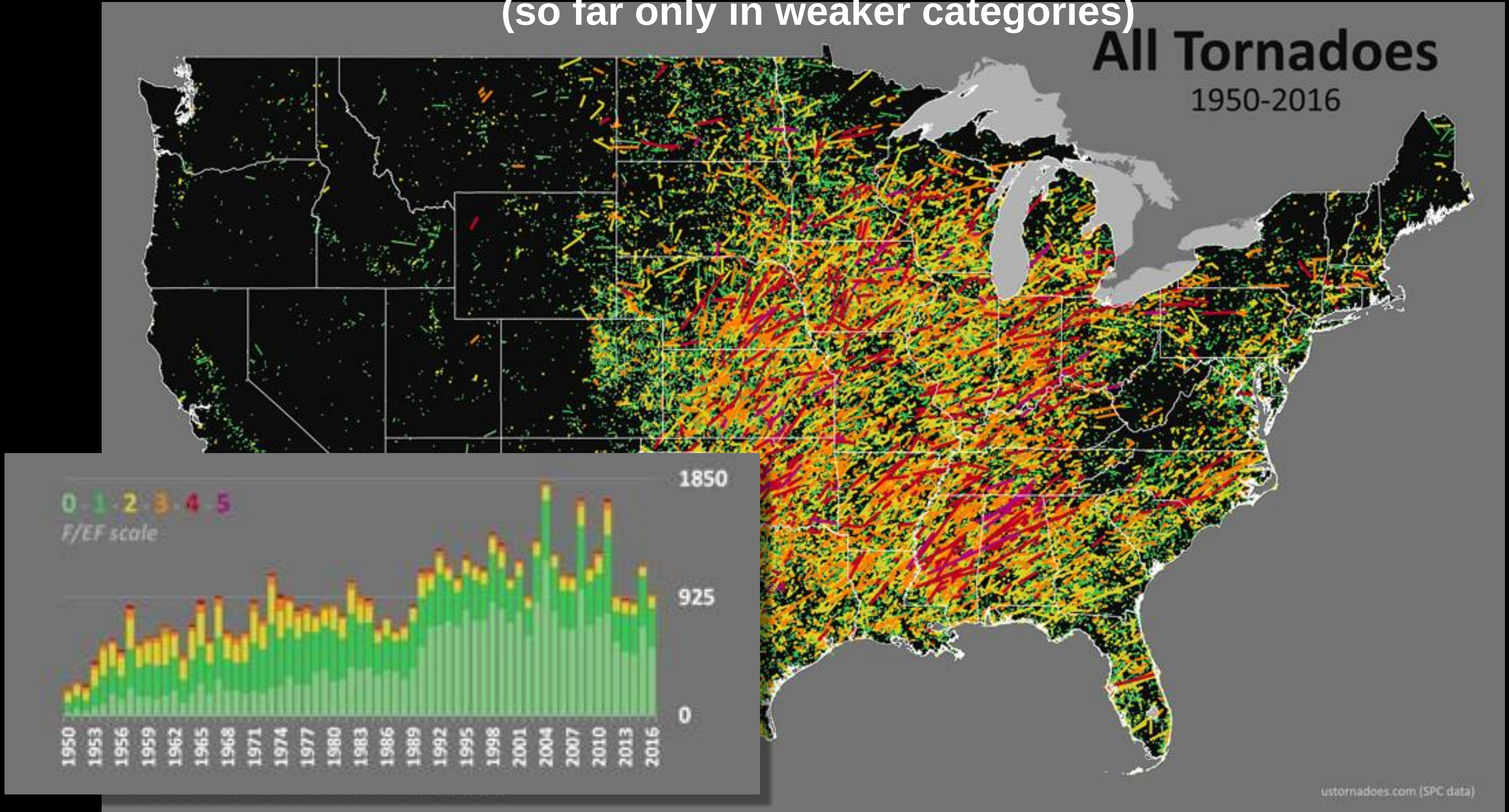
Percent increase from 1958 to 2012 in the amount of precipitation falling in very heavy events.
Very Heavy Precipitation is defined as the heaviest 1% of all daily events from 1958-2012.

Source: Kenneth Kunkel, Cooperative Institute for Climate and Satellites, North Carolina State University and NOAA NCDC

CLIMATE CENTRAL

Increase in annual tornadoes since 1950

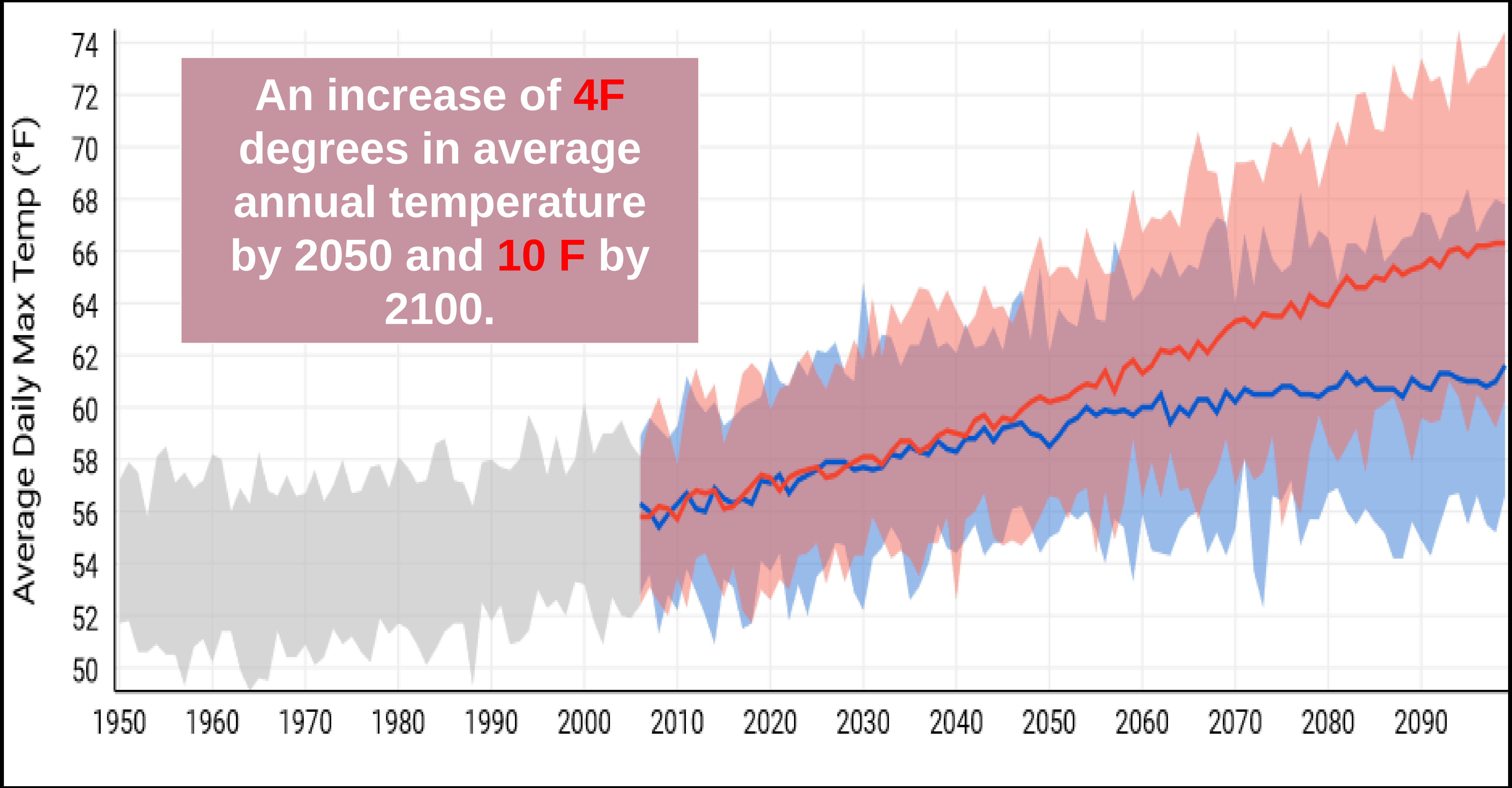
(so far only in weaker categories)



What…does this mean for The Midwest’s future?

Source: NASA

What does this mean for Midwest's Future?



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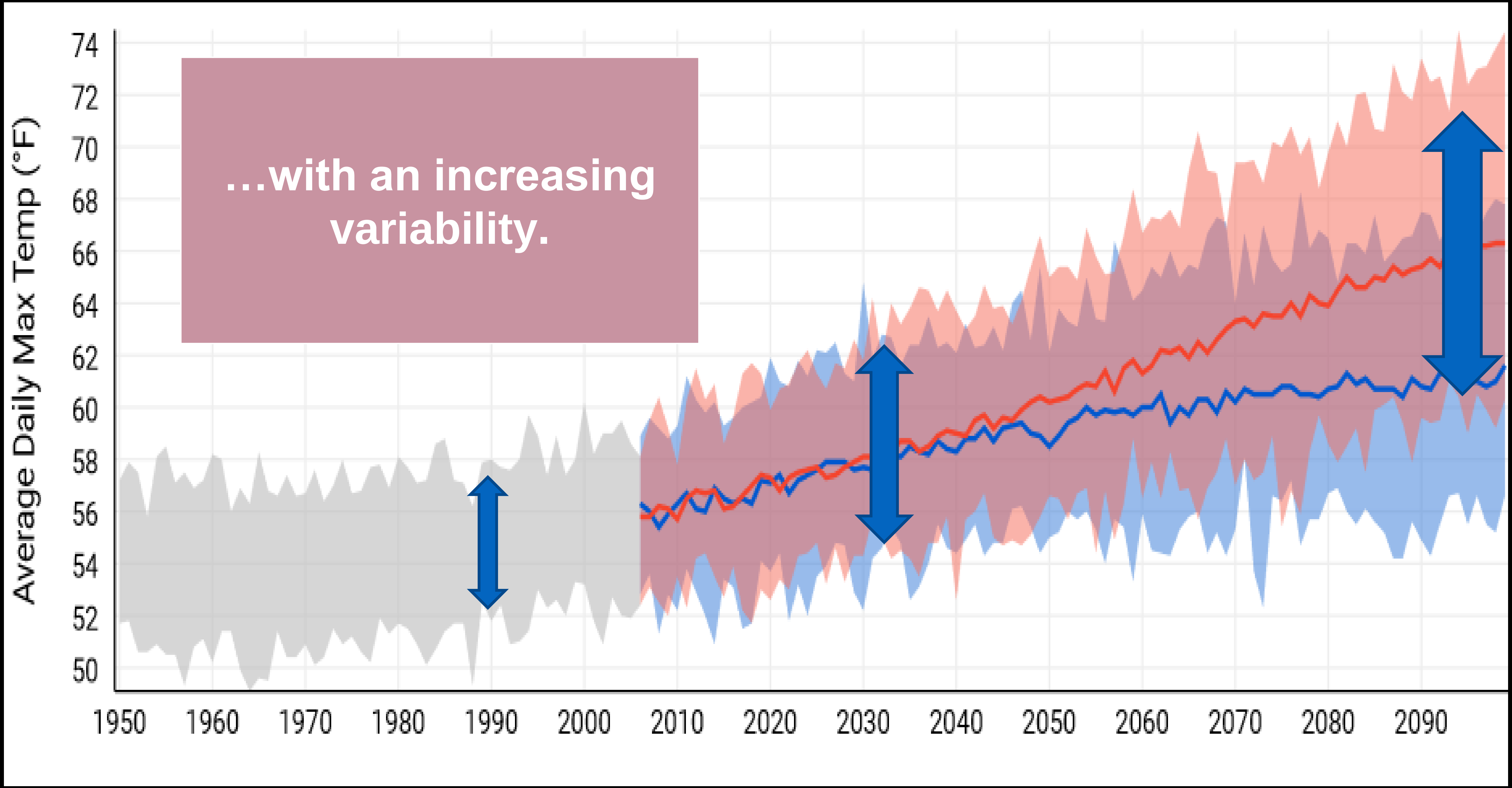

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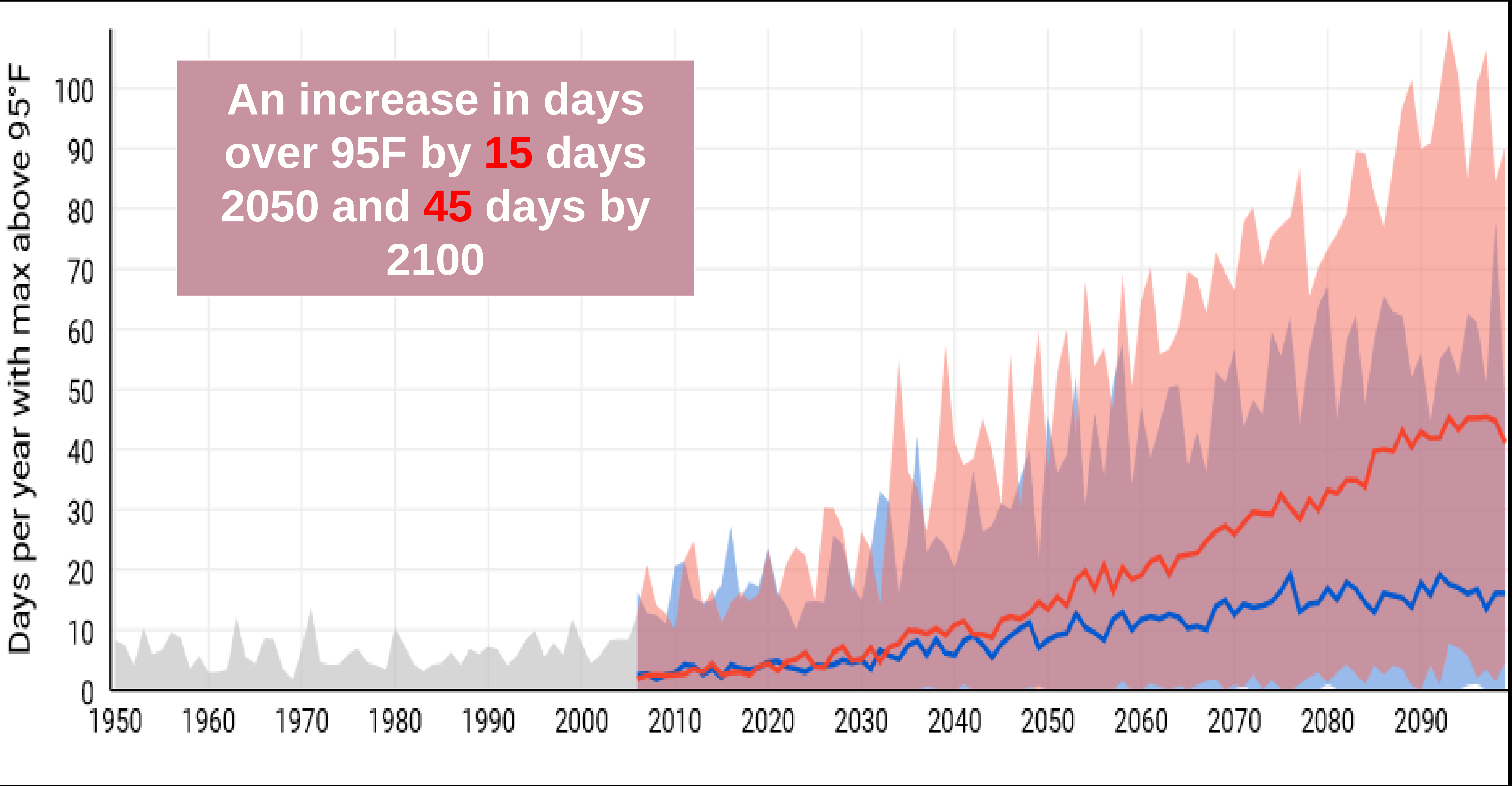

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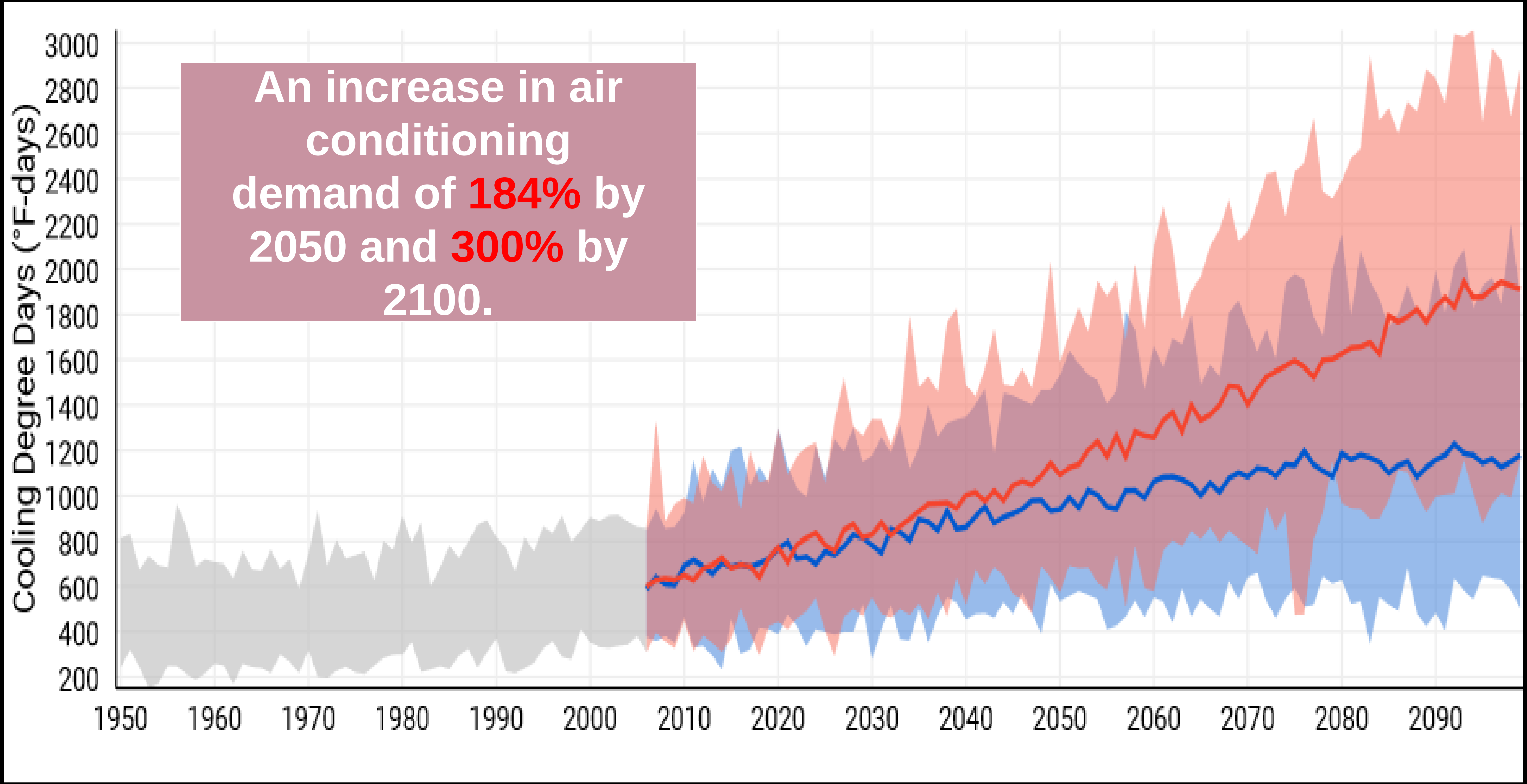

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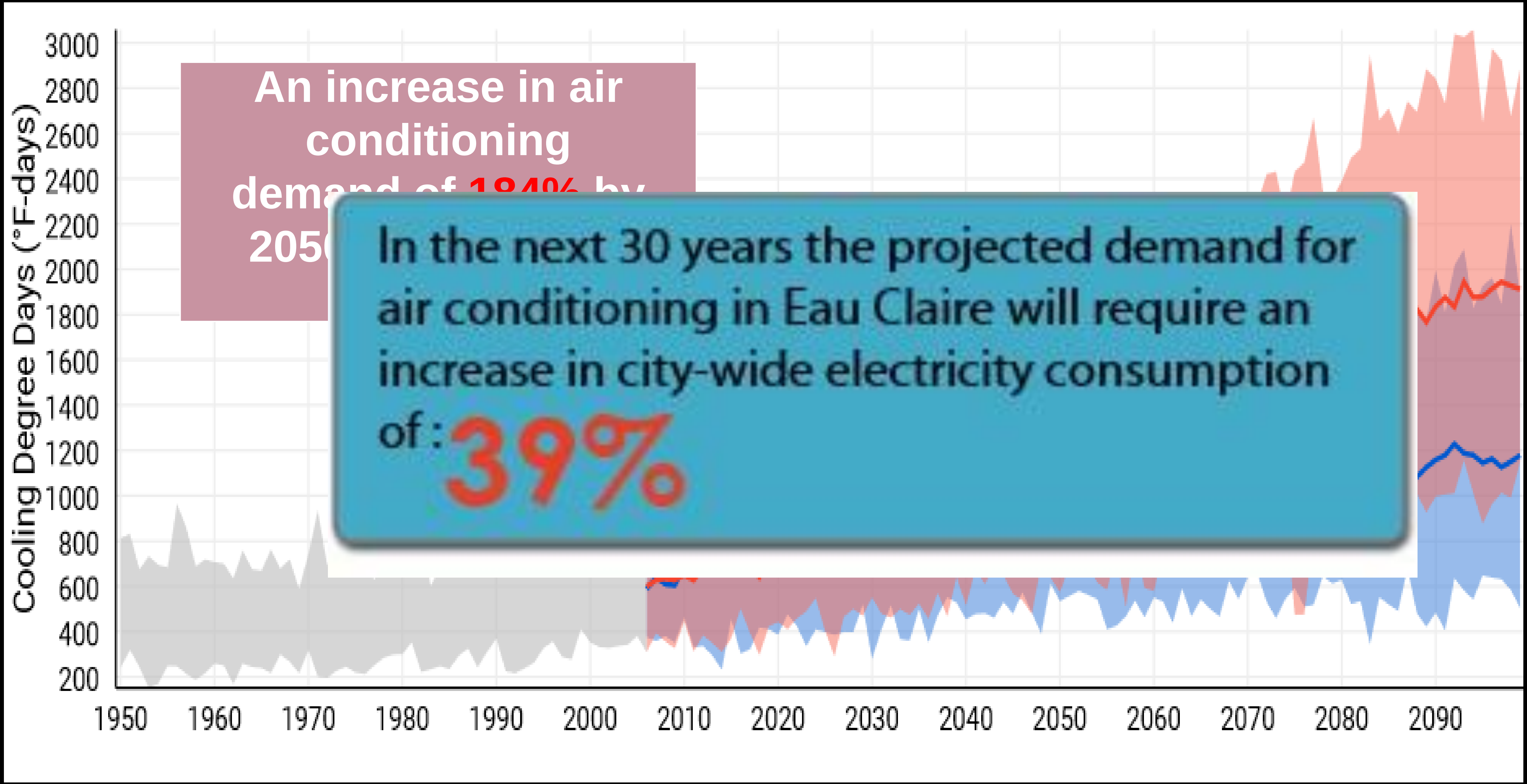
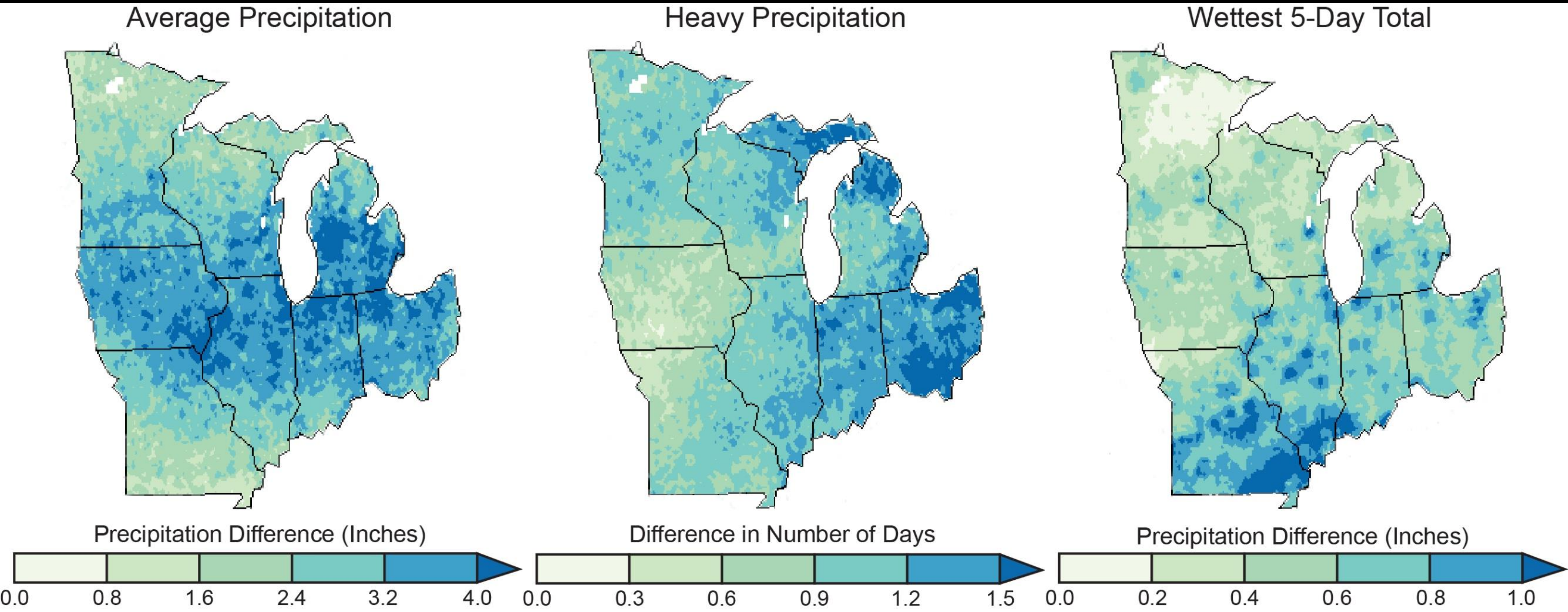
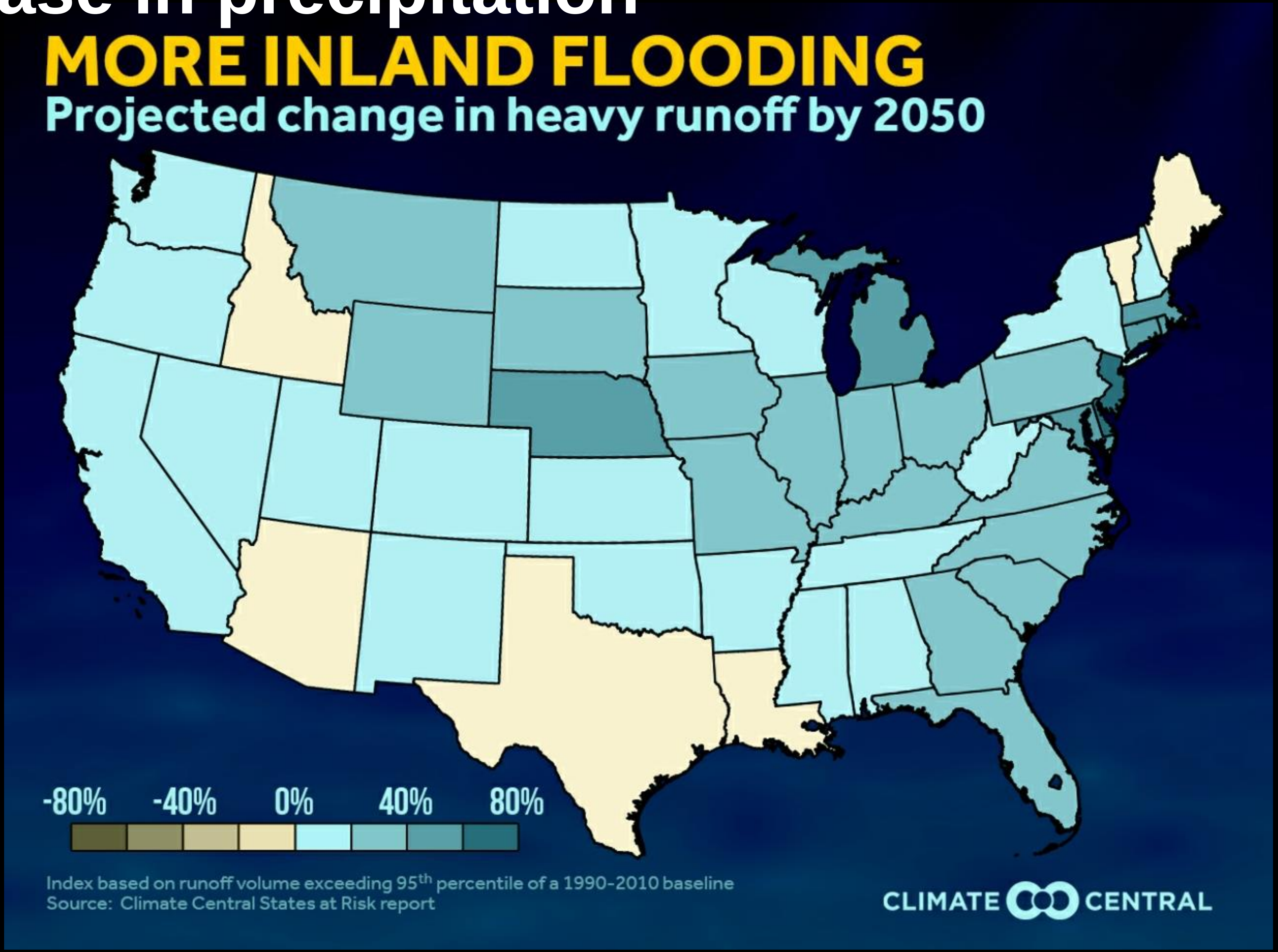


In the next 30 years…
An increase in precipitation



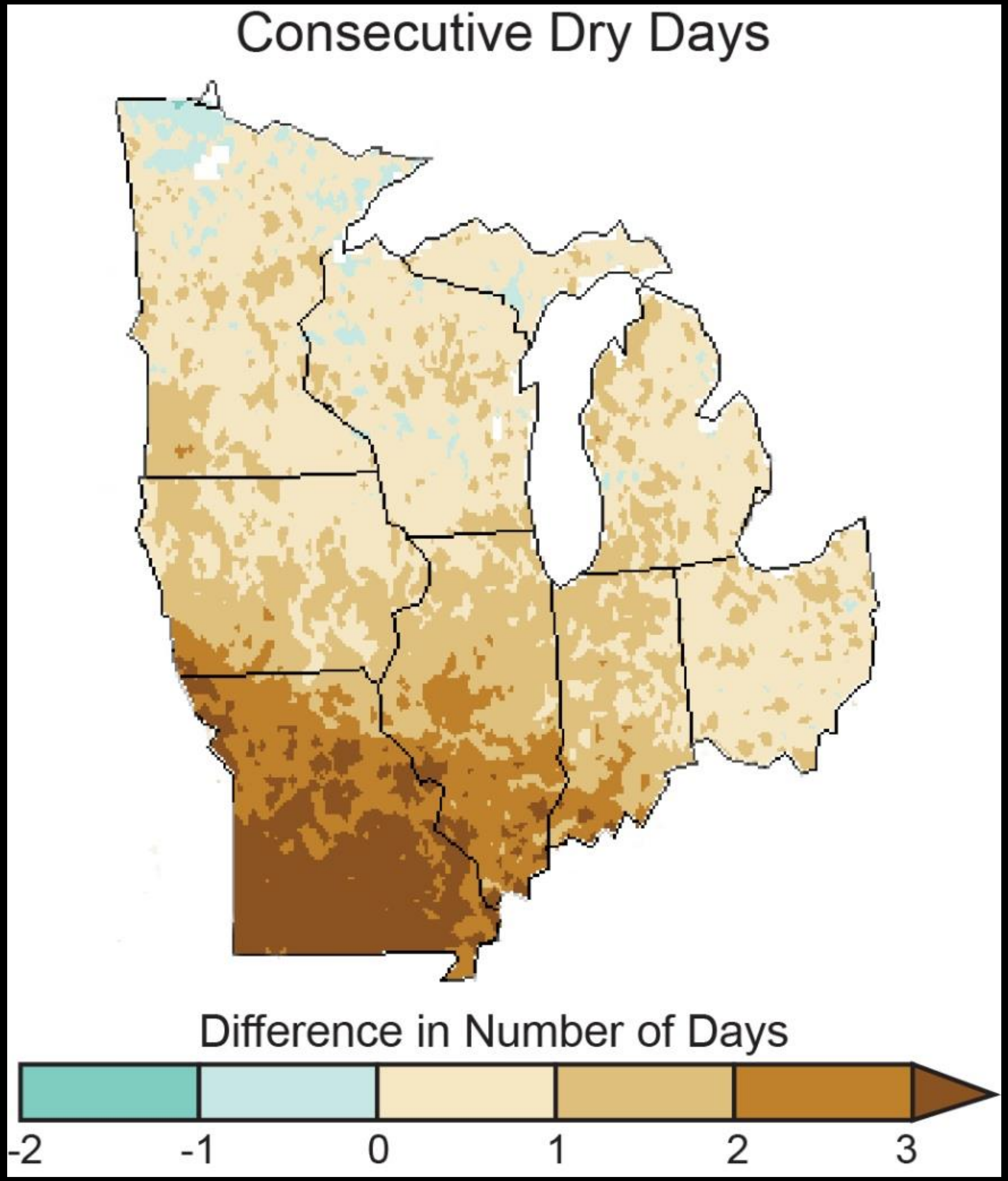
In the next 30 years…
An increase in precipitation

An increase of
flood risk by
20%



In the next 30 years…
An increase in precipitation …and drought

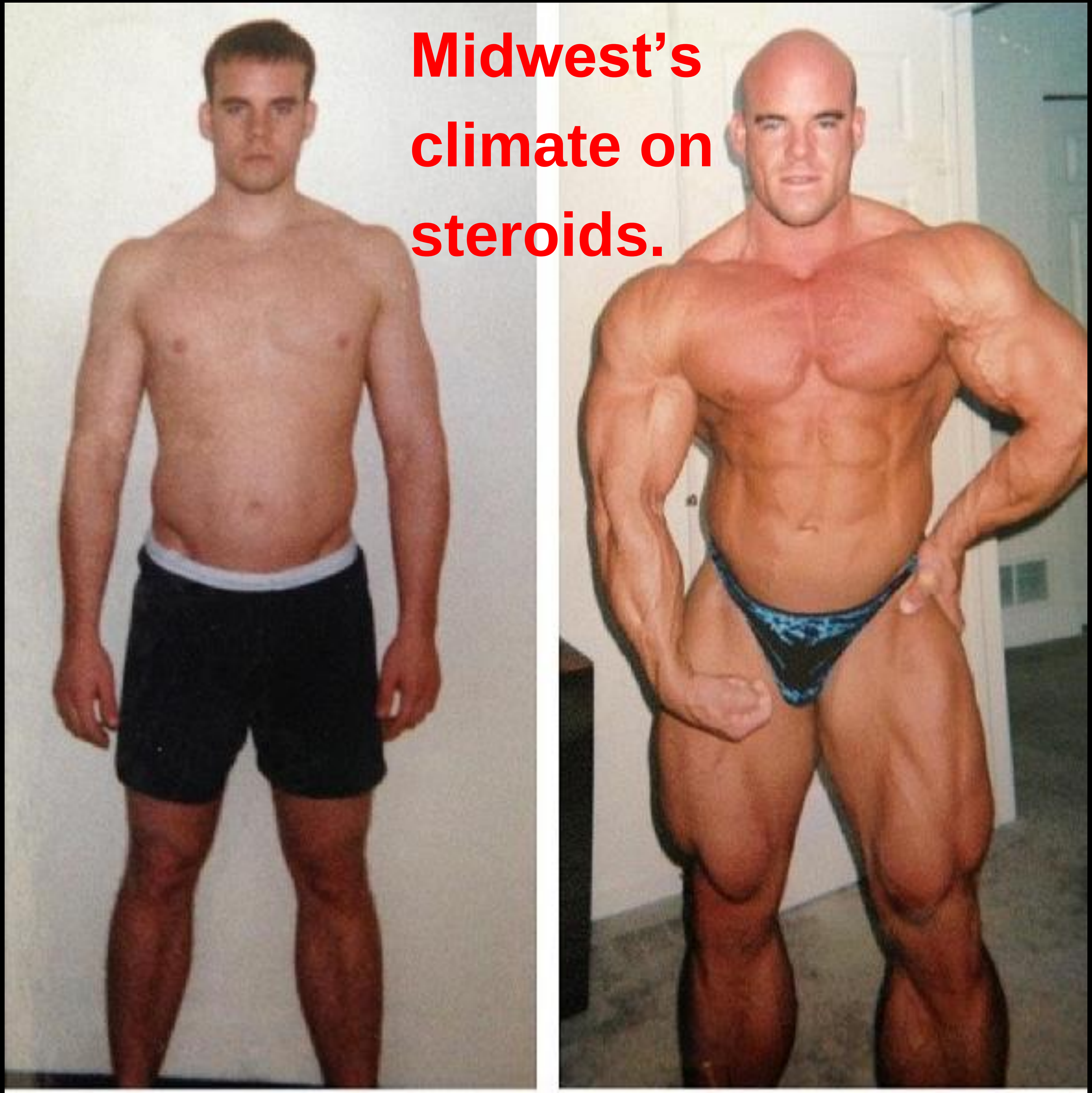
Drought index of severity increase by up to **145%**



In Summary….What does this mean?

Increased Variability and Intensity:

Higher temperatures
With wider swings
Fewer days with rain
With heavier downpours
And stronger storms
Longer dry spells
With an increase in the wettest 5-day period
Fewer days with tornadoes
With more tornadoes per day
…and likely stronger tornadoes



What does this mean for Midwest's Future?

Increased Variability and Intensity:

We need to anticipate increasing frequency of events and a greater potential to swing from one extreme to another.

We need to anticipate the potential of overlapping impacts: tornadoes and floods, extreme heat and power grid failure, flooding in the spring followed by drought in the summer.

Practical Ways For Planners To Advance Resilience

Plan for it!

Practical Ways For Planners To Advance Resilience

Integrate Resilience into Comprehensive Plan

- Ideally – included as an **interwoven, guiding theme** throughout Comprehensive Plan.
- Include a dedicated **Resilience Chapter** in Comprehensive Plan with matrix outlining strategies that are inter-related with other plan chapters.

Or - Develop a Stand-Alone Resilience Plan

- Beneficial if planning is a collaboration between multiple jurisdictions.
- Advance resilience even if Comprehensive Plan update is not scheduled.

Practical Ways For Planners To Advance Resilience

Either way Address Core Community Systems

Food
Water
Energy
Transportation
Housing
Jobs + economy
Social services
Civic preparedness

Most Effective Resilience Plans

Establish goals for each of these systems.
With strategies for each Community Stressor
Strive for actions to be….

Practical Ways For Planners To Advance Resilience

Resilience should be seen as an urgent need for our communities, however…

Possible Challenges To Implementing Resilience Planning

- might be years away from your next comprehensive planning effort.
- may be challenging to secure participation and support from broad range of stakeholders.
- Funding

Practical Ways For Planners To Advance Resilience

Alternative (Initial) Approaches

Conduct smaller, focused study/strategy efforts as addenda to comp plan.

Recommend, three focus areas:

- People
  - Determining Community Vulnerabilities – current and future
  - Mapping Vulnerable Populations
- Ecosystems
  - Tree Canopy
  - Ground Cover / Heat Island Characteristics
- Infrastructure
  - Energy Grid, Emergency Power, and Renewables
  - Roads, Bridges, and their flood vulnerability and emergency accessibility
  - Public Facility vulnerability and potentials to provide resilience services to community (cooling center, shelter, etc)

Case Studies

Example cost effective planning efforts to advance resilience through:

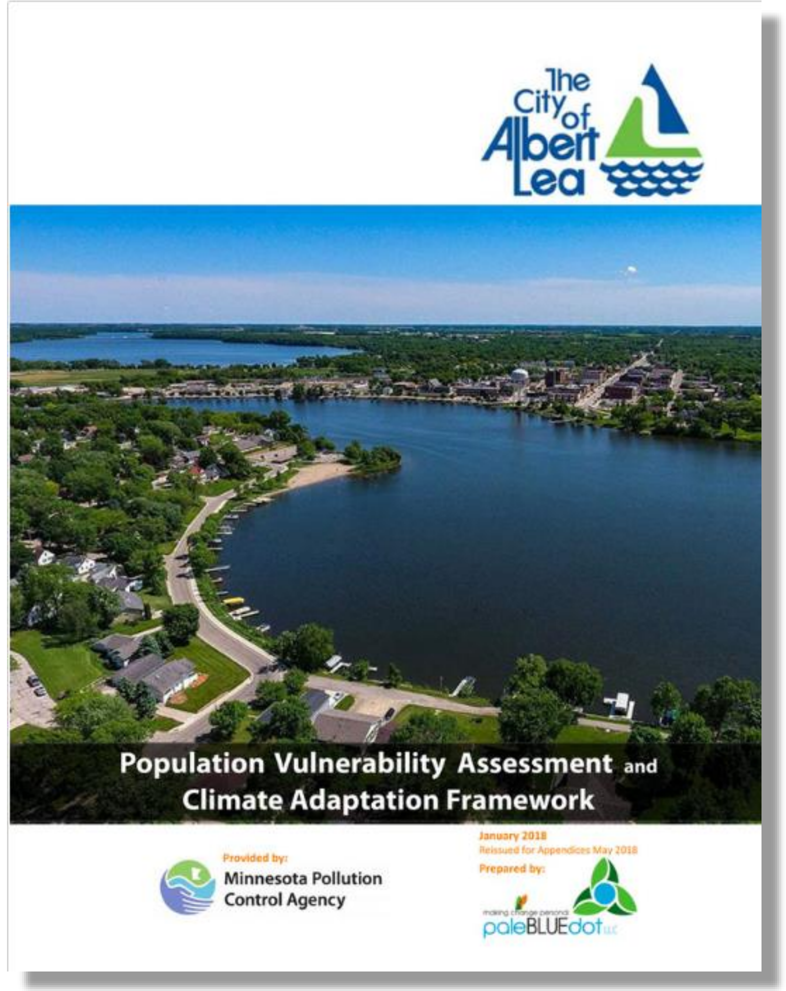
- People
- Trees (ecosystems)
- Power (Infrastructure)

Each can be done with 15-80 hour of effort

Or, for $1,000 - $5,000 depending on community size

Case Studies People

Case Studies People



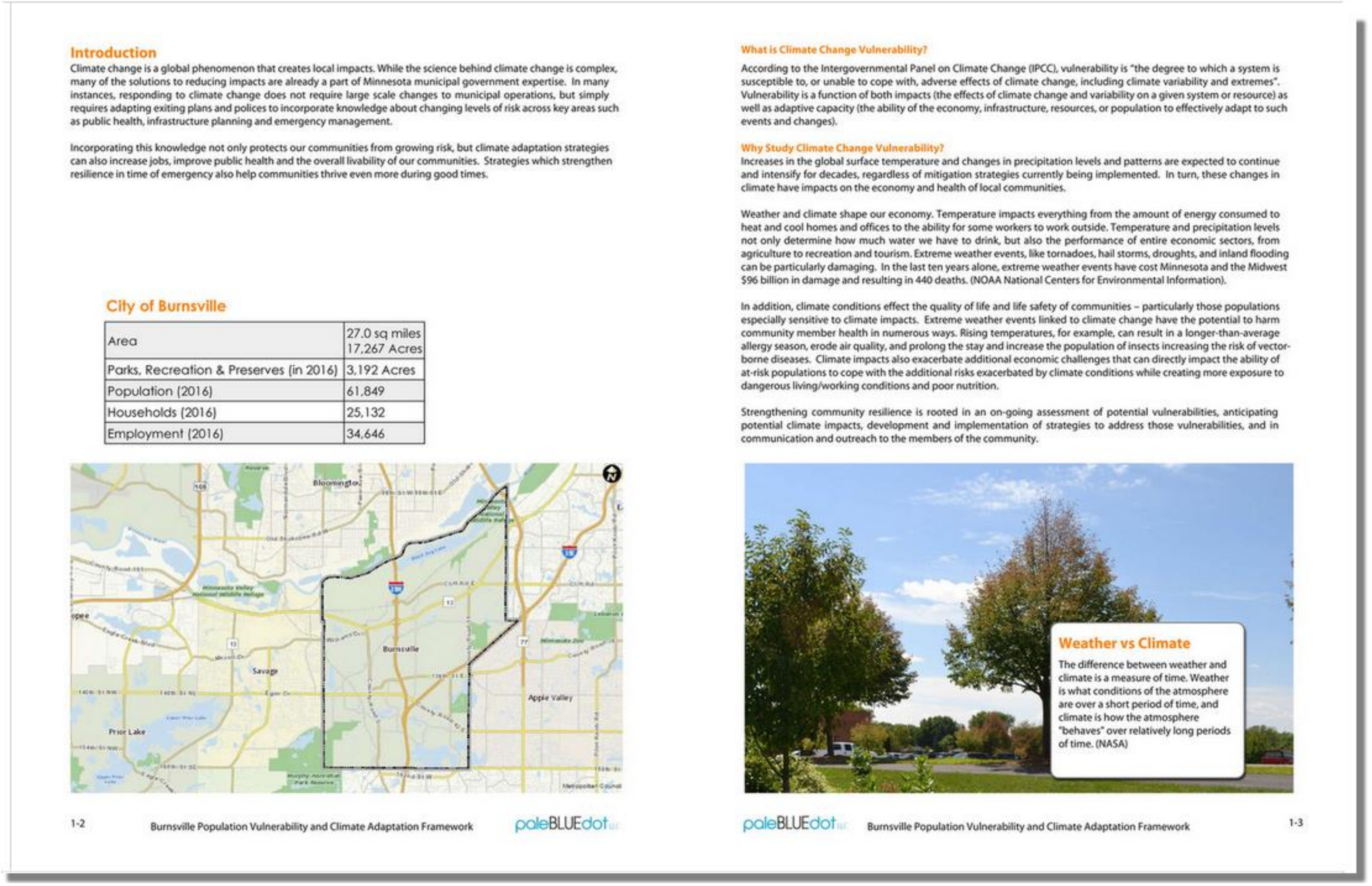
City of Albert Lea

Population Vulnerability Assessment

Case Studies People

Section 01

Introduction



Introduction

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

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

City of Burnsville

Area	27.0 sq miles 17,267 Acres
Parks, Recreation & Preserves (in 2016)	3,192 Acres
Population (2016)	61,849
Households (2016)	25,132
Employment (2016)	34,646

What is Climate Change Vulnerability?

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

Why Study Climate Change Vulnerability?

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

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

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

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

Weather vs Climate

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

City statistics at-a-glance

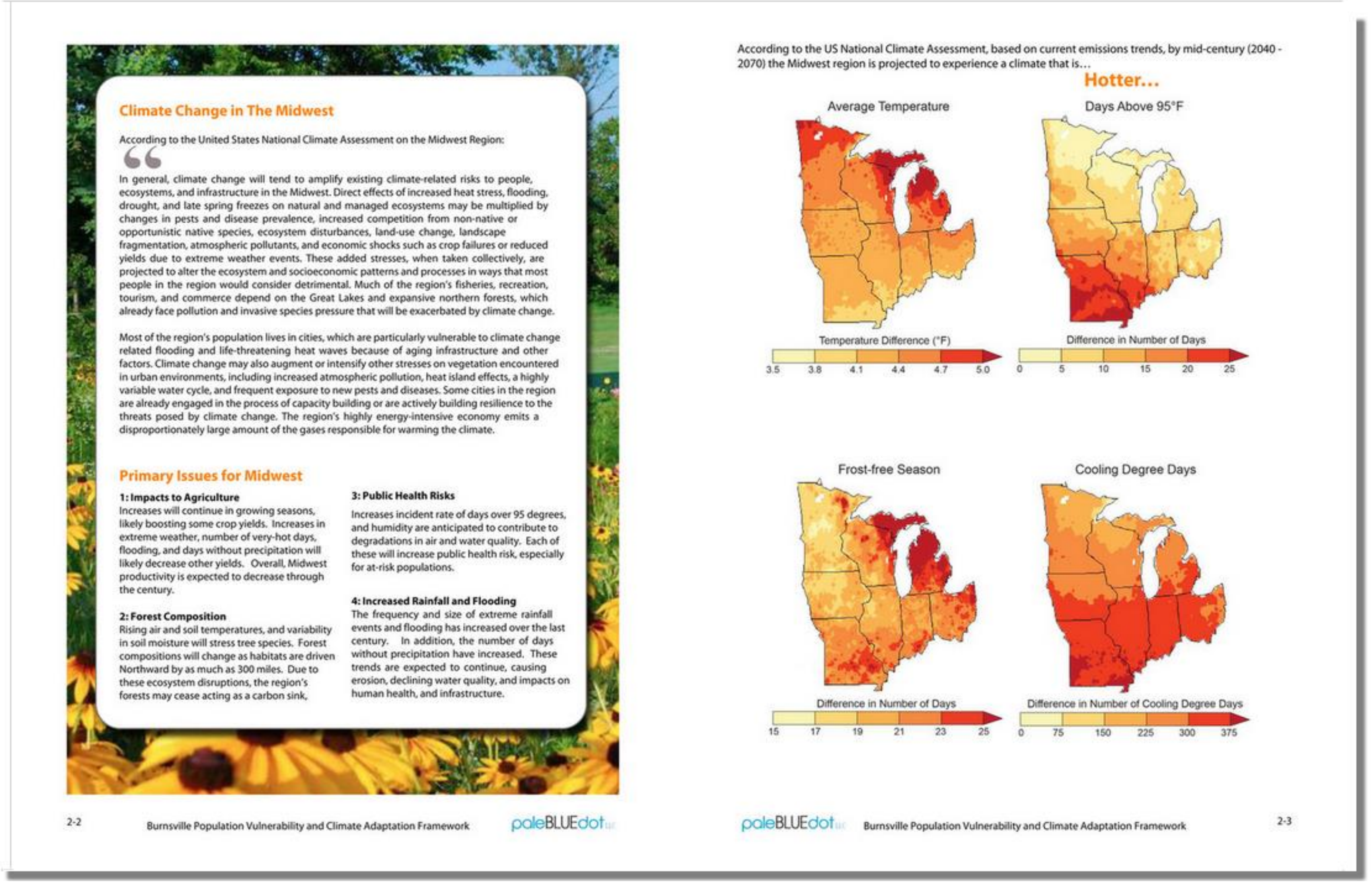
What is climate change vulnerability

Why study climate vulnerability

Case Studies **People**

Section 02

Climate Change
In The Midwest



Climate Change in The Midwest

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

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

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

Primary Issues for Midwest

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

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

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

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

2-2 Burnsville Population Vulnerability and Climate Adaptation Framework paleBLUEdot

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

Hotter…

paleBLUEdot Burnsville Population Vulnerability and Climate Adaptation Framework 2-3

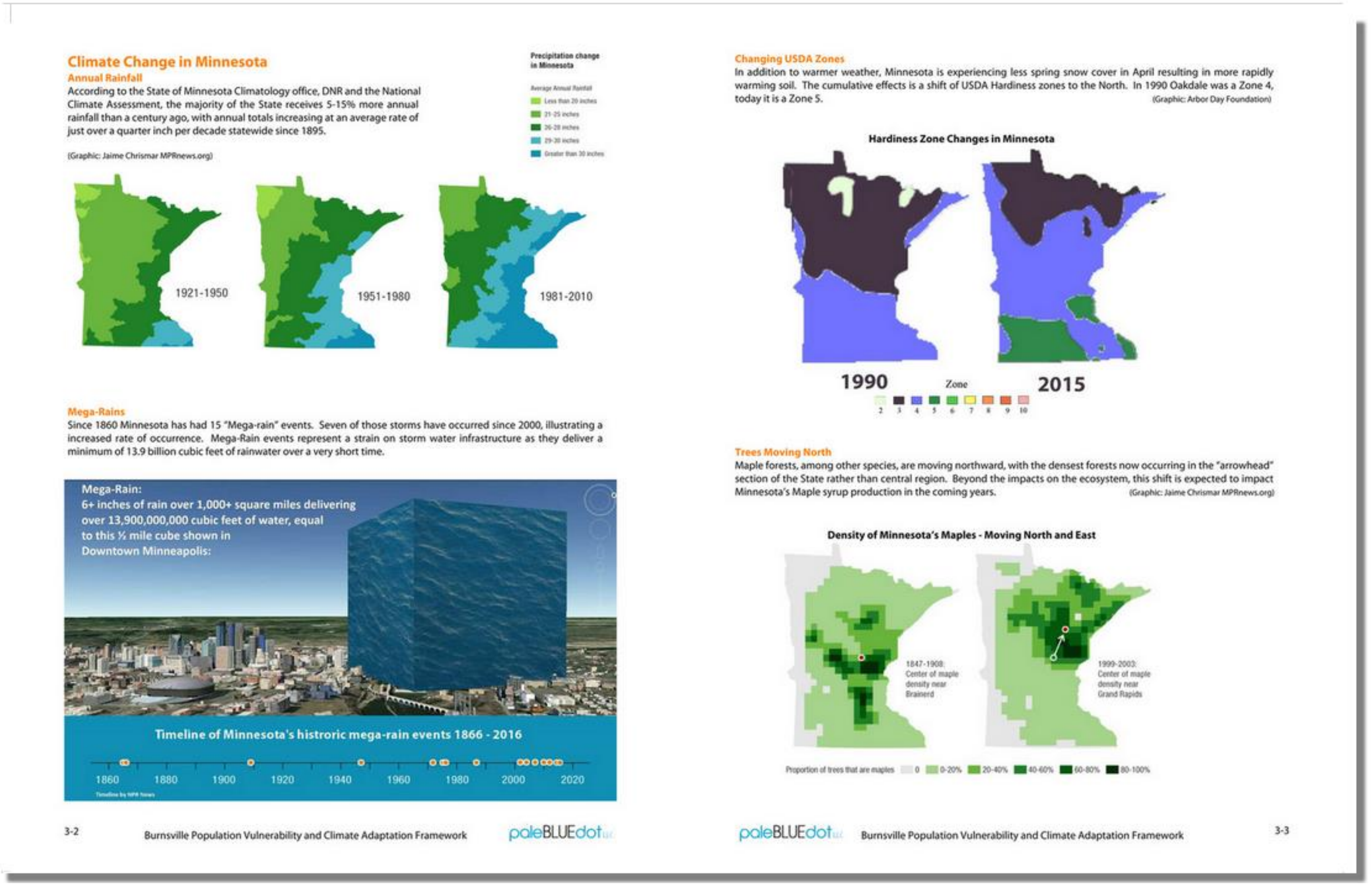
Regional climate change projections

climate change **context**

Case Studies People

Section 03

Climate Change
In Minnesota



Climate Change in Minnesota

Annual Rainfall

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

(Graphic: Jaime Chrismar MPRnews.org)

Mega-Rains

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

Changing USDA Zones

In addition to warmer weather, Minnesota is experiencing less spring snow cover in April resulting in more rapidly warming soil. The cumulative effects is a shift of USDA Hardiness zones to the North. In 1990 Oakdale was a Zone 4, today it is a Zone 5.

(Graphic: Arbor Day Foundation)

Trees Moving North

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

(Graphic: Jaime Chrismar MPRnews.org)

State-wide change in rainfall

Mega-rain event history

Change in USDA hardiness zones

Impacts on tree species distribution

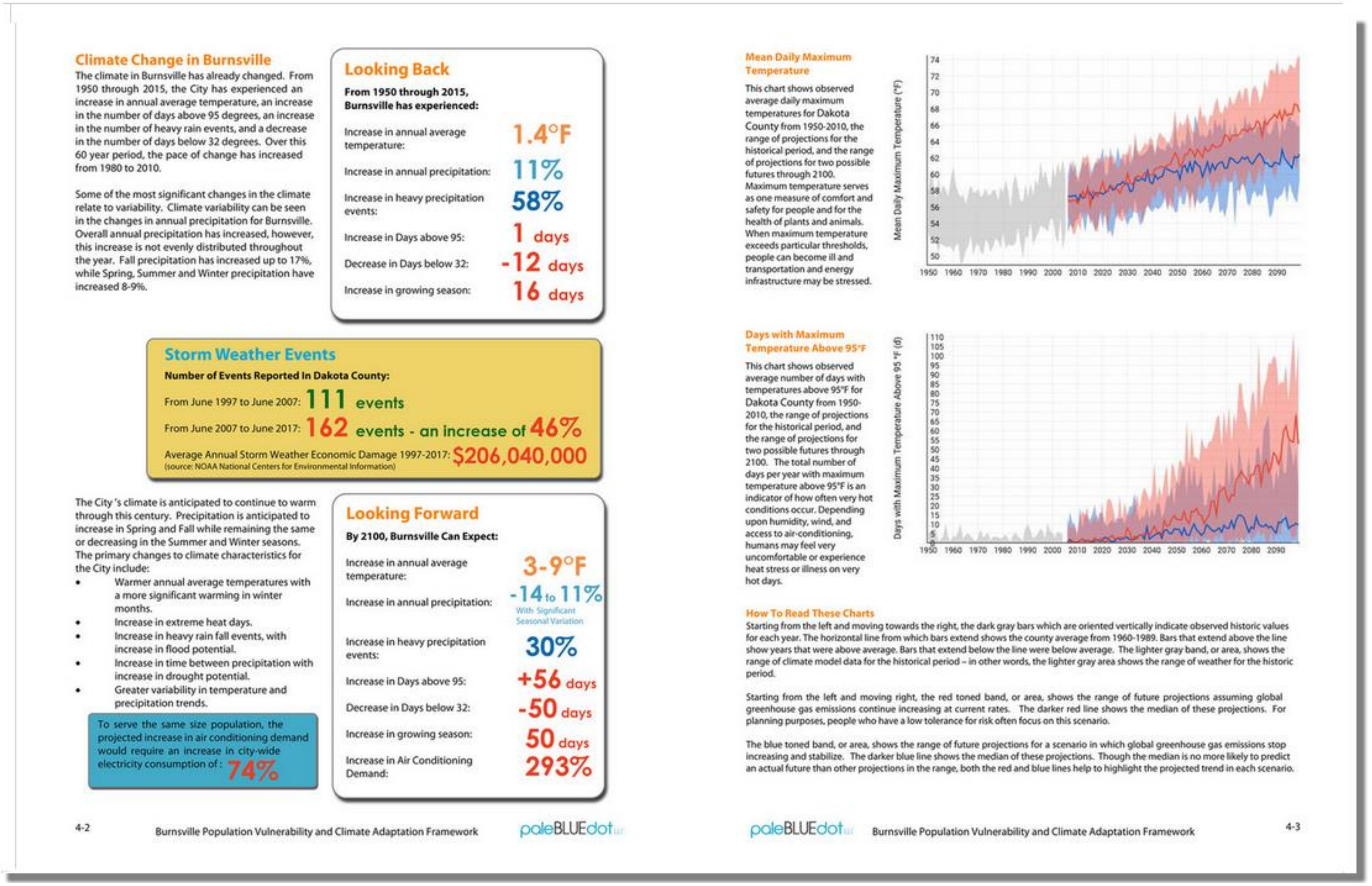
Change in vector-borne diseases

Increases of allergens.

Case Studies People

Section 04

Local Climate Change



Climate Change in Burnsville

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

Some of the most significant changes in the climate relate to variability. Climate variability can be seen in the changes in annual precipitation for Burnsville. Overall annual precipitation has increased, however, this increase is not evenly distributed throughout the year. Fall precipitation has increased up to 17%, while Spring, Summer and Winter precipitation have increased 8-9%.

Looking Back

From 1950 through 2015, Burnsville has experienced:

Increase in annual average temperature:	1.4°F
Increase in annual precipitation:	11%
Increase in heavy precipitation events:	58%
Increase in Days above 95:	1 days
Decrease in Days below 32:	-12 days
Increase in growing season:	16 days

Storm Weather Events

Number of Events Reported In Dakota County:

From June 1997 to June 2007: 111 events

From June 2007 to June 2017: 162 events - an increase of 46%

Average Annual Storm Weather Economic Damage 1997-2017: $206,040,000
(source: NOAA National Centers for Environmental Information)

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

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

To serve the same size population, the projected increase in air conditioning demand would require an increase in city-wide electricity consumption of: 74%

Looking Forward

By 2100, Burnsville Can Expect:

Increase in annual average temperature:	3-9°F
Increase in annual precipitation:	-14 to 11% With Significant Seasonal Variation
Increase in heavy precipitation events:	30%
Increase in Days above 95:	+56 days
Decrease in Days below 32:	-50 days
Increase in growing season:	50 days
Increase in Air Conditioning Demand:	293%

4-2 Burnsville Population Vulnerability and Climate Adaptation Framework paleBLUEdot

Mean Daily Maximum Temperature

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

Days with Maximum Temperature Above 95°F

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

How To Read These Charts

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

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

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

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City specific:

Climate change **history** and **projections**

Change in **extreme weather events**

Economic impact

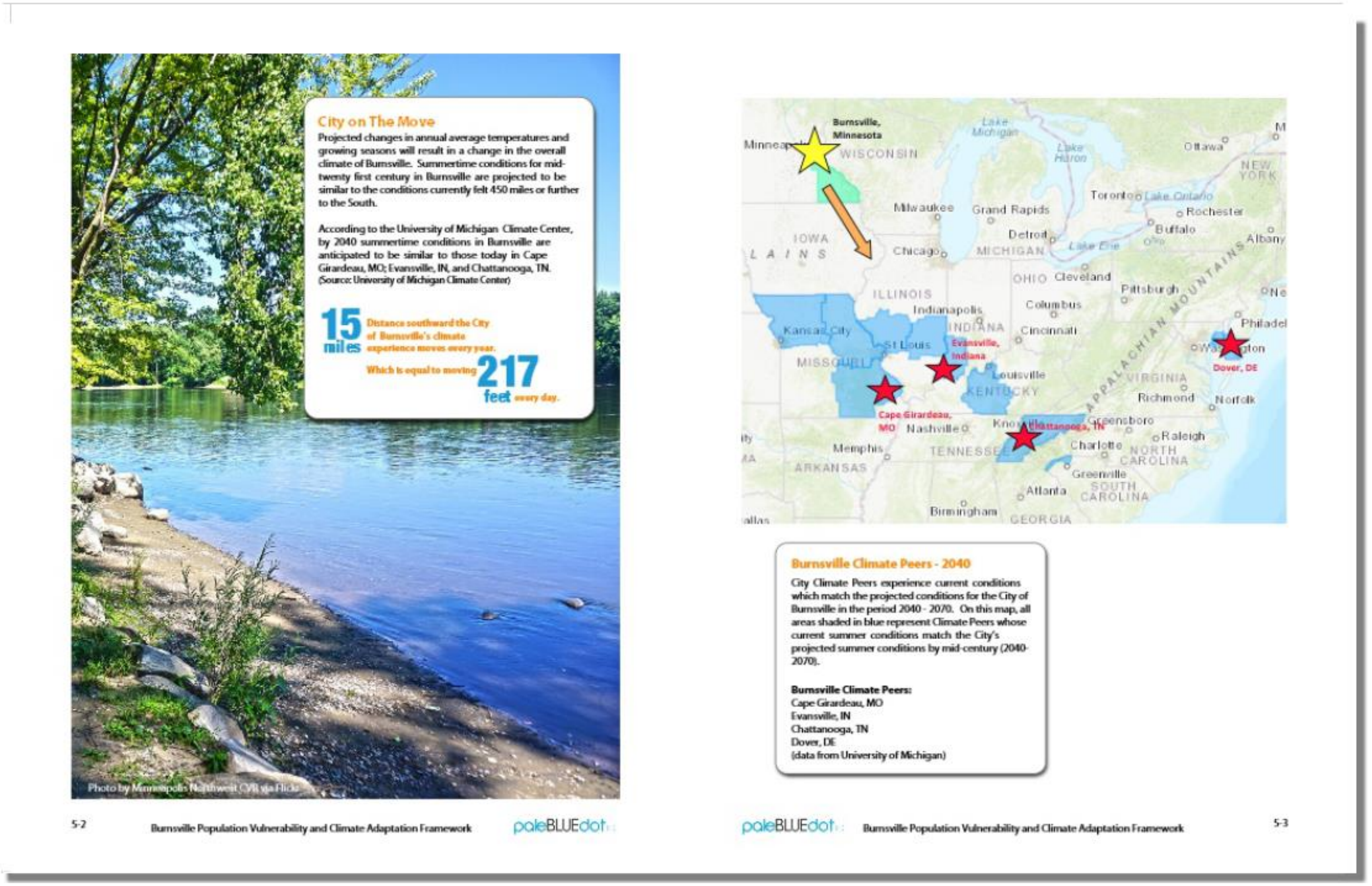
Projected change in **cooling demand**

Resulting increase in **electric use**

Case Studies People

Section 05

City on The Move



City on The Move

Projected changes in annual average temperatures and growing seasons will result in a change in the overall climate of Burnsville. Summertime conditions for mid-twenty first century in Burnsville are projected to be similar to the conditions currently felt 450 miles or further to the South.

According to the University of Michigan Climate Center, by 2040 summertime conditions in Burnsville are anticipated to be similar to those today in Cape Girardeau, MO; Evansville, IN, and Chattanooga, TN. (Source: University of Michigan Climate Center)

15 miles Distance southward the City of Burnsville's climate experience moves every year.

Which is equal to moving 217 feet every day.

Burnsville Climate Peers - 2040

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

Burnsville Climate Peers:
Cape Girardeau, MO
Evansville, IN
Chattanooga, TN
Dover, DE
(data from University of Michigan)

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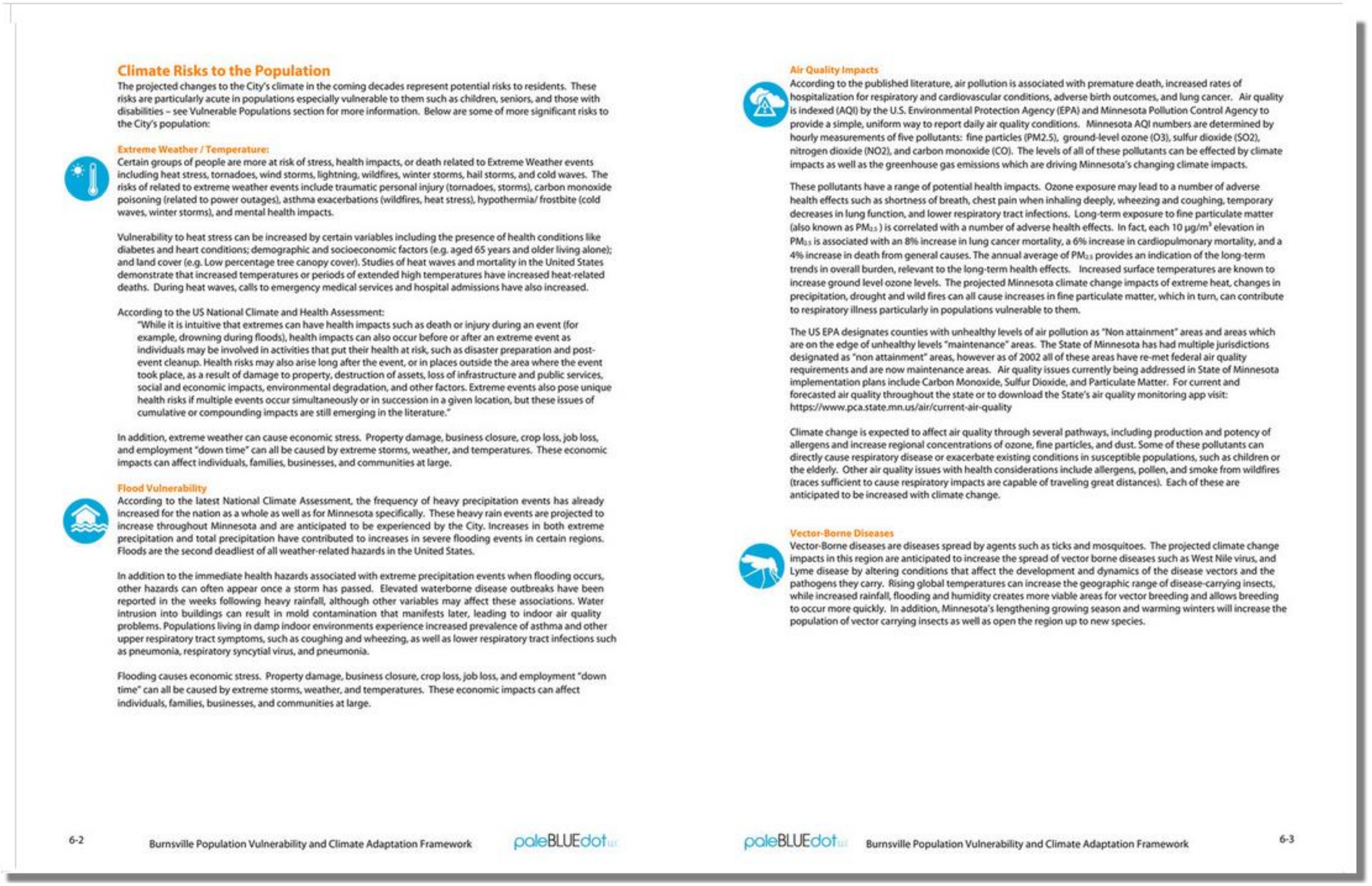
University of Michigan's Climate Impacts and Adaptation Tool (CIAT) Climate Peers

Translated into miles per year and feet per day ecosystem displacement.

Case Studies People

Section 06

Climate Risks to The Population



Climate Risks to the Population

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

Extreme Weather / Temperature:

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

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

According to the US National Climate and Health Assessment:

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

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

Flood Vulnerability

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

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

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

Air Quality Impacts

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

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

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

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

Vector-Borne Diseases

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

Overview of risk to vulnerable population

- Extreme Weather / Temperature
- Flood Vulnerability
- Air Quality Impacts
- Vector-Borne Diseases
- Food Insecurity and Foodborne Diseases
- Water Quality/Quantity
- Waterborne Illness

Case Studies **People**

Section **08**

Climate Resilience Indicators

Burnsville Resilience Indicators - Housing Burden

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

A total of 30% of all Burnsville households are living under a housing cost burden, compared with 26% for all of Dakota County. This number increases to 46% for renter households in the City (compared with 45% for County-wide renters). Since 1990, the percentage of households experiencing cost burden has increased, especially among renters. Families living under housing cost burden are required to spend higher portions of their income on their rent or mortgage, frequently leaving too little to cover other family expenses such as utility costs, housing and equipment maintenance, appropriate medical care, etc.

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

Percentage of Households Experiencing Housing Cost Burden in Burnsville, for years 2011-2015

Housing Type Impacts on Housing Burden

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

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

Burnsville Housing by Type and Occupancy

Housing Type	Housing Units			Owner-Occupied			Renter-Occupied		
	Number	% of Total	State Ave	Number	% of Total	State Ave	Number	% of Total	State Ave
1, detached	11,441	44.70%	67.00%	10,505	66.60%	85.30%	485	5.50%	20.80%
1, attached	5,196	20.30%	7.90%	3,360	21.30%	7.60%	1,641	18.60%	8.40%
2 apartments	179	0.70%	2.30%	16	0.10%	0.60%	150	1.70%	6.30%
3 or 4 apartments	307	1.20%	2.10%	142	0.90%	0.50%	150	1.70%	6.20%
5 to 9 apartments	640	2.50%	2.30%	221	1.40%	0.40%	406	4.60%	6.90%
10 or more apartments	7,141	27.90%	15.60%	899	5.70%	2.20%	5,955	67.50%	49.60%
Mobile home	691	2.70%	2.90%	631	4.00%	3.40%	35	0.40%	1.60%
Total Occupied Units	25,595			15,773	61.6%	71.7%	8,822	34.5%	28.3%

Indicators of general resilience

Economic stress / **wage distribution**

Community **health indicators**

Traffic and pollution patterns

EPA **Environmental Justice** Screen

Indicators of **Housing burden**

Case Studies People

Section 09

Vulnerable Populations


Section 09

Vulnerable Populations

Click to Return to TOC

8-6 Burnsville Population Vulnerability and Climate Adaptation Framework paleBLUEdot

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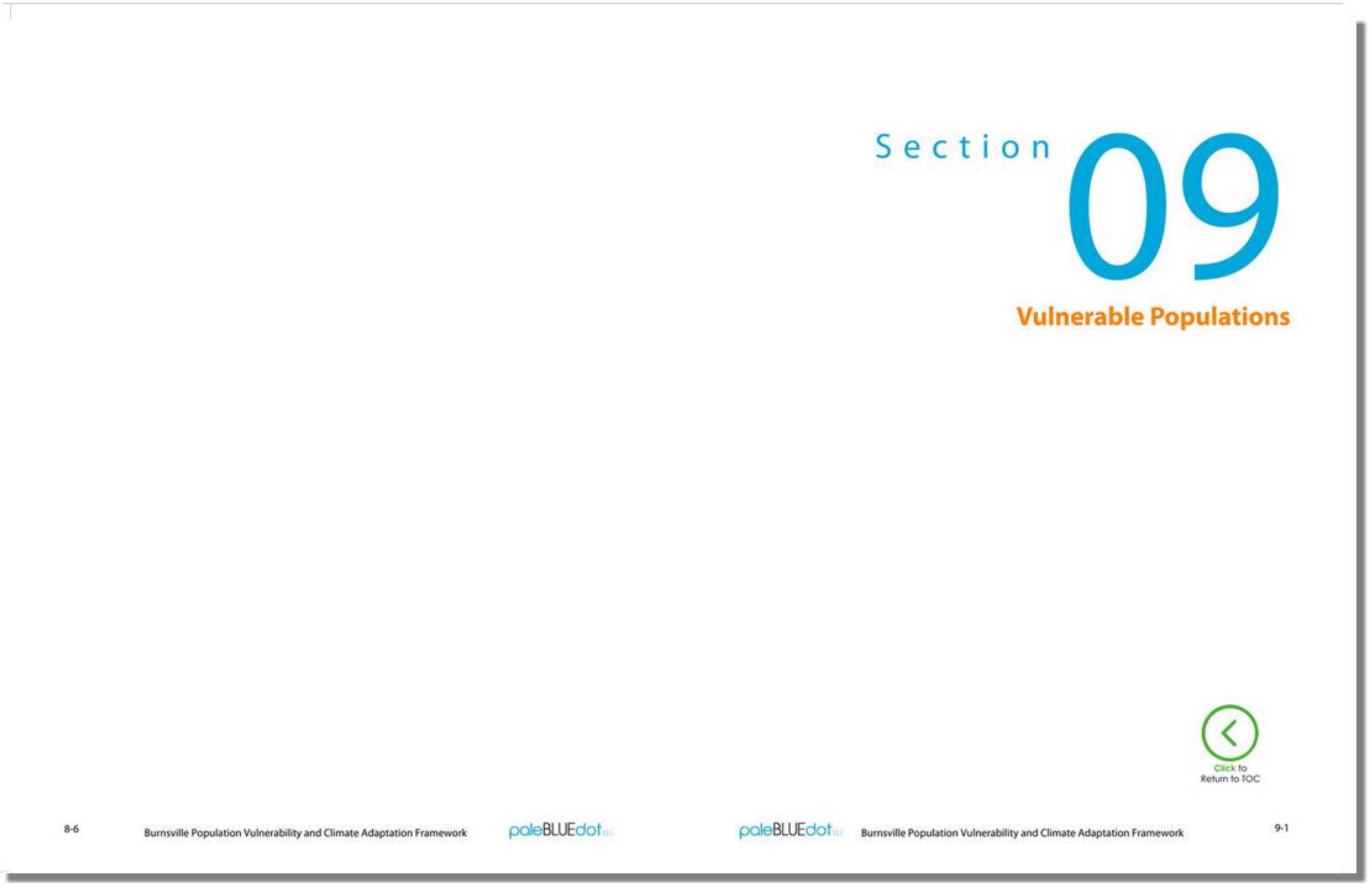
Demographics Mapping by census tract:

- Children under 5
- Older Adults
- Disabilities
- Economic Stress
- People of Color
- Limited English
- At-Risk Workers
- Food Insecurity
- Lack of Vehicle Access

Case Studies People

Section 09
Vulnerable Populations


Section 09
Vulnerable Populations
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8-6 Burnsville Population Vulnerability and Climate Adaptation Framework paleBLUEdot
paleBLUEdot Burnsville Population Vulnerability and Climate Adaptation Framework 9-1

For each vulnerable population:

Why they are climate vulnerable

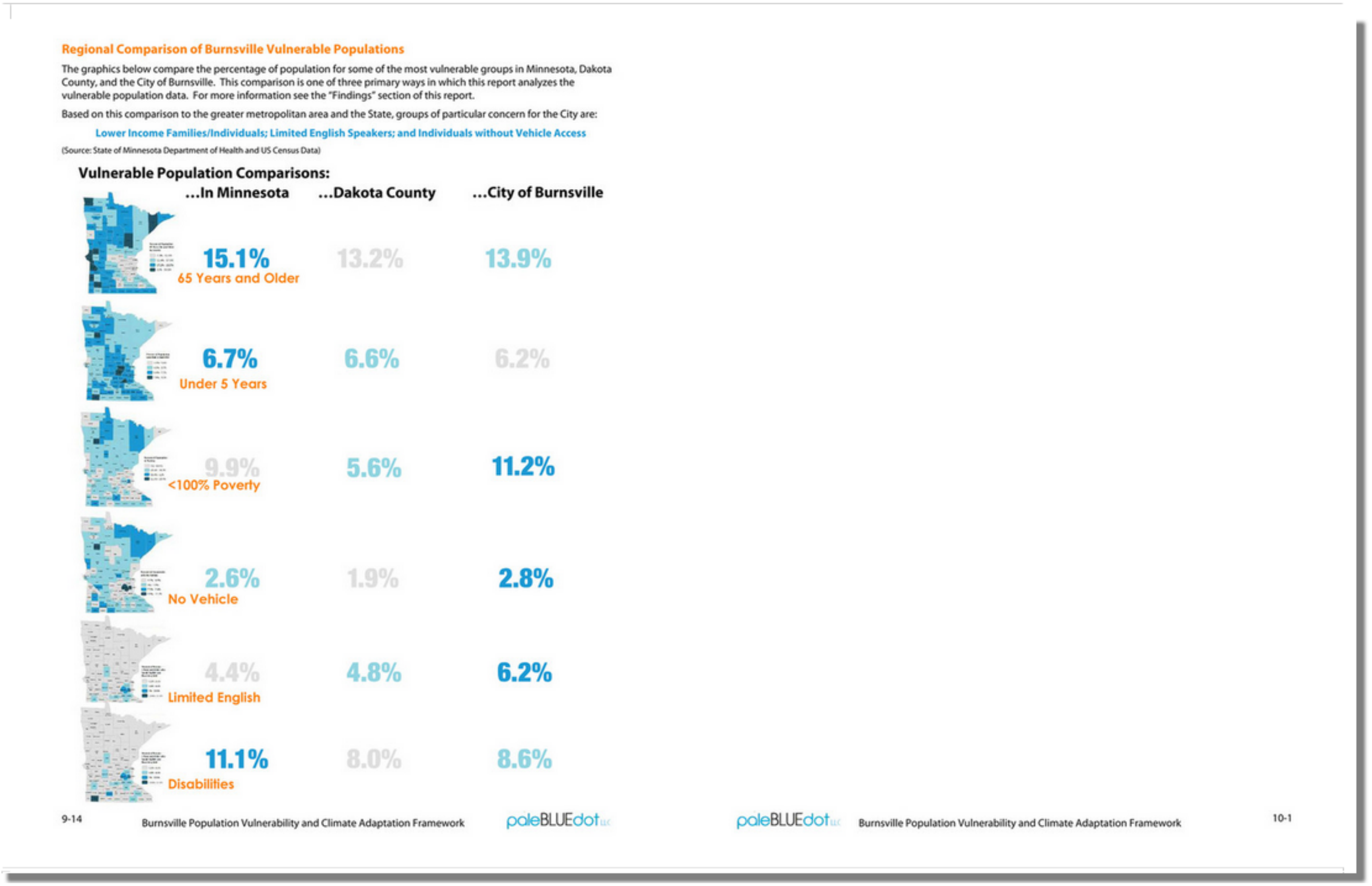
What risks they are vulnerable to

Population density mapping

Case Studies People

Section 09

Vulnerable Populations


Regional Comparison of Burnsville Vulnerable Populations

The graphics below compare the percentage of population for some of the most vulnerable groups in Minnesota, Dakota County, and the City of Burnsville. This comparison is one of three primary ways in which this report analyzes the vulnerable population data. For more information see the "Findings" section of this report.

Based on this comparison to the greater metropolitan area and the State, groups of particular concern for the City are:

Lower Income Families/Individuals; Limited English Speakers; and Individuals without Vehicle Access

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

Vulnerable Population Comparisons:

	...In Minnesota	...Dakota County	...City of Burnsville
65 Years and Older	15.1%	13.2%	13.9%
Under 5 Years	6.7%	6.6%	6.2%
<100% Poverty	9.9%	5.6%	11.2%
No Vehicle	2.6%	1.9%	2.8%
Limited English	4.4%	4.8%	6.2%
Disabilities	11.1%	8.0%	8.6%

9-14 Burnsville Population Vulnerability and Climate Adaptation Framework paleBLUEdot

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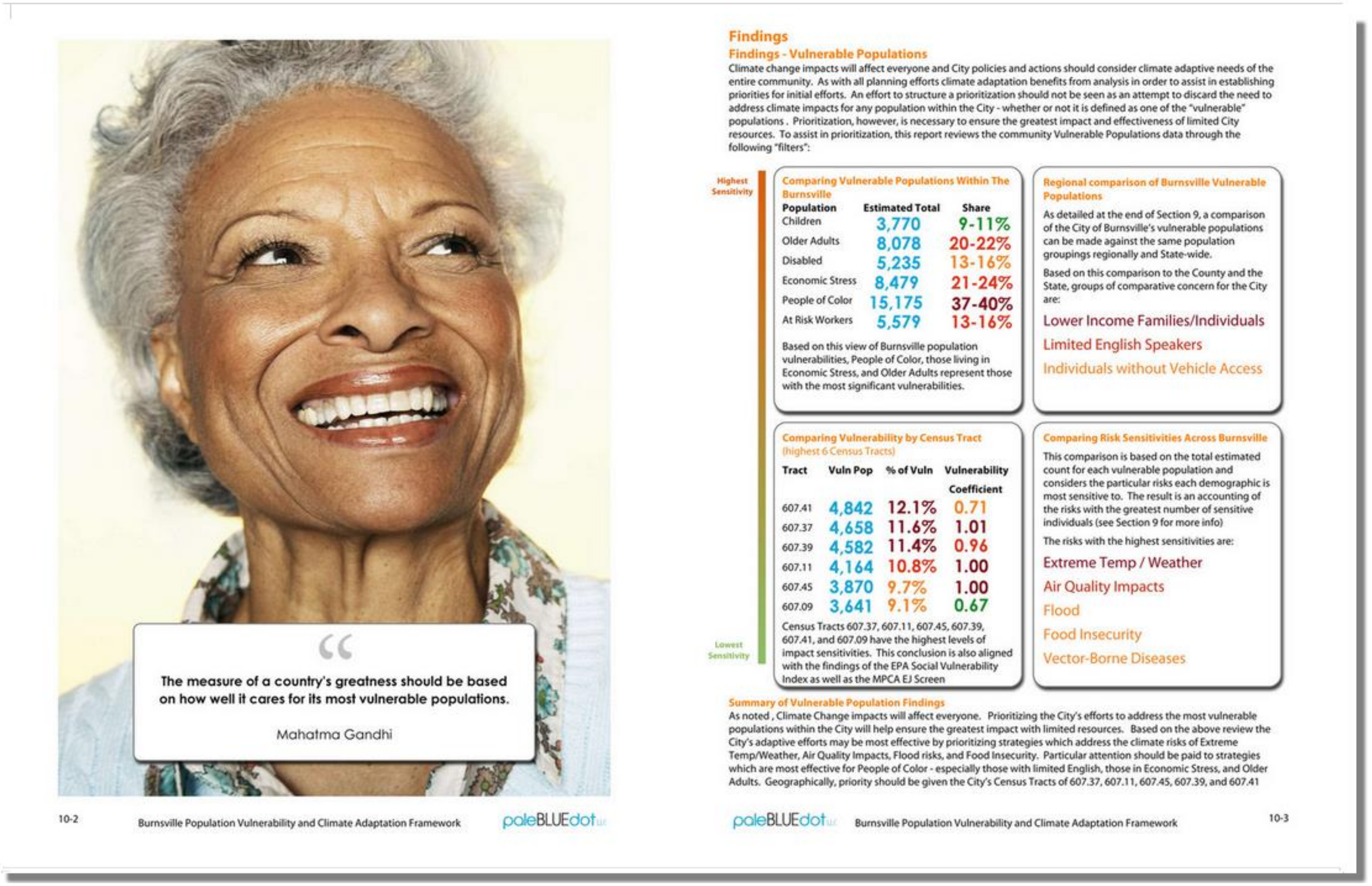
Comparison of these vulnerable populations within the **City** against **County** and **State** populations.

Case Studies **People**

Section 10

Findings



“

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

Mahatma Gandhi

10-2 Burnsville Population Vulnerability and Climate Adaptation Framework paleBLUEdot

Findings

Findings - Vulnerable Populations

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

Highest Sensitivity

Comparing Vulnerable Populations Within The Burnsville

Population	Estimated Total	Share
Children	3,770	9-11%
Older Adults	8,078	20-22%
Disabled	5,235	13-16%
Economic Stress	8,479	21-24%
People of Color	15,175	37-40%
At Risk Workers	5,579	13-16%

Based on this view of Burnsville population vulnerabilities, People of Color, those living in Economic Stress, and Older Adults represent those with the most significant vulnerabilities.

Regional comparison of Burnsville Vulnerable Populations

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

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

Lower Income Families/Individuals

Limited English Speakers

Individuals without Vehicle Access

Comparing Vulnerability by Census Tract (highest 6 Census Tracts)

Tract	Vuln Pop	% of Vuln	Vulnerability Coefficient
607.41	4,842	12.1%	0.71
607.37	4,658	11.6%	1.01
607.39	4,582	11.4%	0.96
607.11	4,164	10.8%	1.00
607.45	3,870	9.7%	1.00
607.09	3,641	9.1%	0.67

Census Tracts 607.37, 607.11, 607.45, 607.39, 607.41, and 607.09 have the highest levels of impact sensitivities. This conclusion is also aligned with the findings of the EPA Social Vulnerability Index as well as the MPCA EJ Screen

Comparing Risk Sensitivities Across Burnsville

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

The risks with the highest sensitivities are:

Extreme Temp / Weather

Air Quality Impacts

Flood

Food Insecurity

Vector-Borne Diseases

Lowest Sensitivity

Summary of Vulnerable Population Findings

As noted , Climate Change impacts will affect everyone. Prioritizing the City's efforts to address the most vulnerable populations within the City will help ensure the greatest impact with limited resources. Based on the above review the City's adaptive efforts may be most effective by prioritizing strategies which address the climate risks of Extreme Temp/Weather, Air Quality Impacts, Flood risks, and Food Insecurity. Particular attention should be paid to strategies which are most effective for People of Color - especially those with limited English, those in Economic Stress, and Older Adults. Geographically, priority should be given the City's Census Tracts of 607.37, 607.11, 607.45, 607.39, and 607.41

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City-specific focus on **prioritization** by:

Comparing vulnerable populations

Targeting geographic areas of highest vulnerability

Ranking climate risks to population based on aggregate sensitivities

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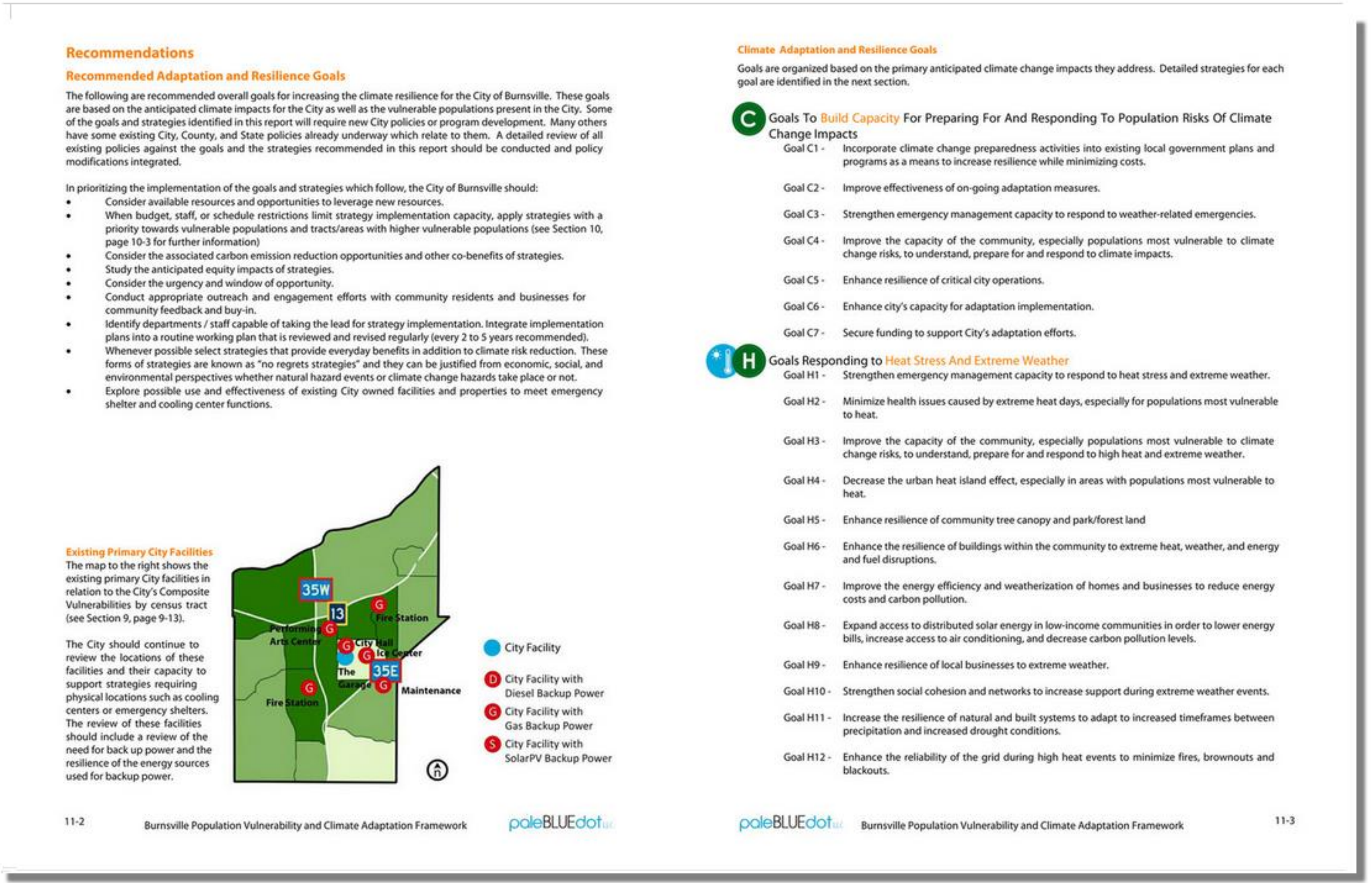
Section 11

Recommendations



Recommendations

Recommended Adaptation and Resilience Goals

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

In prioritizing the implementation of the goals and strategies which follow, the City of Burnsville should:

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

Existing Primary City Facilities

The map to the right shows the existing primary City facilities in relation to the City's Composite Vulnerabilities by census tract (see Section 9, page 9-13).

The City should continue to review the locations of these facilities and their capacity to support strategies requiring physical locations such as cooling centers or emergency shelters. The review of these facilities should include a review of the need for back up power and the resilience of the energy sources used for backup power.

Climate Adaptation and Resilience Goals

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

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

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

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

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

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

Goal C5 - Enhance resilience of critical city operations.

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

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

H Goals Responding to Heat Stress And Extreme Weather

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

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

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

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

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

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

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

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

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

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

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

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

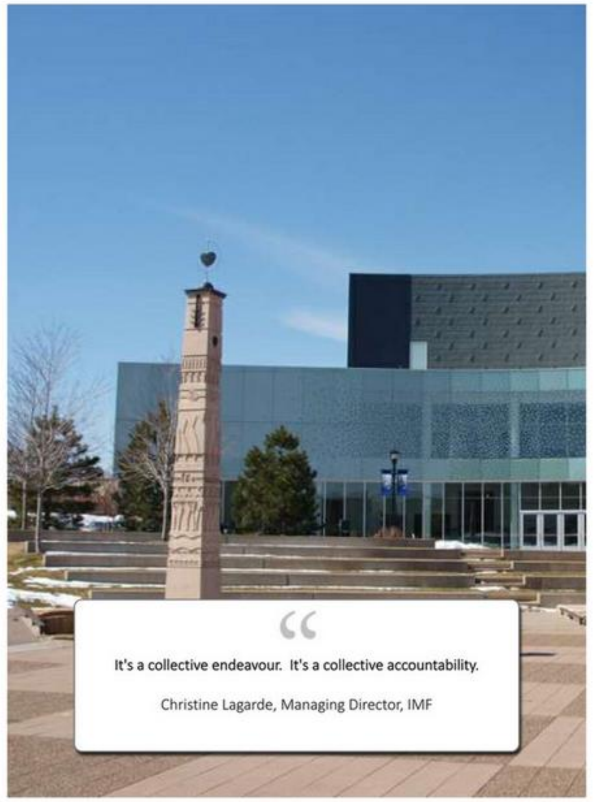
Recommendations based on the city specific **aggregate vulnerabilities**

Climate adaptation **goals**

"**menu of strategies**" which can achieve those recommended goals.

Identify city **resources** available to support adaptation action

Case Studies People



The City of Burnsville has already seen climate changes. The projections for the City's climate by the middle of this century indicate continued increases in temperatures. Additionally, precipitation patterns are anticipated to change, providing an increase in the overall rainfall as well as an increase in the number of days without rain - exacerbating both flooding and drought potential. The City's location as a metro Twin City suburb is prone to heat island effects which act as a multiplier on the overall region's climate extremes.

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

Next Steps

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

Specific recommended next steps are:

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

Section 13

Conclusions and Next Steps

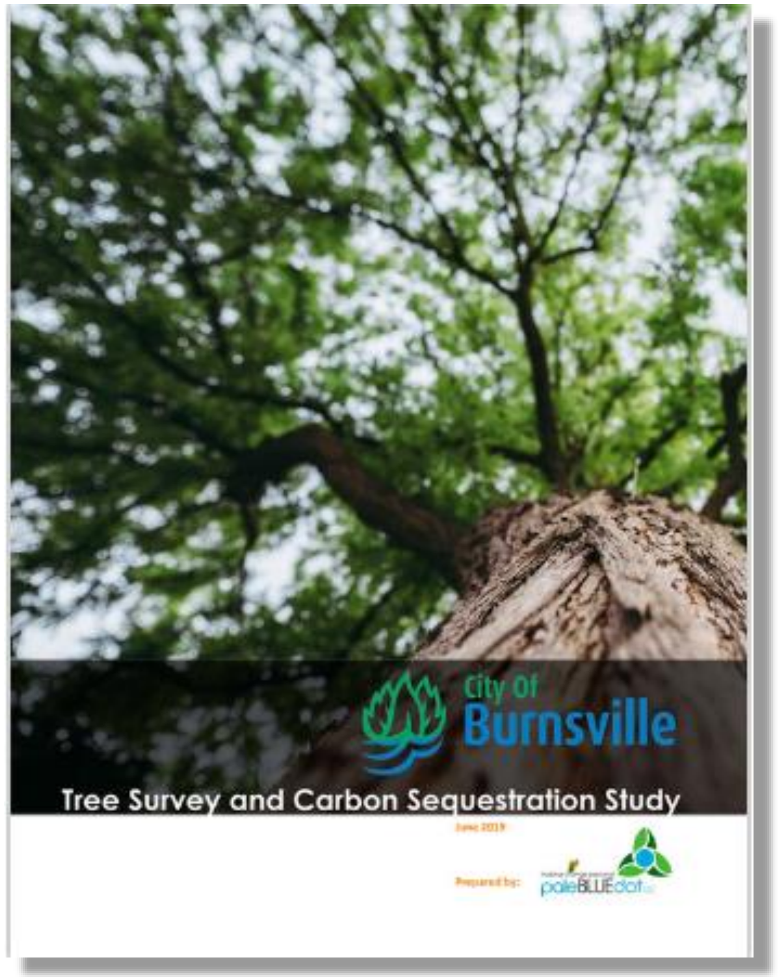
Recommended actions and appropriate next steps to accomplish them

At the completion of this effort, the city has:

- a solid understanding of underlying social, economic, and climate vulnerabilities
- ability to craft strategies to address them
- prioritized based on need, opportunity, and equity data

Case Studies Trees

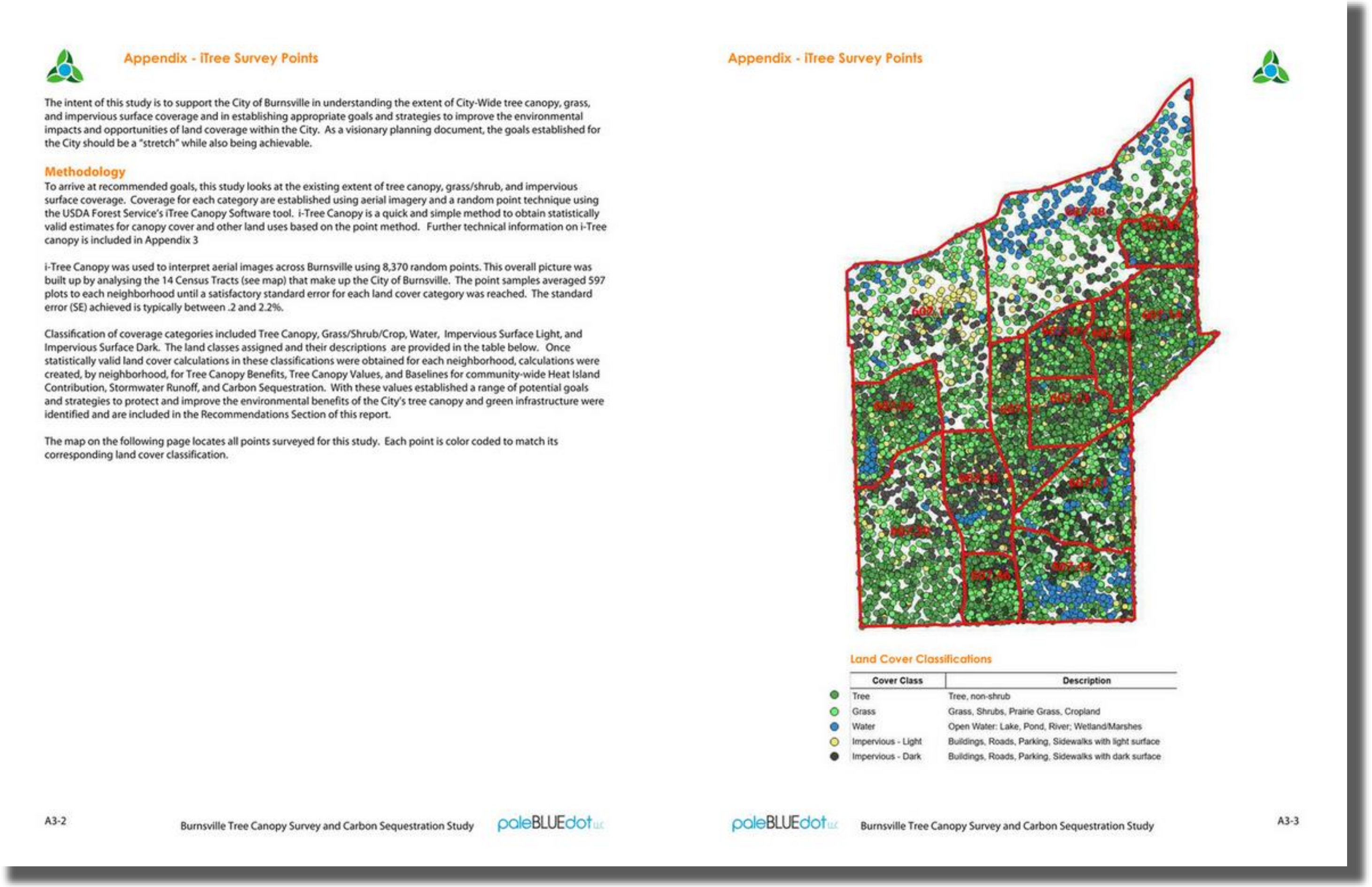
Case Studies Trees



City of Burnsville

Tree Canopy and Ground Cover Survey

Case Studies Trees



Appendix - iTree Survey Points

The intent of this study is to support the City of Burnsville in understanding the extent of City-Wide tree canopy, grass, and impervious surface coverage and in establishing appropriate goals and strategies to improve the environmental impacts and opportunities of land coverage within the City. As a visionary planning document, the goals established for the City should be a "stretch" while also being achievable.

Methodology

To arrive at recommended goals, this study looks at the existing extent of tree canopy, grass/shrub, and impervious surface coverage. Coverage for each category are established using aerial imagery and a random point technique using the USDA Forest Service's iTree Canopy Software tool. i-Tree Canopy is a quick and simple method to obtain statistically valid estimates for canopy cover and other land uses based on the point method. Further technical information on i-Tree canopy is included in Appendix 3

i-Tree Canopy was used to interpret aerial images across Burnsville using 8,370 random points. This overall picture was built up by analysing the 14 Census Tracts (see map) that make up the City of Burnsville. The point samples averaged 597 plots to each neighborhood until a satisfactory standard error for each land cover category was reached. The standard error (SE) achieved is typically between .2 and 2.2%.

Classification of coverage categories included Tree Canopy, Grass/Shrub/Crop, Water, Impervious Surface Light, and Impervious Surface Dark. The land classes assigned and their descriptions are provided in the table below. Once statistically valid land cover calculations in these classifications were obtained for each neighborhood, calculations were created, by neighborhood, for Tree Canopy Benefits, Tree Canopy Values, and Baselines for community-wide Heat Island Contribution, Stormwater Runoff, and Carbon Sequestration. With these values established a range of potential goals and strategies to protect and improve the environmental benefits of the City's tree canopy and green infrastructure were identified and are included in the Recommendations Section of this report.

The map on the following page locates all points surveyed for this study. Each point is color coded to match its corresponding land cover classification.

A3-2 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot LLC

Appendix - iTree Survey Points

Land Cover Classifications

Cover Class	Description
Tree	Tree, non-shrub
Grass	Grass, Shrubs, Prairie Grass, Cropland
Water	Open Water: Lake, Pond, River; Wetland/Marshes
Impervious - Light	Buildings, Roads, Parking, Sidewalks with light surface
Impervious - Dark	Buildings, Roads, Parking, Sidewalks with dark surface

paleBLUEdot LLC Burnsville Tree Canopy Survey and Carbon Sequestration Study A3-3

Tree Canopy impacts on stormwater management, pollution control, and carbon sequestration

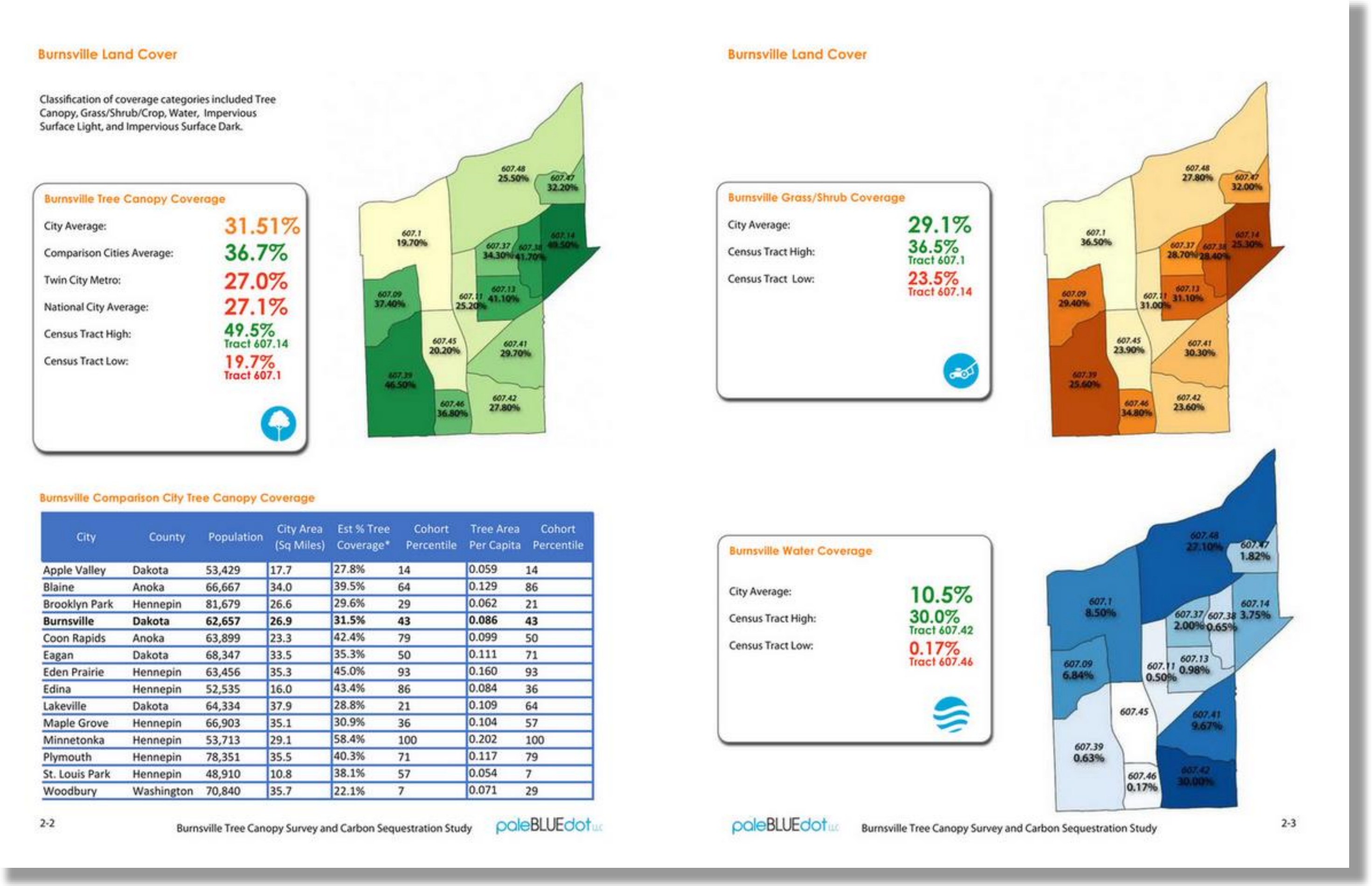
Impervious Surface influence on stormwater management and heat island impacts

Methodology

Case Studies Trees

Section 02

Burnsville Land Coverage



Burnsville Land Cover

Classification of coverage categories included Tree Canopy, Grass/Shrub/Crop, Water, Impervious Surface Light, and Impervious Surface Dark.

Burnsville Tree Canopy Coverage

City Average: 31.51%
Comparison Cities Average: 36.7%
Twin City Metro: 27.0%
National City Average: 27.1%
Census Tract High: 49.5% Tract 607.14
Census Tract Low: 19.7% Tract 607.1

Burnsville Comparison City Tree Canopy Coverage

City	County	Population	City Area (Sq Miles)	Est % Tree Coverage*	Cohort Percentile	Tree Area Per Capita	Cohort Percentile
Apple Valley	Dakota	53,429	17.7	27.8%	14	0.059	14
Blaine	Anoka	66,667	34.0	39.5%	64	0.129	86
Brooklyn Park	Hennepin	81,679	26.6	29.6%	29	0.062	21
Burnsville	**Dakota**	**62,657**	**26.9**	**31.5%**	**43**	**0.086**	**43**
Coon Rapids	Anoka	63,899	23.3	42.4%	79	0.099	50
Eagan	Dakota	68,347	33.5	35.3%	50	0.111	71
Eden Prairie	Hennepin	63,456	35.3	45.0%	93	0.160	93
Edina	Hennepin	52,535	16.0	43.4%	86	0.084	36
Lakeville	Dakota	64,334	37.9	28.8%	21	0.109	64
Maple Grove	Hennepin	66,903	35.1	30.9%	36	0.104	57
Minnetonka	Hennepin	53,713	29.1	58.4%	100	0.202	100
Plymouth	Hennepin	78,351	35.5	40.3%	71	0.117	79
St. Louis Park	Hennepin	48,910	10.8	38.1%	57	0.054	7
Woodbury	Washington	70,840	35.7	22.1%	7	0.071	29

2-2 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot LLC

Burnsville Land Cover

Burnsville Grass/Shrub Coverage

City Average: 29.1%
Census Tract High: 36.5% Tract 607.1
Census Tract Low: 23.5% Tract 607.14

Burnsville Water Coverage

City Average: 10.5%
Census Tract High: 30.0% Tract 607.42
Census Tract Low: 0.17% Tract 607.46

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Measurements by Census Tract:

Tree Canopy coverage and comparison to peer communities

Grass ground coverage

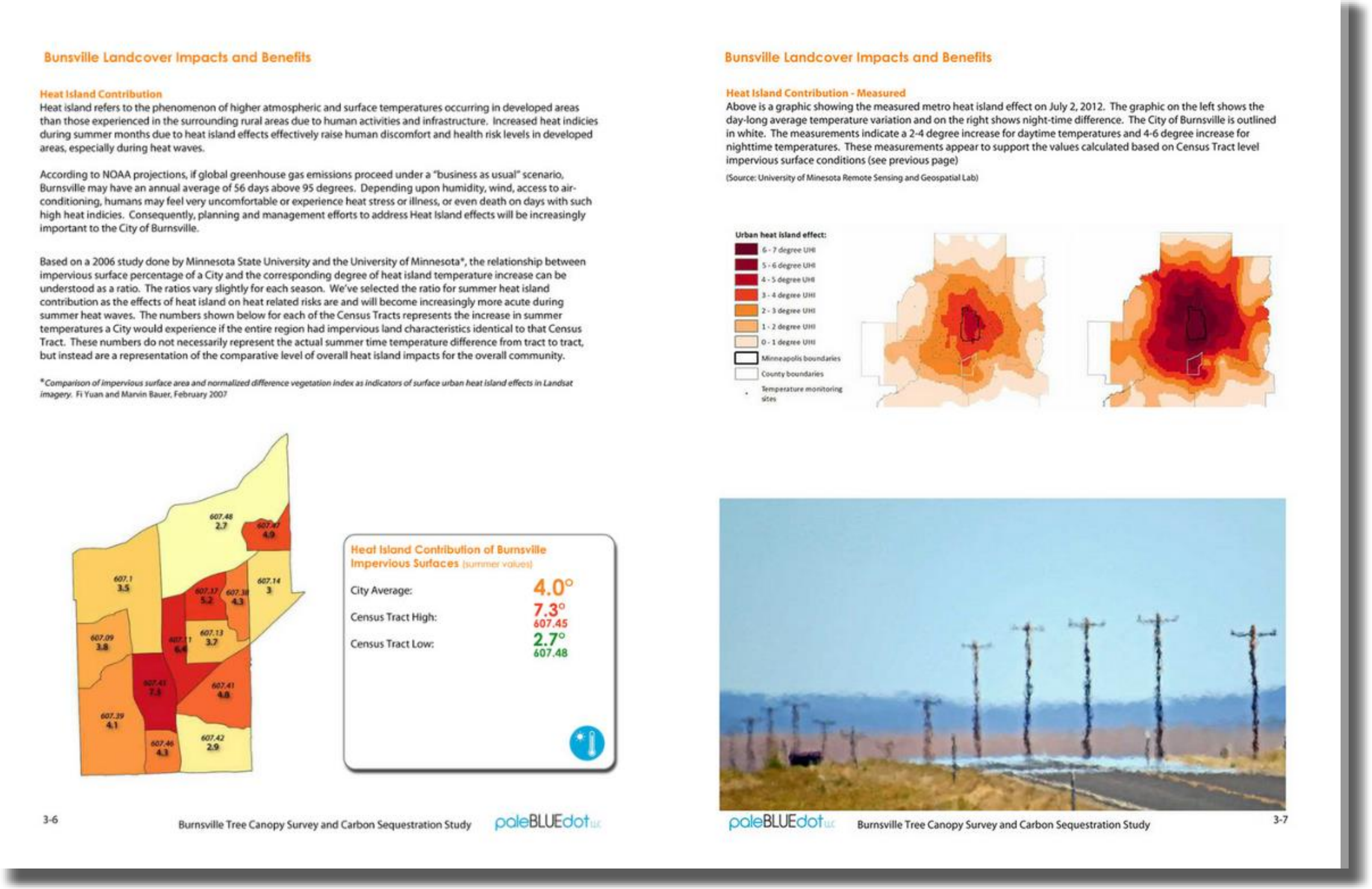
Water + Wetland coverage

Impervious surface coverage light + dark

Case Studies **Trees**

Section **03**

Landcover Impacts and Benefits



Bunsville Landcover Impacts and Benefits

Heat Island Contribution

Heat island refers to the phenomenon of higher atmospheric and surface temperatures occurring in developed areas than those experienced in the surrounding rural areas due to human activities and infrastructure. Increased heat indicies during summer months due to heat island effects effectively raise human discomfort and health risk levels in developed areas, especially during heat waves.

According to NOAA projections, if global greenhouse gas emissions proceed under a "business as usual" scenario, Burnsville may have an annual average of 56 days above 95 degrees. Depending upon humidity, wind, access to air-conditioning, humans may feel very uncomfortable or experience heat stress or illness, or even death on days with such high heat indicies. Consequently, planning and management efforts to address Heat Island effects will be increasingly important to the City of Burnsville.

Based on a 2006 study done by Minnesota State University and the University of Minnesota*, the relationship between impervious surface percentage of a City and the corresponding degree of heat island temperature increase can be understood as a ratio. The ratios vary slightly for each season. We've selected the ratio for summer heat island contribution as the effects of heat island on heat related risks are and will become increasingly more acute during summer heat waves. The numbers shown below for each of the Census Tracts represents the increase in summer temperatures a City would experience if the entire region had impervious land characteristics identical to that Census Tract. These numbers do not necessarily represent the actual summer time temperature difference from tract to tract, but instead are a representation of the comparative level of overall heat island impacts for the overall community.

**Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery.* Fi Yuan and Marvin Bauer, February 2007

Heat Island Contribution of Burnsville Impervious Surfaces (summer values)

City Average:	4.0°
Census Tract High:	7.3° 607.45
Census Tract Low:	2.7° 607.48

3-6 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot LLC

Bunsville Landcover Impacts and Benefits

Heat Island Contribution - Measured

Above is a graphic showing the measured metro heat island effect on July 2, 2012. The graphic on the left shows the day-long average temperature variation and on the right shows night-time difference. The City of Burnsville is outlined in white. The measurements indicate a 2-4 degree increase for daytime temperatures and 4-6 degree increase for nighttime temperatures. These measurements appear to support the values calculated based on Census Tract level impervious surface conditions (see previous page)

(Source: University of Minesota Remote Sensing and Geospatial Lab)

paleBLUEdot LLC Burnsville Tree Canopy Survey and Carbon Sequestration Study 3-7

Calculate by **Census Tract:**

Pollution absorption by trees

Energy savings by trees

Heat Island impacts and benefits

Case Studies **Trees**

Bunsville Landcover Impacts and Benefits

Stormwater Runoff and Management by Green Infrastructure

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

According to data from National Climatic Data Center and NOAA, Burnsville receives 33" of rainfall and 51" of snowfall, for an equivalent of 36.9" of water precipitation annually. That total precipitation level and the impervious surface coverages can then be used to estimate the total stormwater runoff values by neighborhood as indicated below.

Stormwater Runoff and Management by Green Infrastructure

Green Infrastructure such as native grasses, wetlands, and especially trees are a critical stormwater management tool. Healthy green infrastructure within a community can help protect, restore, and mimic the natural water cycle - which has typically been significantly impacted through community development.

To estimate the total stormwater uptake, in gallons, by neighborhood, we have used calculations developed by stormwater sustainability specialist Aarin Teague and US Forestry Service forester Eric Kuehler. Detailed values can only be calculated using detailed soil hydrology data and accurate runoff curve numbers. As that level of detail is not a part of this study, we've used curve number averaged across soil groups A-D for "fair" hydrology and cover conditions. The result should not be considered an accurate indication of total uptake volumes, but rather as an "order of magnitude" analysis tool for comparison between neighborhoods.

The maps on the following page indicate the estimated total annual water uptake of trees and of grass/open land as well as the total green infrastructure water uptake as a percentage of the total stormwater runoff of each neighborhood.

3-8 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot LLC

paleBLUEdot LLC Burnsville Tree Canopy Survey and Carbon Sequestration Study 3-9

Section **03**

Landcover Impacts and Benefits

Calculate by **Census Tract:**

Pollution absorption by trees

Energy savings by trees

Heat Island impacts and benefits

Stormwater **runoff + uptake**

Carbon **sequestration + storage**.

Case Studies Trees

Section 04

Burnsville Tree Canopy Economic Value


Burnsville Tree Canopy Economic Value

In recent years, several computer models have been developed by the USDA Forest Service and collaborators to assist cities in assessing the value and environmental benefits of their tree resources. Each of the benefits outlined in Section 3 of this report have economic benefit as well as environmental benefit.

Air Pollution Removal Values

The air pollutants estimated are the six criteria pollutants included in Section 3 of this report, defined by the U.S. Environmental Protection Agency (EPA); carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), sulfur dioxide (SO2), and particulate matter (PM), which includes particulate matter less than 2.5 microns (PM2.5) and particulate matter greater than 2.5 and less than 10 microns (PM10).

Air pollution removal value estimates are based on procedures detailed in Nowak et al. (2014). This process used local tree cover, leaf area index, percent evergreen, weather, pollution, and population data to estimate pollution removal (g/m2 tree cover) and values ($/m2 tree cover) in urban and rural areas. Current i-Tree Canopy Annual Tree Benefit Estimate values per ton of pollution removed are: CO at $1,333.50; NO2 at $477.89; O3 at $2,443.66; PM2.5 at $91,955.05; SO2 at $163.18; PM10 at $6,268.44, and CO2 sequestration at $35.38.

Building Energy Savings Values

As outlined in Section 3 of this report, building energy savings values can be estimated using average energy affecting tree counts per acre, by community density type, established through the study "Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States." Using these averages, we can estimate the total electrical and natural gas savings contributed by Burnsville's tree canopy.

Building energy savings values are then estimated using an average of $0.10 per kWH of electricity and $0.65 per Therm

Air Pollution Value Provided by Burnsville Tree Canopy Annually

City Total:

$1.279.894

Energy Savings Value Provided by Burnsville Tree Canopy Annually

City Total:

$7.796.219

4-2 Burnsville Tree Canopy Survey and Carbon Sequestration Study

Burnsville Tree Canopy Economic Value

Total Economic Value combines the total Air Pollution Removal value and Building Energy Savings values. It should be noted that the total land area encompassed by each neighborhood differs. Consequently, the total values shown do not necessarily represent tree canopy equity - ie a very large neighborhood with poor tree canopy coverage may still have a higher total tree canopy value than a small neighborhood with excellent canopy coverage. Tree Canopy value equity will be explored through "value per acre" and "value per household" assessments later in this Section.

Total Value Provided by Burnsville Tree Canopy Annually

City of Total:

$9.094.113

Burnsville Tree Canopy Survey and Carbon Sequestration Study 4-3

Calculate by Census Tract:

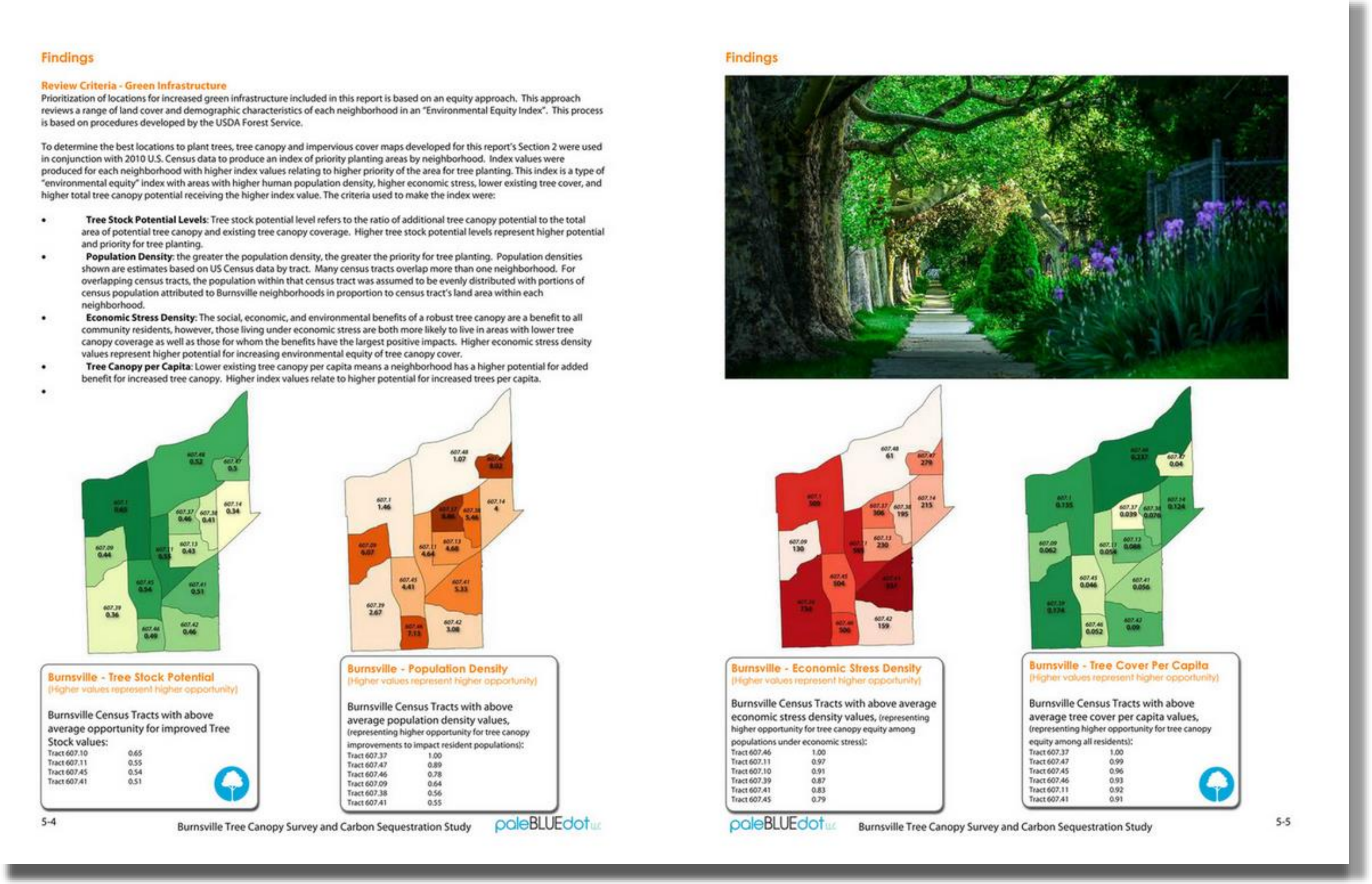
Economic value of Pollution absorption + Energy savings

- **Absolute value**
- **value per acre**
- **value per family**
- **Supporting an equity framework**

Case Studies Trees

Section 05

Findings


Findings

Review Criteria - Green Infrastructure

Prioritization of locations for increased green infrastructure included in this report is based on an equity approach. This approach reviews a range of land cover and demographic characteristics of each neighborhood in an "Environmental Equity Index". This process is based on procedures developed by the USDA Forest Service.

To determine the best locations to plant trees, tree canopy and impervious cover maps developed for this report's Section 2 were used in conjunction with 2010 U.S. Census data to produce an index of priority planting areas by neighborhood. Index values were produced for each neighborhood with higher index values relating to higher priority of the area for tree planting. This index is a type of "environmental equity" index with areas with higher human population density, higher economic stress, lower existing tree cover, and higher total tree canopy potential receiving the higher index value. The criteria used to make the index were:

- **Tree Stock Potential Levels**: Tree stock potential level refers to the ratio of additional tree canopy potential to the total area of potential tree canopy and existing tree canopy coverage. Higher tree stock potential levels represent higher potential and priority for tree planting.
- **Population Density**: the greater the population density, the greater the priority for tree planting. Population densities shown are estimates based on US Census data by tract. Many census tracts overlap more than one neighborhood. For overlapping census tracts, the population within that census tract was assumed to be evenly distributed with portions of census population attributed to Burnsville neighborhoods in proportion to census tract's land area within each neighborhood.
- **Economic Stress Density**: The social, economic, and environmental benefits of a robust tree canopy are a benefit to all community residents, however, those living under economic stress are both more likely to live in areas with lower tree canopy coverage as well as those for whom the benefits have the largest positive impacts. Higher economic stress density values represent higher potential for increasing environmental equity of tree canopy cover.
- **Tree Canopy per Capita**: Lower existing tree canopy per capita means a neighborhood has a higher potential for added benefit for increased tree canopy. Higher index values relate to higher potential for increased trees per capita.

Burnsville - Tree Stock Potential
(Higher values represent higher opportunity)

Burnsville Census Tracts with above average opportunity for improved Tree Stock values:

Tract 607.10	0.65
Tract 607.11	0.55
Tract 607.45	0.54
Tract 607.41	0.51

Burnsville - Population Density
(Higher values represent higher opportunity)

Burnsville Census Tracts with above average population density values, (representing higher opportunity for tree canopy improvements to impact resident populations):

Tract 607.37	1.00
Tract 607.47	0.89
Tract 607.46	0.78
Tract 607.09	0.64
Tract 607.38	0.56
Tract 607.41	0.55

5-4 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot LLC

Findings

Burnsville - Economic Stress Density
(Higher values represent higher opportunity)

Burnsville Census Tracts with above average economic stress density values, (representing higher opportunity for tree canopy equity among populations under economic stress):

Tract 607.46	1.00
Tract 607.11	0.97
Tract 607.10	0.91
Tract 607.39	0.87
Tract 607.41	0.83
Tract 607.45	0.79

Burnsville - Tree Cover Per Capita
(Higher values represent higher opportunity)

Burnsville Census Tracts with above average tree cover per capita values, (representing higher opportunity for tree canopy equity among all residents):

Tract 607.37	1.00
Tract 607.47	0.99
Tract 607.45	0.96
Tract 607.46	0.93
Tract 607.11	0.92
Tract 607.41	0.91

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Assessments by Census Tract:

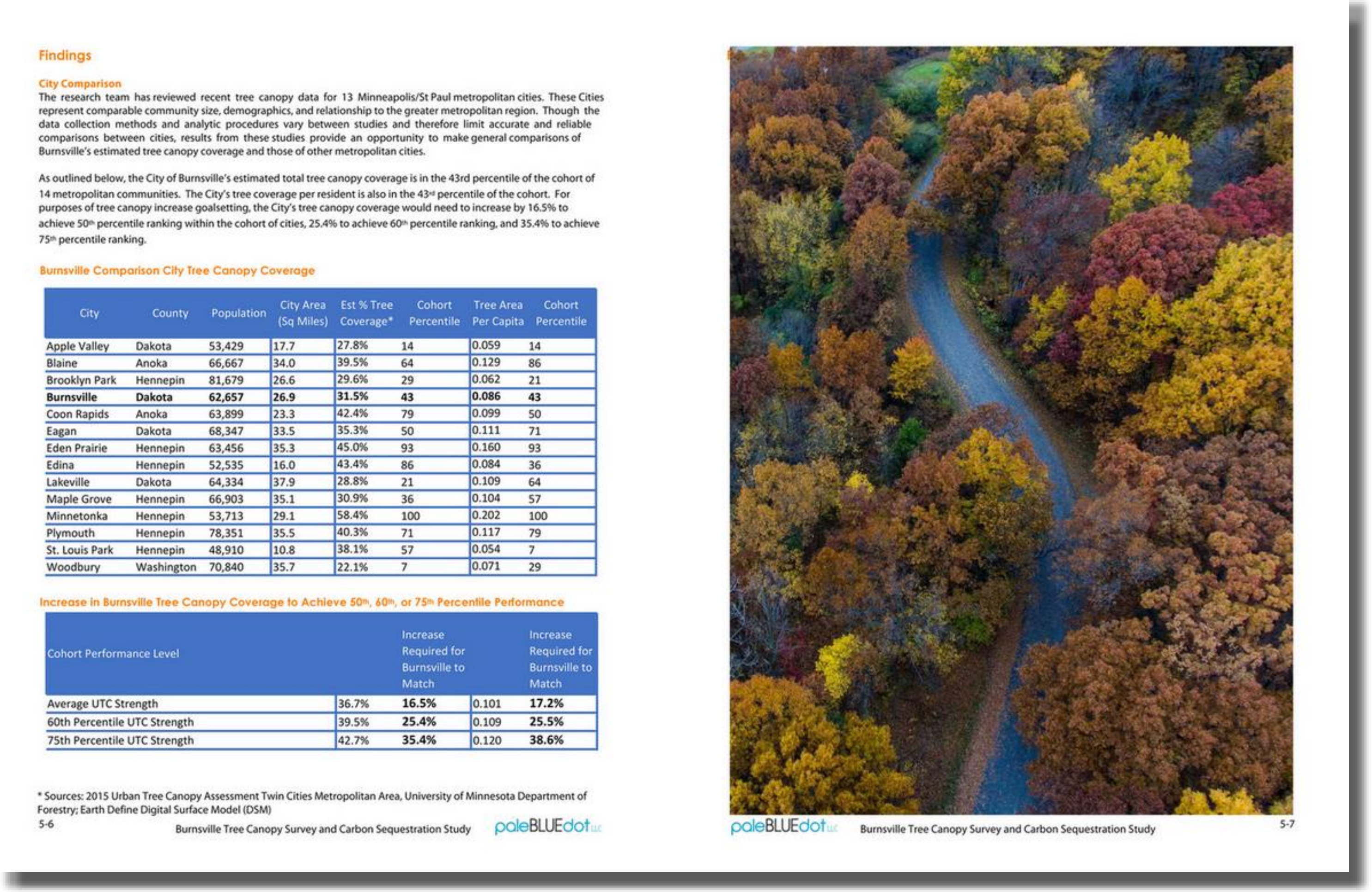
Land coverage comparison by tract.

Identification of tracts with greatest need + opportunity

Case Studies Trees

Section 05

Findings



Findings

City Comparison

The research team has reviewed recent tree canopy data for 13 Minneapolis/St Paul metropolitan cities. These Cities represent comparable community size, demographics, and relationship to the greater metropolitan region. Though the data collection methods and analytic procedures vary between studies and therefore limit accurate and reliable comparisons between cities, results from these studies provide an opportunity to make general comparisons of Burnsville's estimated tree canopy coverage and those of other metropolitan cities.

As outlined below, the City of Burnsville's estimated total tree canopy coverage is in the 43rd percentile of the cohort of 14 metropolitan communities. The City's tree coverage per resident is also in the 43rd percentile of the cohort. For purposes of tree canopy increase goalsetting, the City's tree canopy coverage would need to increase by 16.5% to achieve 50th percentile ranking within the cohort of cities, 25.4% to achieve 60th percentile ranking, and 35.4% to achieve 75th percentile ranking.

Burnsville Comparison City Tree Canopy Coverage

City	County	Population	City Area (Sq Miles)	Est % Tree Coverage*	Cohort Percentile	Tree Area Per Capita	Cohort Percentile
Apple Valley	Dakota	53,429	17.7	27.8%	14	0.059	14
Blaine	Anoka	66,667	34.0	39.5%	64	0.129	86
Brooklyn Park	Hennepin	81,679	26.6	29.6%	29	0.062	21
Burnsville	**Dakota**	**62,657**	**26.9**	**31.5%**	**43**	**0.086**	**43**
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Plymouth	Hennepin	78,351	35.5	40.3%	71	0.117	79
St. Louis Park	Hennepin	48,910	10.8	38.1%	57	0.054	7
Woodbury	Washington	70,840	35.7	22.1%	7	0.071	29

Increase in Burnsville Tree Canopy Coverage to Achieve 50th, 60th, or 75th Percentile Performance

Cohort Performance Level		Increase Required for Burnsville to Match		Increase Required for Burnsville to Match
Average UTC Strength	36.7%	**16.5%**	0.101	**17.2%**
60th Percentile UTC Strength	39.5%	**25.4%**	0.109	**25.5%**
75th Percentile UTC Strength	42.7%	**35.4%**	0.120	**38.6%**

* Sources: 2015 Urban Tree Canopy Assessment Twin Cities Metropolitan Area, University of Minnesota Department of Forestry; Earth Define Digital Surface Model (DSM)

Assessments by Census Tract:

Land coverage comparison by tract.

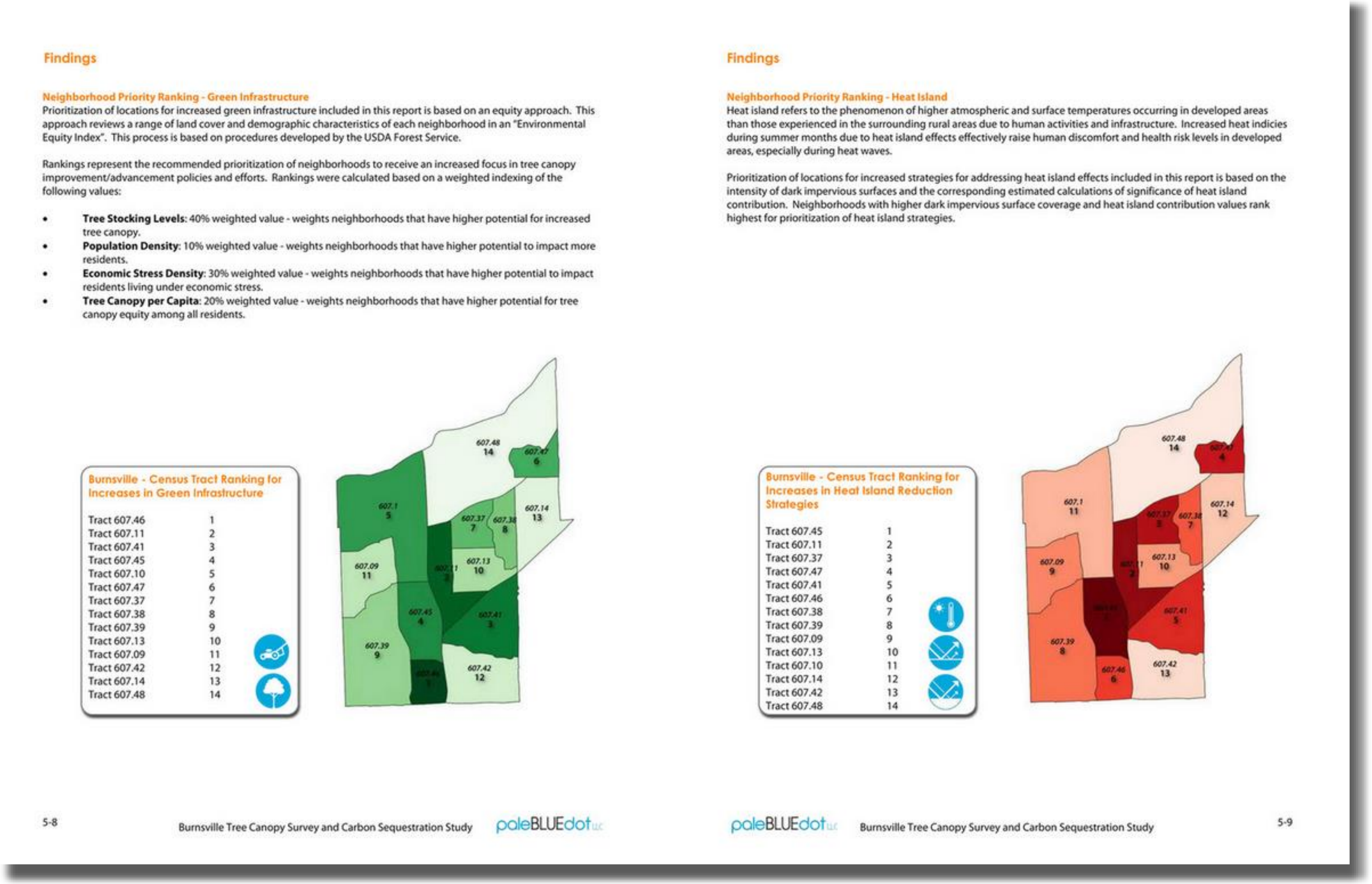
Identification of tracts with greatest need + opportunity

Community comparison + goal setting

Case Studies Trees

Section 05

Findings


Findings

Neighborhood Priority Ranking - Green Infrastructure

Prioritization of locations for increased green infrastructure included in this report is based on an equity approach. This approach reviews a range of land cover and demographic characteristics of each neighborhood in an "Environmental Equity Index". This process is based on procedures developed by the USDA Forest Service.

Rankings represent the recommended prioritization of neighborhoods to receive an increased focus in tree canopy improvement/advancement policies and efforts. Rankings were calculated based on a weighted indexing of the following values:

- **Tree Stocking Levels**: 40% weighted value - weights neighborhoods that have higher potential for increased tree canopy.
- **Population Density**: 10% weighted value - weights neighborhoods that have higher potential to impact more residents.
- **Economic Stress Density**: 30% weighted value - weights neighborhoods that have higher potential to impact residents living under economic stress.
- **Tree Canopy per Capita**: 20% weighted value - weights neighborhoods that have higher potential for tree canopy equity among all residents.

Burnsville - Census Tract Ranking for Increases in Green Infrastructure

Tract 607.46	1
Tract 607.11	2
Tract 607.41	3
Tract 607.45	4
Tract 607.10	5
Tract 607.47	6
Tract 607.37	7
Tract 607.38	8
Tract 607.39	9
Tract 607.13	10
Tract 607.09	11
Tract 607.42	12
Tract 607.14	13
Tract 607.48	14

5-8 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot

Findings

Neighborhood Priority Ranking - Heat Island

Heat island refers to the phenomenon of higher atmospheric and surface temperatures occurring in developed areas than those experienced in the surrounding rural areas due to human activities and infrastructure. Increased heat indicies during summer months due to heat island effects effectively raise human discomfort and health risk levels in developed areas, especially during heat waves.

Prioritization of locations for increased strategies for addressing heat island effects included in this report is based on the intensity of dark impervious surfaces and the corresponding estimated calculations of significance of heat island contribution. Neighborhoods with higher dark impervious surface coverage and heat island contribution values rank highest for prioritization of heat island strategies.

Burnsville - Census Tract Ranking for Increases in Heat Island Reduction Strategies

Tract 607.45	1
Tract 607.11	2
Tract 607.37	3
Tract 607.47	4
Tract 607.41	5
Tract 607.46	6
Tract 607.38	7
Tract 607.39	8
Tract 607.09	9
Tract 607.13	10
Tract 607.10	11
Tract 607.14	12
Tract 607.42	13
Tract 607.48	14

paleBLUEdot Burnsville Tree Canopy Survey and Carbon Sequestration Study 5-9

Assessments by Census Tract:

Land coverage comparison by tract.

Identification of tracts with greatest need + opportunity

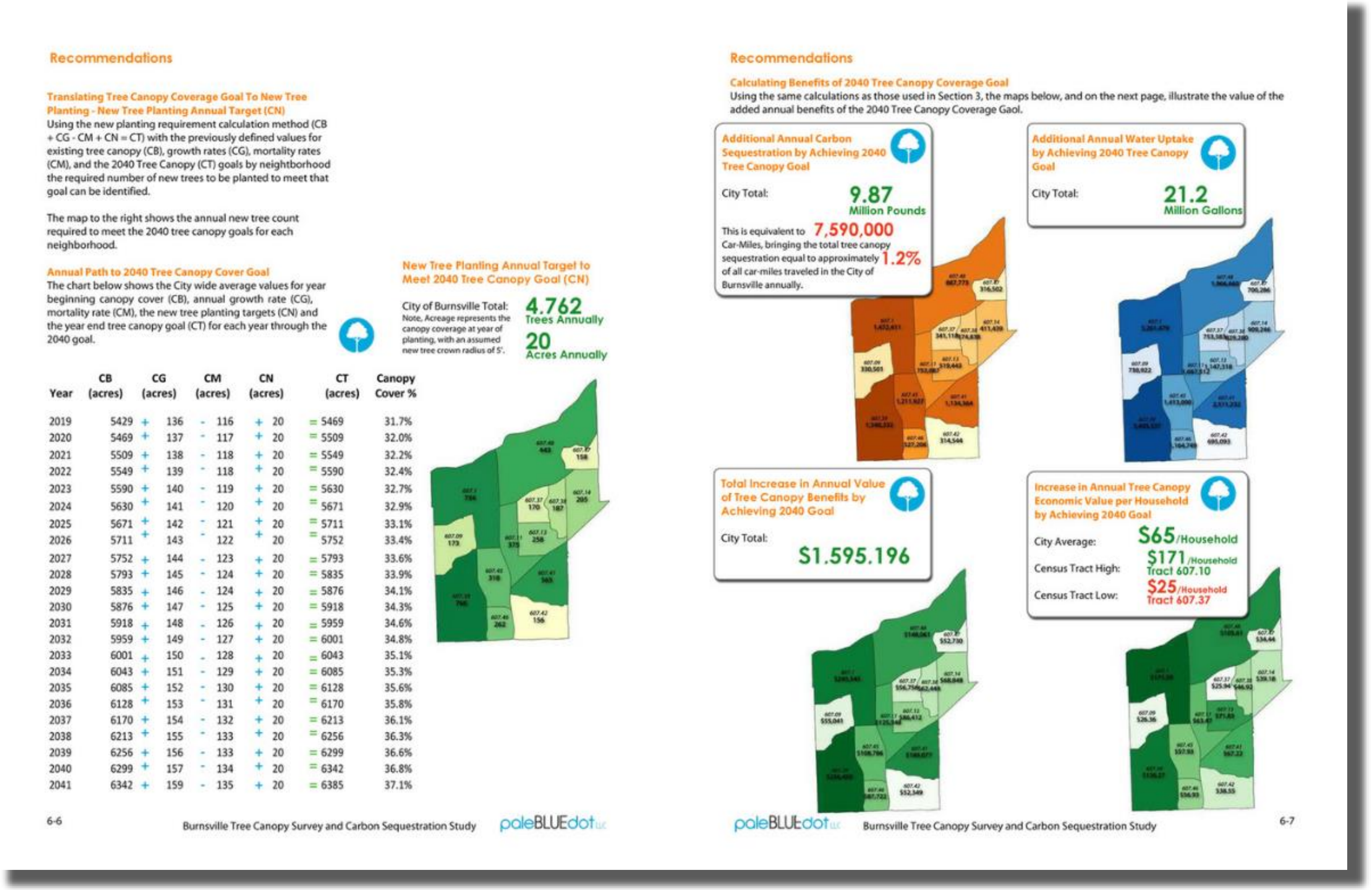
Community comparison + goal setting

Prioritize neighborhoods for tree canopy and heat island strategies based on need, opportunity, vulnerability and equity data

Case Studies Trees

Section 06

Recommendations



Recommendations

Translating Tree Canopy Coverage Goal To New Tree Planting - New Tree Planting Annual Target (CN)

Using the new planting requirement calculation method (CB + CG - CM + CN = CT) with the previously defined values for existing tree canopy (CB), growth rates (CG), mortality rates (CM), and the 2040 Tree Canopy (CT) goals by neighborhood the required number of new trees to be planted to meet that goal can be identified.

The map to the right shows the annual new tree count required to meet the 2040 tree canopy goals for each neighborhood.

Annual Path to 2040 Tree Canopy Cover Goal

The chart below shows the City wide average values for year beginning canopy cover (CB), annual growth rate (CG), mortality rate (CM), the new tree planting targets (CN) and the year end tree canopy goal (CT) for each year through the 2040 goal.

Year	CB (acres)		CG (acres)		CM (acres)		CN (acres)		CT (acres)	Canopy Cover %
2019	5429	+	136	-	116	+	20	=	5469	31.7%
2020	5469	+	137	-	117	+	20	=	5509	32.0%
2021	5509	+	138	-	118	+	20	=	5549	32.2%
2022	5549	+	139	-	118	+	20	=	5590	32.4%
2023	5590	+	140	-	119	+	20	=	5630	32.7%
2024	5630	+	141	-	120	+	20	=	5671	32.9%
2025	5671	+	142	-	121	+	20	=	5711	33.1%
2026	5711	+	143	-	122	+	20	=	5752	33.4%
2027	5752	+	144	-	123	+	20	=	5793	33.6%
2028	5793	+	145	-	124	+	20	=	5835	33.9%
2029	5835	+	146	-	124	+	20	=	5876	34.1%
2030	5876	+	147	-	125	+	20	=	5918	34.3%
2031	5918	+	148	-	126	+	20	=	5959	34.6%
2032	5959	+	149	-	127	+	20	=	6001	34.8%
2033	6001	+	150	-	128	+	20	=	6043	35.1%
2034	6043	+	151	-	129	+	20	=	6085	35.3%
2035	6085	+	152	-	130	+	20	=	6128	35.6%
2036	6128	+	153	-	131	+	20	=	6170	35.8%
2037	6170	+	154	-	132	+	20	=	6213	36.1%
2038	6213	+	155	-	133	+	20	=	6256	36.3%
2039	6256	+	156	-	133	+	20	=	6299	36.6%
2040	6299	+	157	-	134	+	20	=	6342	36.8%
2041	6342	+	159	-	135	+	20	=	6385	37.1%

New Tree Planting Annual Target to Meet 2040 Tree Canopy Goal (CN)

City of Burnsville Total: 4,762 Trees Annually

Note, Acreage represents the canopy coverage at year of planting, with an assumed new tree crown radius of 5'. 20 Acres Annually

6-6 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot

Recommendations

Calculating Benefits of 2040 Tree Canopy Coverage Goal

Using the same calculations as those used in Section 3, the maps below, and on the next page, illustrate the value of the added annual benefits of the 2040 Tree Canopy Coverage Gaol.

Additional Annual Carbon Sequestration by Achieving 2040 Tree Canopy Goal

City Total: 9.87 Million Pounds

This is equivalent to 7,590,000 Car-Miles, bringing the total tree canopy sequestration equal to approximately 1.2% of all car-miles traveled in the City of Burnsville annually.

Additional Annual Water Uptake by Achieving 2040 Tree Canopy Goal

City Total: 21.2 Million Gallons

Total Increase in Annual Value of Tree Canopy Benefits by Achieving 2040 Goal

City Total: $1.595.196

Increase in Annual Tree Canopy Economic Value per Household by Achieving 2040 Goal

City Average: $65/Household

Census Tract High: $171/Household Tract 607.10

Census Tract Low: $25/Household Tract 607.37

paleBLUEdot Burnsville Tree Canopy Survey and Carbon Sequestration Study 6-7

Recommendations by Census Tract:

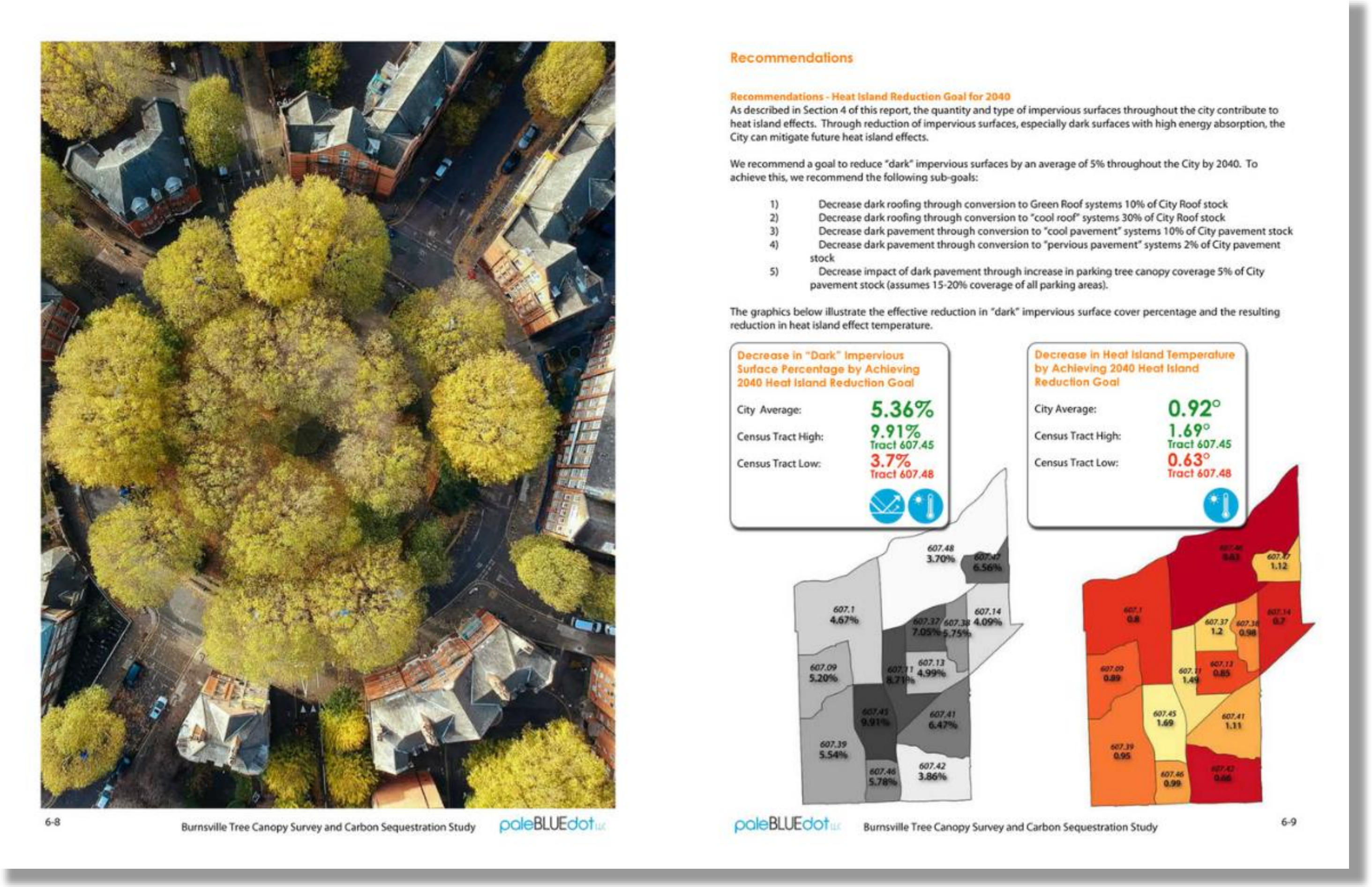
Tree Canopy coverage goals

Projected annual tree loss, growth rate, and **planting required to hit targets**

Case Studies **Trees**

Section **06**

Recommendations


Recommendations

Recommendations - Heat Island Reduction Goal for 2040

As described in Section 4 of this report, the quantity and type of impervious surfaces throughout the city contribute to heat island effects. Through reduction of impervious surfaces, especially dark surfaces with high energy absorption, the City can mitigate future heat island effects.

We recommend a goal to reduce "dark" impervious surfaces by an average of 5% throughout the City by 2040. To achieve this, we recommend the following sub-goals:

1) Decrease dark roofing through conversion to Green Roof systems 10% of City Roof stock
2) Decrease dark roofing through conversion to "cool roof" systems 30% of City Roof stock
3) Decrease dark pavement through conversion to "cool pavement" systems 10% of City pavement stock
4) Decrease dark pavement through conversion to "pervious pavement" systems 2% of City pavement stock
5) Decrease impact of dark pavement through increase in parking tree canopy coverage 5% of City pavement stock (assumes 15-20% coverage of all parking areas).

The graphics below illustrate the effective reduction in "dark" impervious surface cover percentage and the resulting reduction in heat island effect temperature.

Decrease in "Dark" Impervious Surface Percentage by Achieving 2040 Heat Island Reduction Goal

City Average: 5.36%
Census Tract High: 9.91% Tract 607.45
Census Tract Low: 3.7% Tract 607.48

Decrease in Heat Island Temperature by Achieving 2040 Heat Island Reduction Goal

City Average: 0.92°
Census Tract High: 1.69° Tract 607.45
Census Tract Low: 0.63° Tract 607.48

6-8 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot

paleBLUEdot Burnsville Tree Canopy Survey and Carbon Sequestration Study 6-9

Recommendations by **Census Tract:**

Tree Canopy coverage goals

Projected annual tree loss, growth rate, and **planting required to hit targets**

Impervious reduction goals

Calculated **heat island benefits**

Case Studies Trees

Section 07

Menu of Strategies

Menu of Strategies

Lawns and grasslands

L1: Increase pollinator supportiveness of lawns and grasslands in City of Burnsville

L1-1
Conduct a city-wide pollinator habitat assessment and pollinator corridor master plan

L1-2
Develop a pollinator management plan for all city owned and maintained properties.

L1-3
Encourage pollinator friendly green roof development

L1-4
Explore the conversion of boulevard and center island grass plantings to permaculture systems at roads and parking lots.

L1-5
Research, draft, and enact a City of Burnsville Pollinator Support resolution.

L2: Increase Carbon Sequestration values of lawns and grasslands in City of Burnsville

L2-1
Explore implementation of "carbon gardening" practices at city owned properties. Explore options for the elimination of synthetic fertilizer and pesticide use, high mow deck settings, use of biochar amendments, and polyculture lawn mixture.

L2-2
Promote "Carbon Gardening" practices among residents for lawns, ornamental gardens, and produce gardens. Strategies include elimination of synthetic fertilizer and pesticide use, high mow deck settings, use of biochar amendments, and polyculture lawn mixture.

L2-3
Implement a biochar soil amendment for all building and earth working construction sites – improves soil sequestration and builds carbon content of topsoil, and improves water retention and permeability characteristics.

L2-4
Require soil profile rebuilding at all building project sites or compacted soil conditions to reduce erosion and runoff contaminated with fertilizers, increase soil carbon stores and support long-term soil building

L2-5
In conjunction with biochar and soil profile rebuilding requirements, establish a building ordinance requirement to measure soil carbon content prior to and following building and earth working construction projects.

L2-6
Promote the conversion of portions of manicured lawns to restored native prairie/wild flower grasses.

7-2 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot

Menu of Strategies

Tree Canopy

T1: Promote Heat Island awareness and education among residents and businesses

T1-1
Develop educational and informational resources explaining the values and multiple benefits strategically planting trees have for property owners and users to share with residents and businesses.

T2: Increase tree canopy coverage city-wide to meet long-term canopy goals for each neighborhood

T2-1
Conduct a Tree Survey and Carbon Sequestration update at regular intervals (3-5 years) to report on progress and adjust long-term goals and strategies accordingly.

T2-2
Identify strategic locations for increased tree planting capable of meeting long-term canopy goals and develop long range implementation program.

T2-3
Establish a climate adaptive tree plant list for use at all city managed sites and promote with residents, businesses, and contractors within the City. Climate Adaptive plant list should include regional native species that will be strong competitors supporting the adaptation of broader ecosystem.

T2-4
Explore development of additional tree protection and planting ordinances to meet long-term goals.

T2-5
Explore development of additional incentives for tree planting, particularly in targeted areas within the City.

T2-6
Explore development of ordinances specifying a site tree cover equal to the City's 2040 average City tree canopy goal for all building projects requiring site plan approval.

T1-7
The City should explore reserving appropriate lands for the development of a nursery and conduct a study to determine the feasibility of producing its own nursery stock versus entering into a long term relationship with a local grower

T2-8
The City should establish a Citizen Urban Forest Advisory Committee to support the development and execution of public education and engagement, and identification strategies to expand the tree canopy on private land within the City.

T3: Increase resilience of Burnsville tree canopy

T3-1
To anticipate the total city-wide impact of the future loss of Ash trees, we recommend a detailed tree species distribution study be conducted in order to accurately estimate the species make-up of the Burnsville tree canopy.

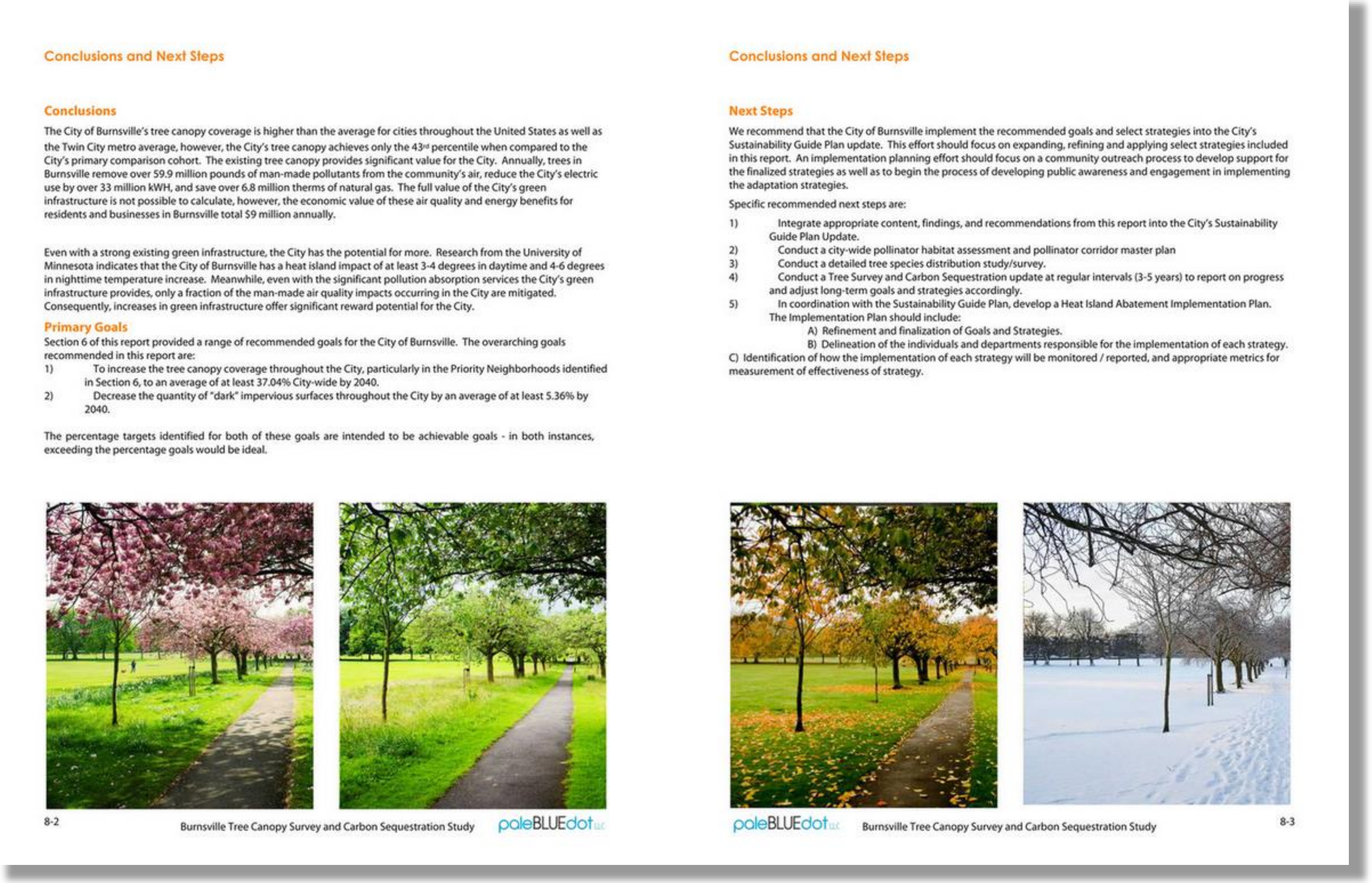
T3-2
Encourage the planting of replacement trees in anticipation of mortality from emerald ash borer and before actual loss of canopy trees in order to diversify age structures.

paleBLUEdot Burnsville Tree Canopy Survey and Carbon Sequestration Study 7-3

Detailed strategies to achieve goals

- Trees
- Grassland + Lawns
- Heat Island Mitigation

Case Studies Trees



Conclusions and Next Steps

Conclusions

The City of Burnsville's tree canopy coverage is higher than the average for cities throughout the United States as well as the Twin City metro average, however, the City's tree canopy achieves only the 43rd percentile when compared to the City's primary comparison cohort. The existing tree canopy provides significant value for the City. Annually, trees in Burnsville remove over 59.9 million pounds of man-made pollutants from the community's air, reduce the City's electric use by over 33 million kWH, and save over 6.8 million therms of natural gas. The full value of the City's green infrastructure is not possible to calculate, however, the economic value of these air quality and energy benefits for residents and businesses in Burnsville total $9 million annually.

Even with a strong existing green infrastructure, the City has the potential for more. Research from the University of Minnesota indicates that the City of Burnsville has a heat island impact of at least 3-4 degrees in daytime and 4-6 degrees in nighttime temperature increase. Meanwhile, even with the significant pollution absorption services the City's green infrastructure provides, only a fraction of the man-made air quality impacts occurring in the City are mitigated. Consequently, increases in green infrastructure offer significant reward potential for the City.

Primary Goals

Section 6 of this report provided a range of recommended goals for the City of Burnsville. The overarching goals recommended in this report are:

1) To increase the tree canopy coverage throughout the City, particularly in the Priority Neighborhoods identified in Section 6, to an average of at least 37.04% City-wide by 2040.
2) Decrease the quantity of "dark" impervious surfaces throughout the City by an average of at least 5.36% by 2040.

The percentage targets identified for both of these goals are intended to be achievable goals - in both instances, exceeding the percentage goals would be ideal.

8-2 Burnsville Tree Canopy Survey and Carbon Sequestration Study paleBLUEdot

Conclusions and Next Steps

Next Steps

We recommend that the City of Burnsville implement the recommended goals and select strategies into the City's Sustainability Guide Plan update. This effort should focus on expanding, refining and applying select strategies included in this report. An implementation planning effort should focus on a community outreach process to develop support for the finalized strategies as well as to begin the process of developing public awareness and engagement in implementing the adaptation strategies.

Specific recommended next steps are:

1) Integrate appropriate content, findings, and recommendations from this report into the City's Sustainability Guide Plan Update.
2) Conduct a city-wide pollinator habitat assessment and pollinator corridor master plan
3) Conduct a detailed tree species distribution study/survey.
4) Conduct a Tree Survey and Carbon Sequestration update at regular intervals (3-5 years) to report on progress and adjust long-term goals and strategies accordingly.
5) In coordination with the Sustainability Guide Plan, develop a Heat Island Abatement Implementation Plan. The Implementation Plan should include:
   - A) Refinement and finalization of Goals and Strategies.
   - B) Delineation of the individuals and departments responsible for the implementation of each strategy.

C) Identification of how the implementation of each strategy will be monitored / reported, and appropriate metrics for measurement of effectiveness of strategy.

paleBLUEdot Burnsville Tree Canopy Survey and Carbon Sequestration Study 8-3

Section 08

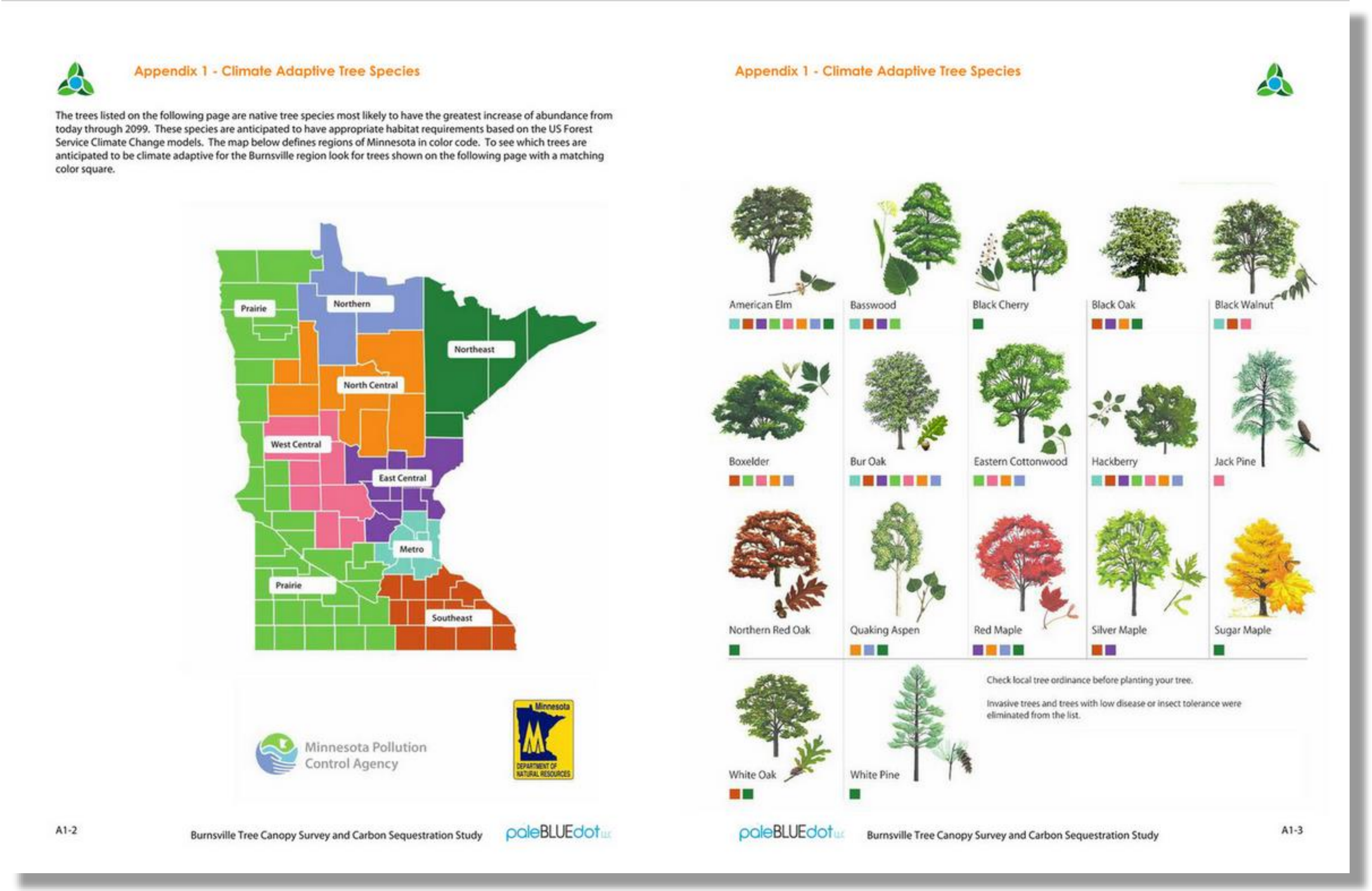
Conclusions and Next Steps

Conclusions and Next Steps

At the completion of this effort, the city has:

- a solid understanding of the underlying urban ecosystem vulnerabilities, heat island, and stormwater characteristics.
- ability to craft strategies to address them.
- prioritized based on need, opportunity, and equity data

Case Studies Trees



Appendix A1

Climate Adaptive Tree Species

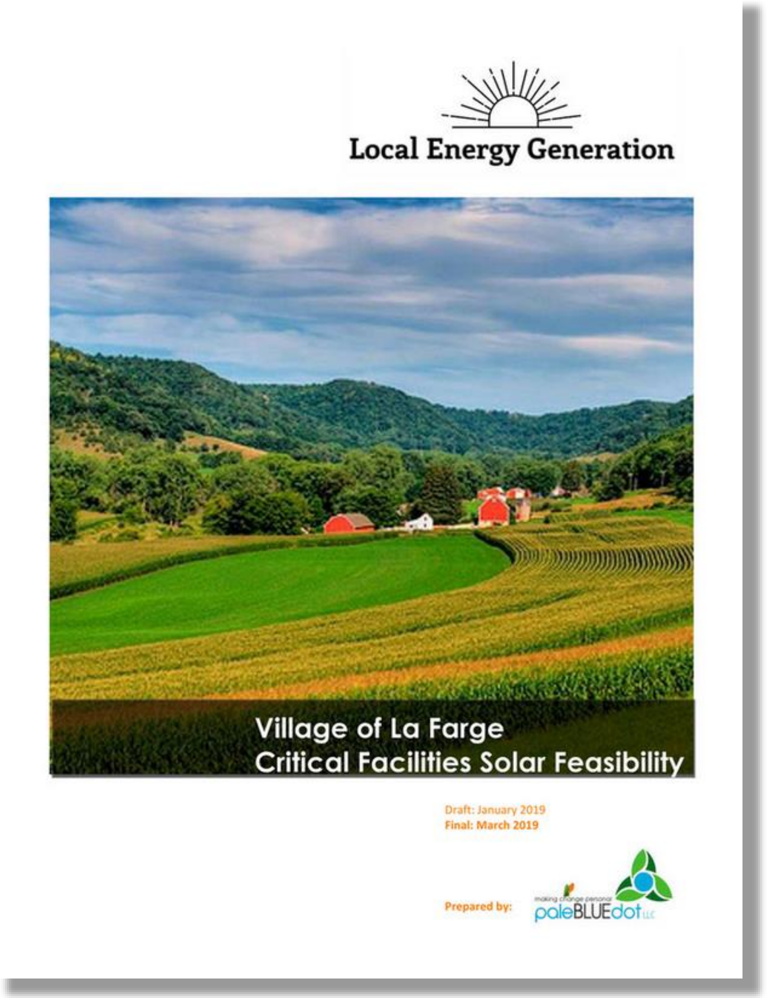
Bonus:

Climate adaptive tree species list

- Support city tree management plan
- Available to public

Case Studies Power

Case Studies Power



Village of LaFarge

Energy Resilience And Renewable Energy Assessment

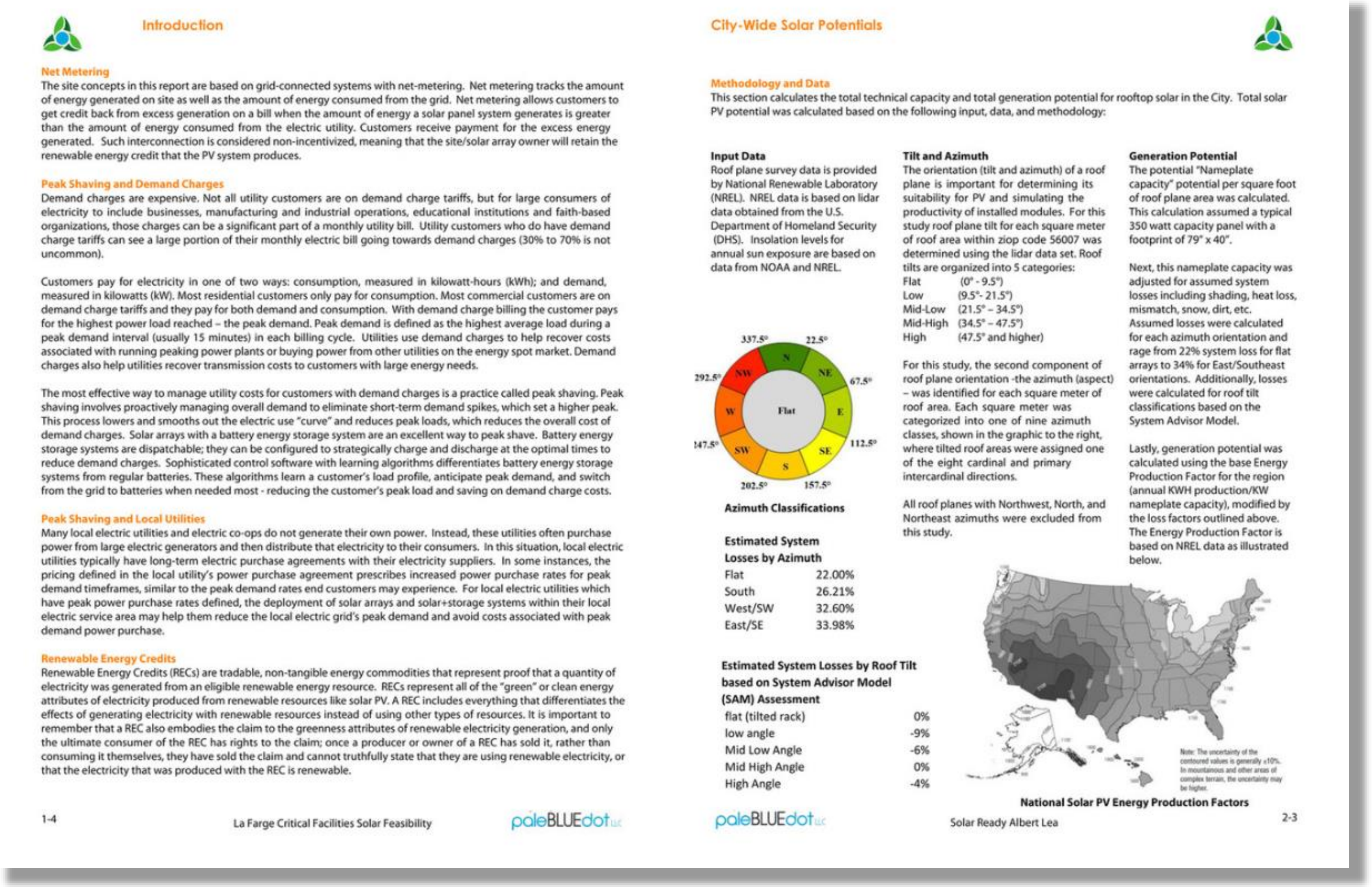
Case Studies **Power**

Section 01

Introduction

Reviewing community energy vulnerability

Renewable Energy market overview



Introduction

Net Metering

The site concepts in this report are based on grid-connected systems with net-metering. Net metering tracks the amount of energy generated on site as well as the amount of energy consumed from the grid. Net metering allows customers to get credit back from excess generation on a bill when the amount of energy a solar panel system generates is greater than the amount of energy consumed from the electric utility. Customers receive payment for the excess energy generated. Such interconnection is considered non-incentivized, meaning that the site/solar array owner will retain the renewable energy credit that the PV system produces.

Peak Shaving and Demand Charges

Demand charges are expensive. Not all utility customers are on demand charge tariffs, but for large consumers of electricity to include businesses, manufacturing and industrial operations, educational institutions and faith-based organizations, those charges can be a significant part of a monthly utility bill. Utility customers who do have demand charge tariffs can see a large portion of their monthly electric bill going towards demand charges (30% to 70% is not uncommon).

Customers pay for electricity in one of two ways: consumption, measured in kilowatt-hours (kWh); and demand, measured in kilowatts (kW). Most residential customers only pay for consumption. Most commercial customers are on demand charge tariffs and they pay for both demand and consumption. With demand charge billing the customer pays for the highest power load reached – the peak demand. Peak demand is defined as the highest average load during a peak demand interval (usually 15 minutes) in each billing cycle. Utilities use demand charges to help recover costs associated with running peaking power plants or buying power from other utilities on the energy spot market. Demand charges also help utilities recover transmission costs to customers with large energy needs.

The most effective way to manage utility costs for customers with demand charges is a practice called peak shaving. Peak shaving involves proactively managing overall demand to eliminate short-term demand spikes, which set a higher peak. This process lowers and smooths out the electric use "curve" and reduces peak loads, which reduces the overall cost of demand charges. Solar arrays with a battery energy storage system are an excellent way to peak shave. Battery energy storage systems are dispatchable; they can be configured to strategically charge and discharge at the optimal times to reduce demand charges. Sophisticated control software with learning algorithms differentiates battery energy storage systems from regular batteries. These algorithms learn a customer's load profile, anticipate peak demand, and switch from the grid to batteries when needed most - reducing the customer's peak load and saving on demand charge costs.

Peak Shaving and Local Utilities

Many local electric utilities and electric co-ops do not generate their own power. Instead, these utilities often purchase power from large electric generators and then distribute that electricity to their consumers. In this situation, local electric utilities typically have long-term electric purchase agreements with their electricity suppliers. In some instances, the pricing defined in the local utility's power purchase agreement prescribes increased power purchase rates for peak demand timeframes, similar to the peak demand rates end customers may experience. For local electric utilities which have peak power purchase rates defined, the deployment of solar arrays and solar+storage systems within their local electric service area may help them reduce the local electric grid's peak demand and avoid costs associated with peak demand power purchase.

Renewable Energy Credits

Renewable Energy Credits (RECs) are tradable, non-tangible energy commodities that represent proof that a quantity of electricity was generated from an eligible renewable energy resource. RECs represent all of the "green" or clean energy attributes of electricity produced from renewable resources like solar PV. A REC includes everything that differentiates the effects of generating electricity with renewable resources instead of using other types of resources. It is important to remember that a REC also embodies the claim to the greenness attributes of renewable electricity generation, and only the ultimate consumer of the REC has rights to the claim; once a producer or owner of a REC has sold it, rather than consuming it themselves, they have sold the claim and cannot truthfully state that they are using renewable electricity, or that the electricity that was produced with the REC is renewable.

1-4 La Farge Critical Facilities Solar Feasibility paleBLUEdot LLC

City-Wide Solar Potentials

Methodology and Data

This section calculates the total technical capacity and total generation potential for rooftop solar in the City. Total solar PV potential was calculated based on the following input, data, and methodology:

Input Data

Roof plane survey data is provided by National Renewable Laboratory (NREL). NREL data is based on lidar data obtained from the U.S. Department of Homeland Security (DHS). Insolation levels for annual sun exposure are based on data from NOAA and NREL.

Azimuth Classifications

Estimated System Losses by Azimuth

Flat	22.00%
South	26.21%
West/SW	32.60%
East/SE	33.98%

Estimated System Losses by Roof Tilt based on System Advisor Model (SAM) Assessment

flat (tilted rack)	0%
low angle	-9%
Mid Low Angle	-6%
Mid High Angle	0%
High Angle	-4%

Tilt and Azimuth

The orientation (tilt and azimuth) of a roof plane is important for determining its suitability for PV and simulating the productivity of installed modules. For this study roof plane tilt for each square meter of roof area within ziop code 56007 was determined using the lidar data set. Roof tilts are organized into 5 categories:

Flat	(0° - 9.5°)
Low	(9.5°- 21.5°)
Mid-Low	(21.5° – 34.5°)
Mid-High	(34.5° – 47.5°)
High	(47.5° and higher)

For this study, the second component of roof plane orientation -the azimuth (aspect) – was identified for each square meter of roof area. Each square meter was categorized into one of nine azimuth classes, shown in the graphic to the right, where tilted roof areas were assigned one of the eight cardinal and primary intercardinal directions.

All roof planes with Northwest, North, and Northeast azimuths were excluded from this study.

Generation Potential

The potential "Nameplate capacity" potential per square foot of roof plane area was calculated. This calculation assumed a typical 350 watt capacity panel with a footprint of 79" x 40".

Next, this nameplate capacity was adjusted for assumed system losses including shading, heat loss, mismatch, snow, dirt, etc. Assumed losses were calculated for each azimuth orientation and rage from 22% system loss for flat arrays to 34% for East/Southeast orientations. Additionally, losses were calculated for roof tilt classifications based on the System Advisor Model.

Lastly, generation potential was calculated using the base Energy Production Factor for the region (annual KWH production/KW nameplate capacity), modified by the loss factors outlined above. The Energy Production Factor is based on NREL data as illustrated below.

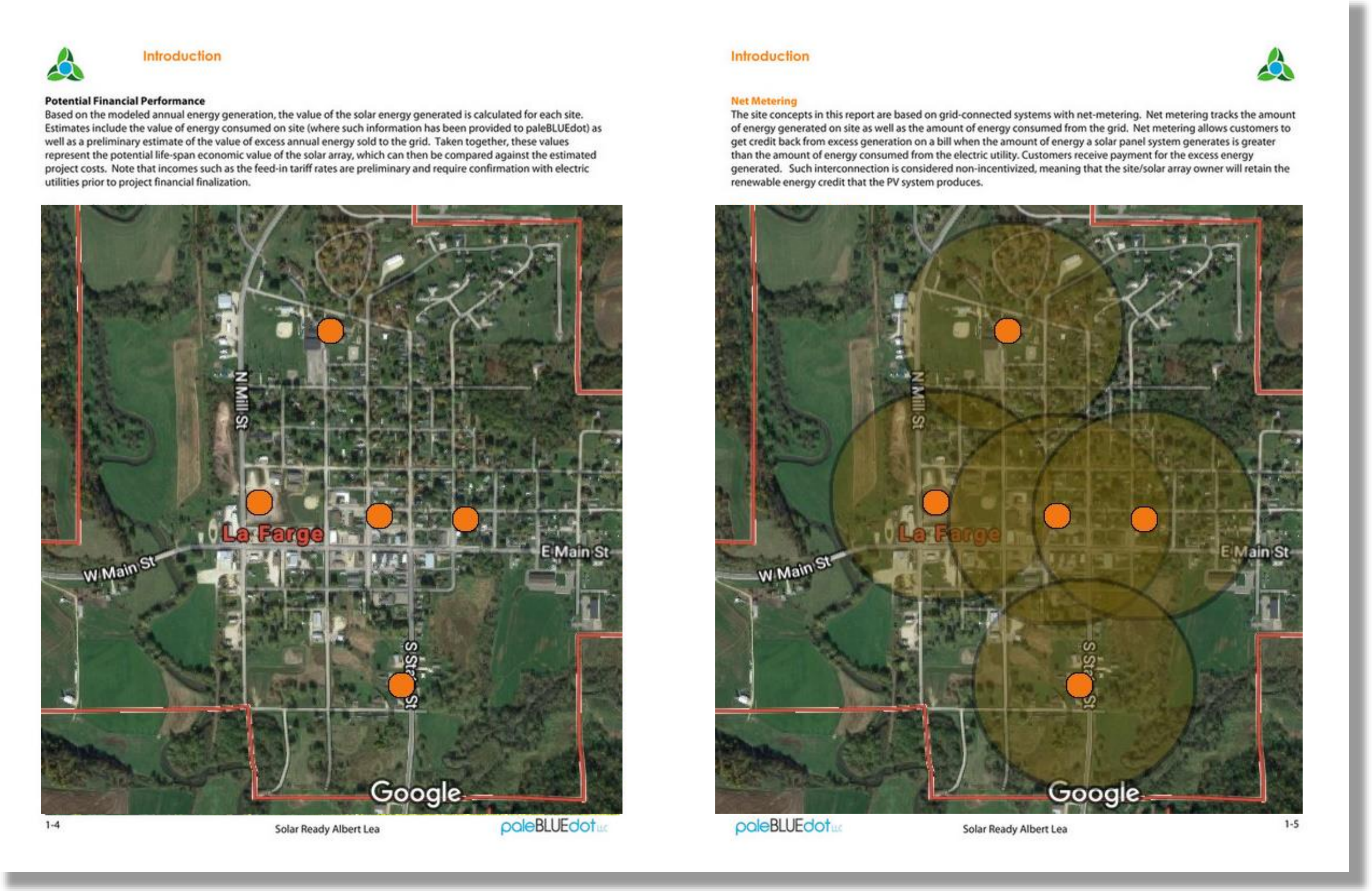
National Solar PV Energy Production Factors

paleBLUEdot LLC Solar Ready Albert Lea 2-3

Case Studies Power

Section 01

Introduction



Introduction

Potential Financial Performance

Based on the modeled annual energy generation, the value of the solar energy generated is calculated for each site. Estimates include the value of energy consumed on site (where such information has been provided to paleBLUEdot) as well as a preliminary estimate of the value of excess annual energy sold to the grid. Taken together, these values represent the potential life-span economic value of the solar array, which can then be compared against the estimated project costs. Note that incomes such as the feed-in tariff rates are preliminary and require confirmation with electric utilities prior to project financial finalization.

Introduction

Net Metering

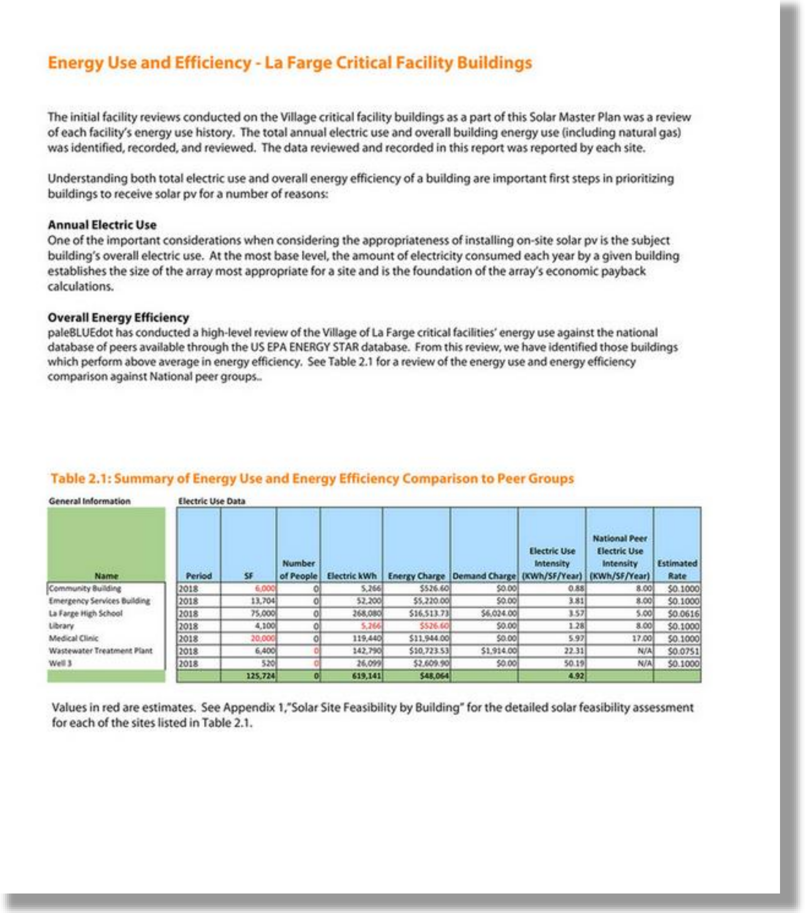
The site concepts in this report are based on grid-connected systems with net-metering. Net metering tracks the amount of energy generated on site as well as the amount of energy consumed from the grid. Net metering allows customers to get credit back from excess generation on a bill when the amount of energy a solar panel system generates is greater than the amount of energy consumed from the electric utility. Customers receive payment for the excess energy generated. Such interconnection is considered non-incentivized, meaning that the site/solar array owner will retain the renewable energy credit that the PV system produces.

Reviewing community energy vulnerability

Renewable Energy market overview

Identification of critical emergency response + support community resources

Case Studies Power



Energy Use and Efficiency - La Farge Critical Facility Buildings

The initial facility reviews conducted on the Village critical facility buildings as a part of this Solar Master Plan was a review of each facility's energy use history. The total annual electric use and overall building energy use (including natural gas) was identified, recorded, and reviewed. The data reviewed and recorded in this report was reported by each site.

Understanding both total electric use and overall energy efficiency of a building are important first steps in prioritizing buildings to receive solar pv for a number of reasons:

Annual Electric Use
One of the important considerations when considering the appropriateness of installing on-site solar pv is the subject building's overall electric use. At the most base level, the amount of electricity consumed each year by a given building establishes the size of the array most appropriate for a site and is the foundation of the array's economic payback calculations.

Overall Energy Efficiency
paleBLUEdot has conducted a high-level review of the Village of La Farge critical facilities' energy use against the national database of peers available through the US EPA ENERGY STAR database. From this review, we have identified those buildings which perform above average in energy efficiency. See Table 2.1 for a review of the energy use and energy efficiency comparison against National peer groups..

Table 2.1: Summary of Energy Use and Energy Efficiency Comparison to Peer Groups

General Information	Electric Use Data								
Name	Period	SF	Number of People	Electric kWh	Energy Charge	Demand Charge	Electric Use Intensity (KWh/SF/Year)	National Peer Electric Use Intensity (KWh/SF/Year)	Estimated Rate
Community Building	2018	6,000	0	5,266	$526.60	$0.00	0.88	8.00	$0.1000
Emergency Services Building	2018	13,704	0	52,200	$5,220.00	$0.00	3.81	8.00	$0.1000
La Farge High School	2018	75,000	0	268,080	$16,513.73	$6,024.00	3.57	5.00	$0.0616
Library	2018	4,100	0	5,266	$526.60	$0.00	1.28	8.00	$0.1000
Medical Clinic	2018	20,000	0	119,440	$11,944.00	$0.00	5.97	17.00	$0.1000
Wastewater Treatment Plant	2018	6,400	0	142,790	$10,723.53	$1,914.00	22.31	N/A	$0.0751
Well 3	2018	520	0	26,099	$2,609.90	$0.00	50.19	N/A	$0.1000
		125,724	0	619,141	$48,064		4.92		

Values in red are estimates. See Appendix 1,"Solar Site Feasibility by Building" for the detailed solar feasibility assessment for each of the sites listed in Table 2.1.

Section 02

Energy Use and Efficiency

La Farge Critical Facility Buildings

Review of key site **energy use** history and financial metrics

- Electrical
- Natural Gas

Determination of site Energy Use Intensity (**EUI**)

Identification of energy savings **potential**

Case Studies Power

Section 03

Solar Feasibility- La Farge Critical Facility Buildings

Solar Feasibility - La Farge Critical Facility Buildings

The goal of the solar feasibility concept development is to explore the general potential for solar pv on each site with the goal of achieving a Zero Net Energy site where possible (a site which generates as much electricity within a year as it consumes within the same timeframe).

Prioritization was given to rooftop solar arrays, with ground mounted and "carport" arrays being included only for sites which required them to achieve Zero Net Energy, or for building sites which can reasonably be assumed to have a structure incapable of supporting a rooftop array and where such arrays are reasonably feasible. Prior to proceeding further with the planning of any rooftop solar pv array, an assessment of the structure of each building included in this section should be conducted. All sites which have a ground mounted array in this section should have a civil engineering review of the site areas anticipating solar arrays to verify appropriate soil and site conditions.

A preliminary opinion of cost as well as a preliminary 30 year energy generation and value projection have been developed for each site. Costs are intended to illustrate Order of Magnitude and are preliminary in nature. Cost unit prices are based on 2017 national averages provided by the National Renewable Energy Laboratory, modified using local construction cost indices and are adjusted to 2019 numbers. The 30 year value projections include estimates of base and solar buy back electric rates based on information available from the subject utility. Electric rates should be validated prior to proceeding further with the planning of any site.

Solar Feasibility Assessment
The detailed Solar Feasibility Assessment for each of the sites can be found in Appendix 1 of this report. The Solar Feasibility Assessment included a review of overall solar feasibility as well as development of solar pv concept designs for each recommended site. These efforts consisted of:

Determining the feasibility of solar energy :

- Conducting remote review of each recommended site using satellite data of each subject building and site.
- Identifying current and planned future building and site conditions which create impediment to solar pv installations.
- Identifying and record solar obstructions impacting potential solar pv performance.

Solar PV Concept Design.

- Creating concept design(s) for building and/or site solar PV array at each recommended site. Concept designs include overall array configuration, tilt, azimuth, and preliminary panel and inverter selections.
- Modeling annual solar pv performance based on detailed design components, historic local weather data,

Table 3.1: Summary of Solar Feasibility

General Information	Solar Feasibiltiy Concept									
Name	Name-plate Capacity: Rooftop	Name-plate Capacity: Ground	Name-plate Capacity: Carport	Estimated Year 1 Generation	Estimated 30 Year Generation Total	Annual Generation Percent of Consumption	Achieves Net Zero	Electric Utility	Value	Cost (excludes potential tax benefits)
Community Building	5.25			3,894	104,228	73.95%		La Farge Utilities	$13,928	$17,306
Emergency Services Building	45.20			61,080	1,634,890	117.01%	Yes	La Farge Utilities	$172,818	$119,976
La Farge High School	237.70			322,800	8,640,185	120.41%	Yes	La Farge Utilities	$1,030,785	$569,307
Library	11.60			13,150	351,978	119.55%	Yes	La Farge Utilities	$47,035	$31,416
Medical Clinic	66.20	29.40		130,280	3,487,123	109.08%	Yes	La Farge Utilities	$383,563	$252,691
Wastewater Treatment Plant		129.40		169,300	4,531,547	118.57%	Yes	La Farge Utilities	$554,299	$414,468
Well 3	3.15			3,135	83,913	12.01%		La Farge Utilities	$11,213	$10,036
	369	159	0	703,639	18,833,864				$2,213,641	$1,415,200

See Appendix 1,"Solar Site Feasibility by Building" for the detailed solar feasibility assessment for each of the sites listed in Table 3.1.

3-2 La Farge Critical Facilities Solar Feasibility paleBLUEdot LLC

Rooftop La Farge Community Center, 202 N. State St. La Farge, WI 54639

Report

Project Name	La Farge Community Center
Project Address	202 N. State St. La Farge, WI 54639
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

Design	Rooftop
Module DC Nameplate	5.25 kW
Inverter AC Nameplate	4.60 kW Load Ratio: 1.14
Annual Production	3.894 MWh
Performance Ratio	45.7%
kWh/kWp	741.7
Weather Dataset	TMY, 10km Grid (43.55,-90.65), NREL (prospector)
Simulator Version	4ab5b1e958-759ee99472-ade922f37c-7aff015308

Project Location

Monthly Production

Sources of System Loss

Inverters: 2.6%
Optimizers: 2.9%
Temperature: 0.7%
Irradiance: 2.6%
Soiling: 2.0%
Reflection: 3.0%
Shading: 40.4%

Annual Production

	Description
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance
	POA Irradiance
	Shaded Irradiance
	Irradiance after Reflection
	Irradiance after Soiling
	Total Collector Irradiance
Energy (kWh)	Nameplate
	Output at Irradiance Levels
	Output at Cell Temperature Derate
	Output After Mismatch
	Optimizer Output
	Optimal DC Output
	Constrained DC Output
	Inverter Output
	Energy to Grid
Temperature Metrics	
	Avg. Operating Ambient Temp
	Avg. Operating Cell Temp
Simulation Metrics	

paleBLUEdot LLC La Farge Critical Facilities Solar Feasibility 3-3

Detailed on-site solar **feasibility assessments** at all key sites

Project **energy generation** potential and **cost** estimates

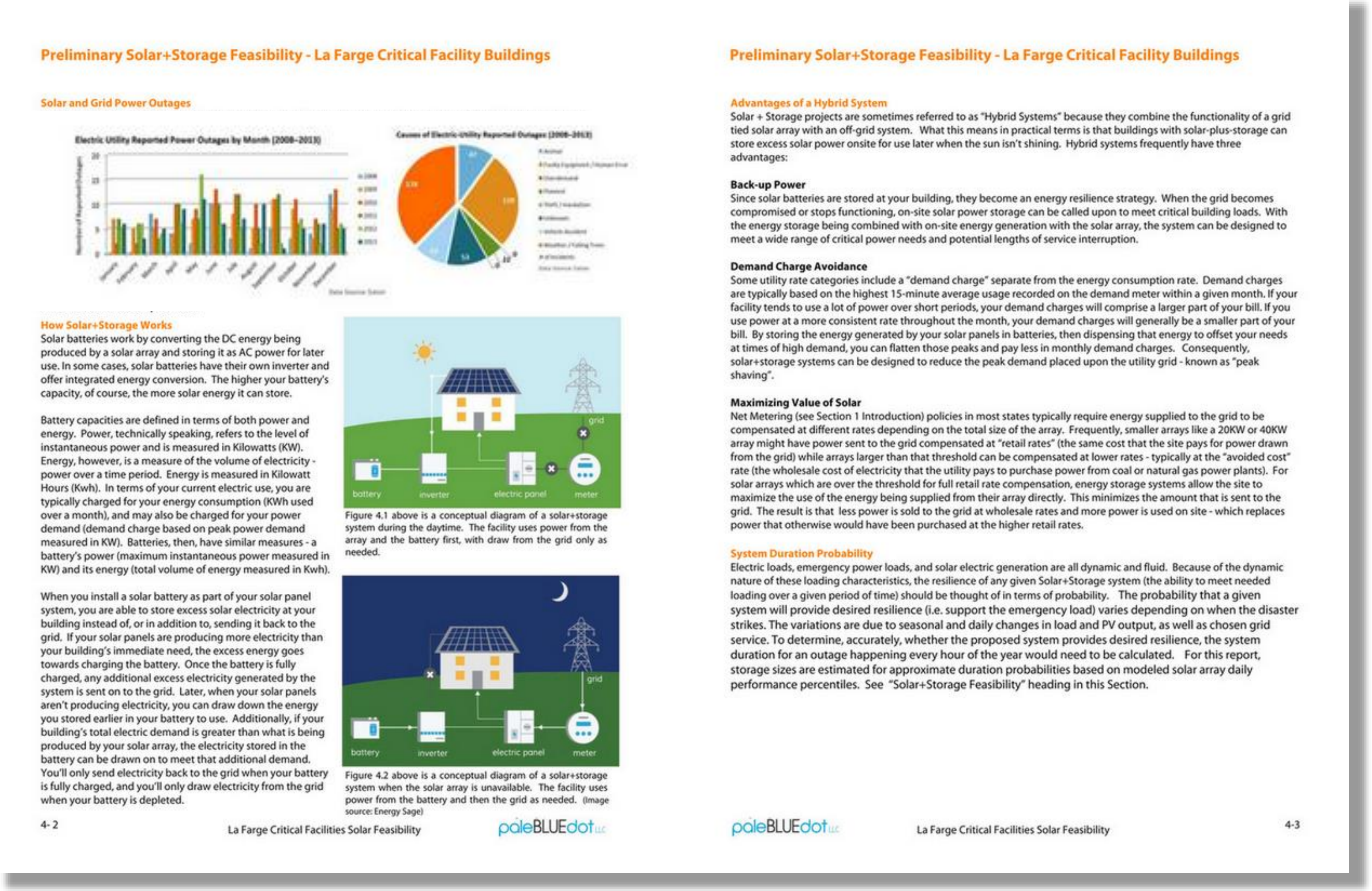
Calculate **payback**

Prioritization of sites for implementation

Case Studies Power

Section **04**

Preliminary Solar+Storage Feasibility



Solar and Grid Power Outages

How Solar+Storage Works

Solar batteries work by converting the DC energy being produced by a solar array and storing it as AC power for later use. In some cases, solar batteries have their own inverter and offer integrated energy conversion. The higher your battery's capacity, of course, the more solar energy it can store.

Battery capacities are defined in terms of both power and energy. Power, technically speaking, refers to the level of instantaneous power and is measured in Kilowatts (KW). Energy, however, is a measure of the volume of electricity - power over a time period. Energy is measured in Kilowatt Hours (Kwh). In terms of your current electric use, you are typically charged for your energy consumption (KWh used over a month), and may also be charged for your power demand (demand charge based on peak power demand measured in KW). Batteries, then, have similar measures - a battery's power (maximum instantaneous power measured in KW) and its energy (total volume of energy measured in Kwh).

When you install a solar battery as part of your solar panel system, you are able to store excess solar electricity at your building instead of, or in addition to, sending it back to the grid. If your solar panels are producing more electricity than your building's immediate need, the excess energy goes towards charging the battery. Once the battery is fully charged, any additional excess electricity generated by the system is sent on to the grid. Later, when your solar panels aren't producing electricity, you can draw down the energy you stored earlier in your battery to use. Additionally, if your building's total electric demand is greater than what is being produced by your solar array, the electricity stored in the battery can be drawn on to meet that additional demand. You'll only send electricity back to the grid when your battery is fully charged, and you'll only draw electricity from the grid when your battery is depleted.

Figure 4.1 above is a conceptual diagram of a solar+storage system during the daytime. The facility uses power from the array and the battery first, with draw from the grid only as needed.

Figure 4.2 above is a conceptual diagram of a solar+storage system when the solar array is unavailable. The facility uses power from the battery and then the grid as needed. (Image source: Energy Sage)

Advantages of a Hybrid System

Solar + Storage projects are sometimes referred to as "Hybrid Systems" because they combine the functionality of a grid tied solar array with an off-grid system. What this means in practical terms is that buildings with solar-plus-storage can store excess solar power onsite for use later when the sun isn't shining. Hybrid systems frequently have three advantages:

Back-up Power

Since solar batteries are stored at your building, they become an energy resilience strategy. When the grid becomes compromised or stops functioning, on-site solar power storage can be called upon to meet critical building loads. With the energy storage being combined with on-site energy generation with the solar array, the system can be designed to meet a wide range of critical power needs and potential lengths of service interruption.

Demand Charge Avoidance

Some utility rate categories include a "demand charge" separate from the energy consumption rate. Demand charges are typically based on the highest 15-minute average usage recorded on the demand meter within a given month. If your facility tends to use a lot of power over short periods, your demand charges will comprise a larger part of your bill. If you use power at a more consistent rate throughout the month, your demand charges will generally be a smaller part of your bill. By storing the energy generated by your solar panels in batteries, then dispensing that energy to offset your needs at times of high demand, you can flatten those peaks and pay less in monthly demand charges. Consequently, solar+storage systems can be designed to reduce the peak demand placed upon the utility grid - known as "peak shaving".

Maximizing Value of Solar

Net Metering (see Section 1 Introduction) policies in most states typically require energy supplied to the grid to be compensated at different rates depending on the total size of the array. Frequently, smaller arrays like a 20KW or 40KW array might have power sent to the grid compensated at "retail rates" (the same cost that the site pays for power drawn from the grid) while arrays larger than that threshold can be compensated at lower rates - typically at the "avoided cost" rate (the wholesale cost of electricity that the utility pays to purchase power from coal or natural gas power plants). For solar arrays which are over the threshold for full retail rate compensation, energy storage systems allow the site to maximize the use of the energy being supplied from their array directly. This minimizes the amount that is sent to the grid. The result is that less power is sold to the grid at wholesale rates and more power is used on site - which replaces power that otherwise would have been purchased at the higher retail rates.

System Duration Probability

Electric loads, emergency power loads, and solar electric generation are all dynamic and fluid. Because of the dynamic nature of these loading characteristics, the resilience of any given Solar+Storage system (the ability to meet needed loading over a given period of time) should be thought of in terms of probability. The probability that a given system will provide desired resilience (i.e. support the emergency load) varies depending on when the disaster strikes. The variations are due to seasonal and daily changes in load and PV output, as well as chosen grid service. To determine, accurately, whether the proposed system provides desired resilience, the system duration for an outage happening every hour of the year would need to be calculated. For this report, storage sizes are estimated for approximate duration probabilities based on modeled solar array daily performance percentiles. See "Solar+Storage Feasibility" heading in this Section.

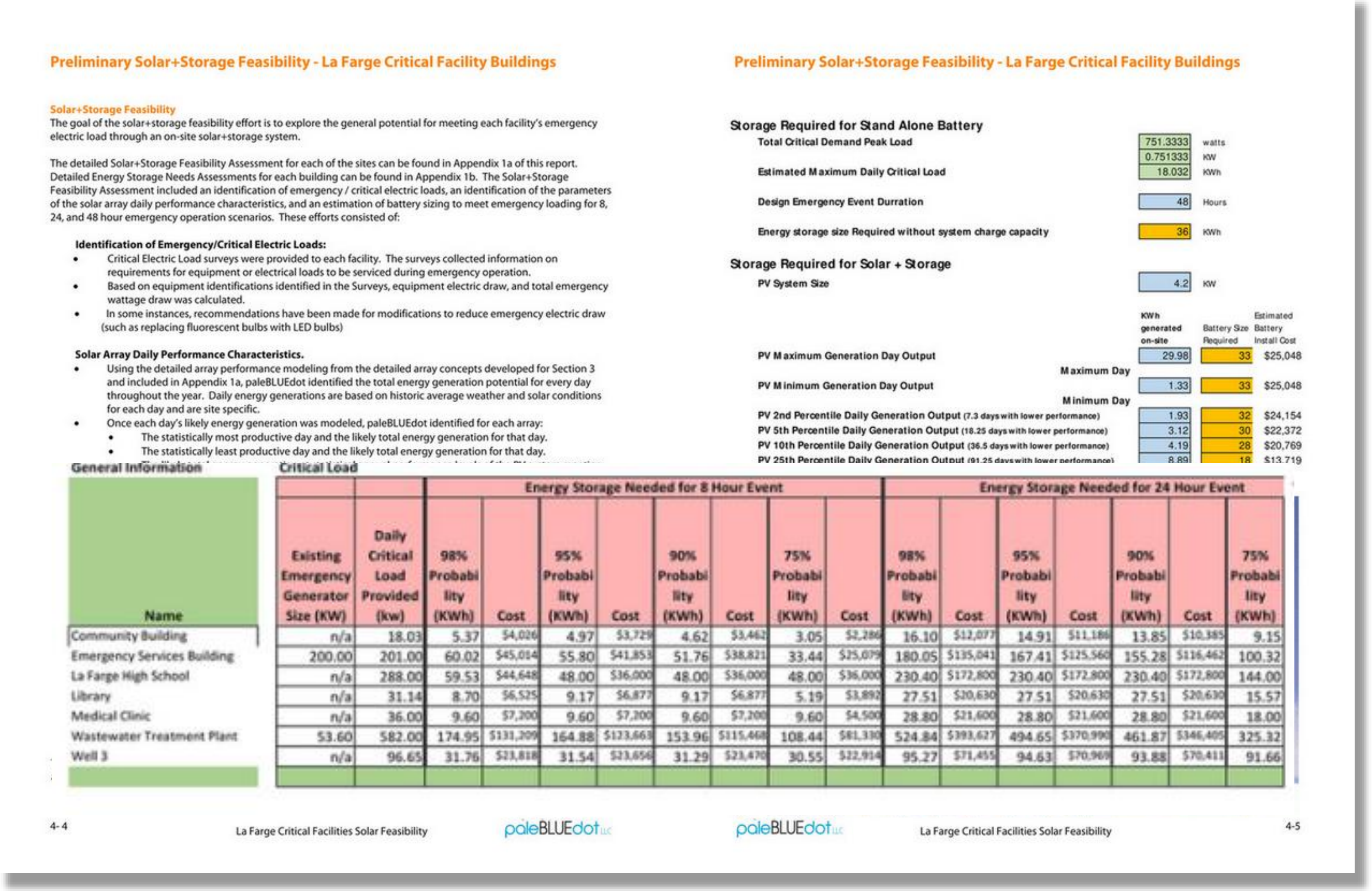
Review of grid outage history and drivers

Review of energy resilience options (solar+storage, nano-grid, microgrid)

Case Studies Power

Section 04

Preliminary Solar+Storage Feasibility



Preliminary Solar+Storage Feasibility - La Farge Critical Facility Buildings

Solar+Storage Feasibility

The goal of the solar+storage feasibility effort is to explore the general potential for meeting each facility's emergency electric load through an on-site solar+storage system.

The detailed Solar+Storage Feasibility Assessment for each of the sites can be found in Appendix 1a of this report. Detailed Energy Storage Needs Assessments for each building can be found in Appendix 1b. The Solar+Storage Feasibility Assessment included an identification of emergency / critical electric loads, an identification of the parameters of the solar array daily performance characteristics, and an estimation of battery sizing to meet emergency loading for 8, 24, and 48 hour emergency operation scenarios. These efforts consisted of:

Identification of Emergency/Critical Electric Loads:
- Critical Electric Load surveys were provided to each facility. The surveys collected information on requirements for equipment or electrical loads to be serviced during emergency operation.
- Based on equipment identifications identified in the Surveys, equipment electric draw, and total emergency wattage draw was calculated.
- In some instances, recommendations have been made for modifications to reduce emergency electric draw (such as replacing fluorescent bulbs with LED bulbs)

Solar Array Daily Performance Characteristics.
- Using the detailed array performance modeling from the detailed array concepts developed for Section 3 and included in Appendix 1a, paleBLUEdot identified the total energy generation potential for every day throughout the year. Daily energy generations are based on historic average weather and solar conditions for each day and are site specific.
- Once each day's likely energy generation was modeled, paleBLUEdot identified for each array:
  - The statistically most productive day and the likely total energy generation for that day.
  - The statistically least productive day and the likely total energy generation for that day.

General Information	Critical Load		Energy Storage Needed for 8 Hour Event								Energy Storage Needed for 24 Hour Event							
Name	Existing Emergency Generator Size (KW)	Daily Critical Load Provided (kw)	98% Probability (KWh)	Cost	95% Probability (KWh)	Cost	90% Probability (KWh)	Cost	75% Probability (KWh)	Cost	98% Probability (KWh)	Cost	95% Probability (KWh)	Cost	90% Probability (KWh)	Cost	75% Probability (KWh)
Community Building	n/a	18.03	5.37	$4,026	4.97	$3,729	4.62	$3,462	3.05	$2,286	16.10	$12,077	14.91	$11,186	13.85	$10,385	9.15
Emergency Services Building	200.00	201.00	60.02	$45,014	55.80	$41,853	51.76	$38,821	33.44	$25,079	180.05	$135,041	167.41	$125,560	155.28	$116,462	100.32
La Farge High School	n/a	288.00	59.53	$44,648	48.00	$36,000	48.00	$36,000	48.00	$36,000	230.40	$172,800	230.40	$172,800	230.40	$172,800	144.00
Library	n/a	31.14	8.70	$6,525	9.17	$6,877	9.17	$6,877	5.19	$3,892	27.51	$20,630	27.51	$20,630	27.51	$20,630	15.57
Medical Clinic	n/a	36.00	9.60	$7,200	9.60	$7,200	9.60	$7,200	9.60	$4,500	28.80	$21,600	28.80	$21,600	28.80	$21,600	18.00
Wastewater Treatment Plant	53.60	582.00	174.95	$131,209	164.88	$123,663	153.96	$115,468	108.44	$81,330	524.84	$393,627	494.65	$370,990	461.87	$346,405	325.32
Well 3	n/a	96.65	31.76	$23,818	31.54	$23,656	31.29	$23,470	30.55	$22,914	95.27	$71,455	94.63	$70,969	93.88	$70,411	91.66

4-4 La Farge Critical Facilities Solar Feasibility

Preliminary Solar+Storage Feasibility - La Farge Critical Facility Buildings

Storage Required for Stand Alone Battery

Total Critical Demand Peak Load	751.3333	watts
	0.751333	KW
Estimated Maximum Daily Critical Load	18.032	KWh
Design Emergency Event Durration	48	Hours
Energy storage size Required without system charge capacity	36	KWh

Storage Required for Solar + Storage

PV System Size	4.2	KW

	KWh generated on-site	Battery Size Required	Estimated Battery Install Cost
PV Maximum Generation Day Output (Maximum Day)	29.98	33	$25,048
PV Minimum Generation Day Output (Minimum Day)	1.33	33	$25,048
PV 2nd Percentile Daily Generation Output (7.3 days with lower performance)	1.93	32	$24,154
PV 5th Percentile Daily Generation Output (18.25 days with lower performance)	3.12	30	$22,372
PV 10th Percentile Daily Generation Output (36.5 days with lower performance)	4.19	28	$20,769
PV 25th Percentile Daily Generation Output (91.25 days with lower performance)	8.89	18	$13,719

La Farge Critical Facilities Solar Feasibility 4-5

Review of grid outage history and drivers

Review of energy resilience options (solar+storage, nano-grid, microgrid)

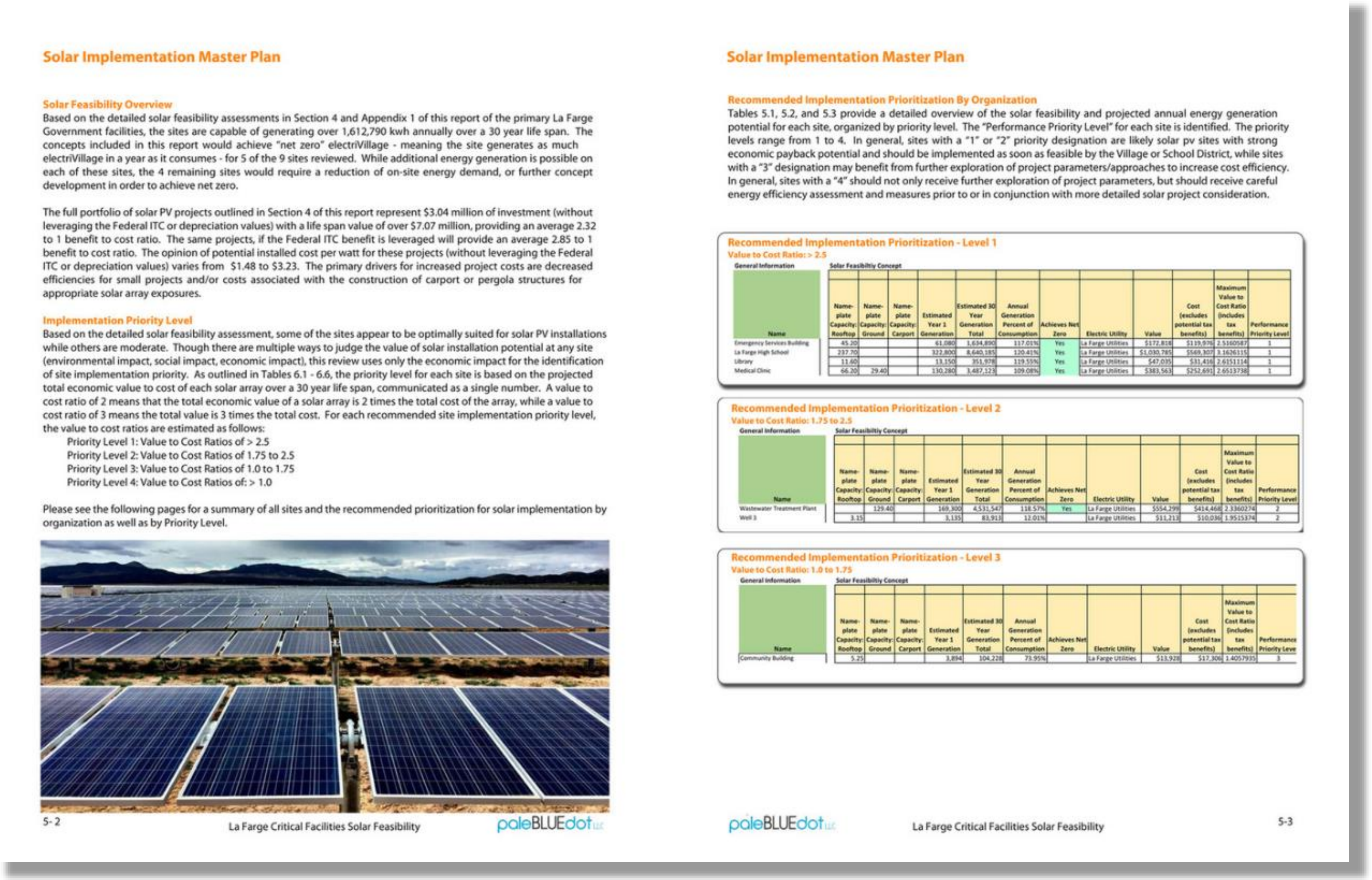
Backup load identification

Battery sizing for range of outage events

Case Studies Power

Section 05

Solar Implementation Master Plan - La Farge



Solar Implementation Master Plan

Solar Feasibility Overview

Based on the detailed solar feasibility assessments in Section 4 and Appendix 1 of this report of the primary La Farge Government facilities, the sites are capable of generating over 1,612,790 kwh annually over a 30 year life span. The concepts included in this report would achieve "net zero" electriVillage - meaning the site generates as much electriVillage in a year as it consumes - for 5 of the 9 sites reviewed. While additional energy generation is possible on each of these sites, the 4 remaining sites would require a reduction of on-site energy demand, or further concept development in order to achieve net zero.

The full portfolio of solar PV projects outlined in Section 4 of this report represent $3.04 million of investment (without leveraging the Federal ITC or depreciation values) with a life span value of over $7.07 million, providing an average 2.32 to 1 benefit to cost ratio. The same projects, if the Federal ITC benefit is leveraged will provide an average 2.85 to 1 benefit to cost ratio. The opinion of potential installed cost per watt for these projects (without leveraging the Federal ITC or depreciation values) varies from $1.48 to $3.23. The primary drivers for increased project costs are decreased efficiencies for small projects and/or costs associated with the construction of carport or pergola structures for appropriate solar array exposures.

Implementation Priority Level

Based on the detailed solar feasibility assessment, some of the sites appear to be optimally suited for solar PV installations while others are moderate. Though there are multiple ways to judge the value of solar installation potential at any site (environmental impact, social impact, economic impact), this review uses only the economic impact for the identification of site implementation priority. As outlined in Tables 6.1 - 6.6, the priority level for each site is based on the projected total economic value to cost of each solar array over a 30 year life span, communicated as a single number. A value to cost ratio of 2 means that the total economic value of a solar array is 2 times the total cost of the array, while a value to cost ratio of 3 means the total value is 3 times the total cost. For each recommended site implementation priority level, the value to cost ratios are estimated as follows:

Priority Level 1: Value to Cost Ratios of > 2.5
Priority Level 2: Value to Cost Ratios of 1.75 to 2.5
Priority Level 3: Value to Cost Ratios of 1.0 to 1.75
Priority Level 4: Value to Cost Ratios of: > 1.0

Please see the following pages for a summary of all sites and the recommended prioritization for solar implementation by organization as well as by Priority Level.

Solar Implementation Master Plan

Recommended Implementation Prioritization By Organization

Tables 5.1, 5.2, and 5.3 provide a detailed overview of the solar feasibility and projected annual energy generation potential for each site, organized by priority level. The "Performance Priority Level" for each site is identified. The priority levels range from 1 to 4. In general, sites with a "1" or "2" priority designation are likely solar pv sites with strong economic payback potential and should be implemented as soon as feasible by the Village or School District, while sites with a "3" designation may benefit from further exploration of project parameters/approaches to increase cost efficiency. In general, sites with a "4" should not only receive further exploration of project parameters, but should receive careful energy efficiency assessment and measures prior to or in conjunction with more detailed solar project consideration.

Recommended Implementation Prioritization - Level 1
Value to Cost Ratio: > 2.5

General Information	Solar Feasibiltiy Concept											
Name	Name-plate Capacity: Rooftop	Name-plate Capacity: Ground	Name-plate Capacity: Carport	Estimated Year 1 Generation	Estimated 30 Year Generation Total	Annual Generation Percent of Consumption	Achieves Net Zero	Electric Utility	Value	Cost (excludes potential tax benefits)	Maximum Value to Cost Ratio (includes tax benefits)	Performance Priority Level
Emergency Services Building	45.20			61,080	1,634,890	117.01%	Yes	La Farge Utilities	$172,818	$119,976	2.5160587	1
La Farge High School	237.70			322,800	8,640,185	120.41%	Yes	La Farge Utilities	$1,030,785	$569,307	3.1626115	1
Library	11.60			13,150	351,978	119.55%	Yes	La Farge Utilities	$47,035	$31,416	2.6151114	1
Medical Clinic	66.20	29.40		130,280	3,487,123	109.08%	Yes	La Farge Utilities	$383,563	$252,691	2.6513738	1

Recommended Implementation Prioritization - Level 2
Value to Cost Ratio: 1.75 to 2.5

General Information	Solar Feasibiltiy Concept											
Name	Name-plate Capacity: Rooftop	Name-plate Capacity: Ground	Name-plate Capacity: Carport	Estimated Year 1 Generation	Estimated 30 Year Generation Total	Annual Generation Percent of Consumption	Achieves Net Zero	Electric Utility	Value	Cost (excludes potential tax benefits)	Maximum Value to Cost Ratio (includes tax benefits)	Performance Priority Level
Wastewater Treatment Plant		129.40		169,300	4,531,547	118.57%	Yes	La Farge Utilities	$554,299	$414,468	2.3360274	2
Well 3	3.15			3,135	83,913	12.01%		La Farge Utilities	$11,213	$10,036	1.9515374	2

Recommended Implementation Prioritization - Level 3
Value to Cost Ratio: 1.0 to 1.75

General Information	Solar Feasibiltiy Concept											
Name	Name-plate Capacity: Rooftop	Name-plate Capacity: Ground	Name-plate Capacity: Carport	Estimated Year 1 Generation	Estimated 30 Year Generation Total	Annual Generation Percent of Consumption	Achieves Net Zero	Electric Utility	Value	Cost (excludes potential tax benefits)	Maximum Value to Cost Ratio (includes tax benefits)	Performance Priority Leve
Community Building	5.25			3,894	104,228	73.95%		La Farge Utilities	$13,928	$17,306	1.4057935	3

Prioritize sites for on-site solar and storage

Recommend **financing + ownership** structure

Identify implementation **timeframe**

Recommend site specific **procurement** options - including "**no cost**" 3rd party approaches

Case Studies Power

Section 06

Economic Benefits

Economic Benefits

Project Delivery / Ownership Options
Solar pv systems may be procured and owned by the building site owner directly in project delivery methods similar to constructing a new building. Alternative project delivery options exist such as Solar Lease, Power Purchase, and "Reverse Lease" agreements. These alternative delivery methods use 3rd party entities for one or more aspects of the procurement, ownership, or tax equity utilization of the solar array. Third party agreements of this nature frequently have a solar array purchase or full ownership transfer opportunity at a future date such as in year 7, year 10, or year 20. For a Village or school district, the advantage of one of these 3rd party project delivery is the ability to leverage project savings due to the Federal Solar Incentive Tax Credit (ITC), currently capable of reducing the cost of a solar pv by up to 30%.

The "Lifetime Cost of Solar" projections represented in this report assume the utilization of one or more of the potential 3rd party engagement options in order to maximize the advantages of the ITC. The full economic potential for the Village of La Farge will vary depending on the exact nature of the project delivery and ownership option chosen. The economic potentials shown here are reasonable, good faith projections and illustrate the general order of magnitude potential.

The economic potential for of solar investment for the Village of La Farge is comprised of two parts: long-term energy cost savings, and job training and employment potential.

Long-Term Energy Cost Savings - La Farge Critical Facility Buildings
Regardless of the project delivery method or ownership option selected for the Village solar projects, most of the projects represented in this report will deliver a long-term electric utility cost savings. For direct purchase/ownership solar array projects, the initial years will experience an increase in costs as the infrastructure is paid off, however significant annual savings will be experienced in later years when the array is fully paid for and producing electricity for "free." For projects utilizing 3rd party ownership structures, the cost savings should be reflected immediately in first year operational cost savings and without significant up-front project costs, however the total-long term cost savings will be somewhat less than those experienced in direct purchase/ownership projects.

Based on the preliminary Opinions of Project Cost, Energy Generation Schedules, and Potential Revenue Values included in Section 3 of this report, the following is the total potential long-term energy cost savings for both direct purchase/ownership as well as 3rd party ownership options for all projects included in Section 4 of this report:

Project Delivery Method	Preliminary Potential Total Net Value to Village (30 year)
Direct Purchase / Ownership Without ITC:	\$1,150,000 - \$1,250,000
Direct Purchase / Ownership With ITC Reverse Lease:	\$750,000 - \$850,000
3rd Party Ownership:	\$170,000 - \$250,000

Economic Benefits

Job Training and Employment Potential - Mountain Iron Government Buildings and Utility Scale Solar
As with all energy sources, whether borne directly or by a 3rd party, solar PV installations require investment up-front for construction and installation as well as annual maintenance costs. When measured on a per unit of energy consumed, these costs are similar, or more competitive than, the costs associated with other energy sources. Unlike almost all other forms of electricity, however, a significant portion of the initial and on-going costs associated with solar PV are capable of remaining in the local economy. This means that for communities who plan carefully for the increase in renewable energy, a local economic development potential exists.

Using the National Renewable Energy Laboratory (NREL) JEDI econoomic model, the potential local economic benefit of solar projects can be estimated. Using the 1,357 KW of solar pv capacity represented by the potential Mountain Iron government facility solar pv portfolio as well as the 10 MW of solar capacity of the recommended Utility Scale Solar Site A projects, the combined portfolio's \$19.17 million in potential installation costs could generate \$760,000 in potential local employment investment and economic impacts. On-going maintenance and support for the Project Priority Levels 1 and 2 only over a 30 year life span could generate a further \$44,000 annually in potential local employment investment. This Project Priority Level 1 and 2 investment could generate 8 jobs during construction as well as 1.5 permanent jobs in the community (including induced expenditures). Below is a breakout of the village potential Job Training and Employment potential of 871 KW of new installed solar pv capacity

Table 6.1: Preliminary Job Training and Employment Potential - Summary Results
(Project Implementation of all critical facility sites)

Local Economic Impacts - Summary Results

	Jobs	Earnings Million 2018\$	Output Million 2018\$	Value Added Million 2018\$
During construction period				
Project Development and Onsite Labor Impacts	2	\$0.24	\$0.32	\$0.26
Construction and Interconnection Labor	1	\$0.21		
Construction Related Services	1	\$0.03		
Equipment and Supply Chain Impacts	2	\$0.10	\$0.40	\$0.20
Induced Impacts	1	\$0.06	\$0.19	\$0.12
Total Impacts	**5**	**\$0.40**	**\$0.92**	**\$0.59**

	Annual Jobs	Annual Earnings Million 2018\$	Annual Output Million 2018\$	Annual Output Million 2018\$
During operating years (annual)				
Onsite Labor Impacts	1	\$0.02	\$1.54	\$1.54
Local Revenue and Supply Chain Impacts	0	\$0.01	\$0.55	\$0.42
Induced Impacts	0	\$0.01	\$0.76	\$0.41
Total Impacts	**1**	**\$0.03**	**\$2.85**	**\$2.38**

Notes: Earnings and Output values are millions of dollars in year 2019 dollars. Jobs are full-time equivalent for one year.
Plant workers includes field technicians, administration and management.
Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures.
The analysis does not include impacts associated with spending of plant "profits."
Totals may not add up due to independent rounding.

Calculate long-term energy cost savings

Identify construction job potential

Calculate long-term job and economic development potential

Case Studies **Power**

Section **07**

Environmental Benefits

Environmental Benefits

Increasing use of Solar PV for electricity generation for La Farge critical facilities will offer additional indirect benefits, namely the reduction of Greenhouse Gas emissions (GHG) and the reduction of fresh water use.

Greenhouse Gas and Electricity

Greenhouse gas emissions form, primarily, from the burning of fossil fuels. The carbon footprint of electricity is the total greenhouse gas emissions throughout the life-cycle from source fuel extraction through to end user electricity. According to the Intergovernmental Panel on Climate Change (IPCC), the median greenhouse gas emission, measured in metric tonnes, for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Metric Tonnes GHG/MWh
Hydroelectric	.004
Wind	.012
Nuclear	.016
Biomass	.018
Geothermal	.045
Solar PV	.046
Natural gas	.469
Coal	1.001

The Water/Energy Nexus

Water and energy are inextricably linked in our current modern infrastructure. Water is used in all phases of energy production. Energy is required to extract, pump and deliver water for use, and to treat waste-water so it can be safely returned to the environment. The cumulative impact of electricity generation on our water sources can be significant, and varies by fuel source. According to The River Network, the average fresh water use for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Gallons/MWh
Hydroelectric	29,920
Wind	1
Nuclear	2,995
Biomass	2
Geothermal	2
Solar PV	2
Natural gas	1,512
Coal	7,143

Environmental Benefits

Current Regional Electric Grid Profile

According to reports on the Electricity Supply by Energy Source for the Upper Midwest grid region, the average greenhouse gas emissions per 1 Mwh of electricity is .365 Metric Tonnes. Using the River Network average fresh water use by fuel type, the average water use per 1 Mwh or electricity in the LLBO region is 5,306.5 gallons.

Based on these numbers, for every Mwh of electricity delivered through solar pv for La Farge facilities or community/utility scale solar arrays, the Village can reduce its annual Greenhouse Gas emissions accounting by .365 metric tonnes (full life-cycle Greenhouse Gas emissions reduction is .319 metric tonnes) and its water footprint by 5,306.5 gallons.

Over a 30 year life span for the full project portfolio detailed in Section 3, this equates to a reduction of 6,008 metric tonnes of greenhouse gas (over 117.8 million cubic feet of man made atmosphere) and 99,941,900 gallons of water conserved. See the chart below for the Environmental Benefit by project priority level.

Table 7.1: Carbon And Water Footprint Reduction Potential - 30 Year Life Span

Government Building Solar Arrays:

Priority Level Group	Annual Generation	GHG Emission Reduction	Water Footprint Reduction
1	527 Mwh	4,502 mTons	74.9 Million Gallons
2	172.4 Mwh	1,472 mTons	24.5 Million Gallons
3	3.9 Mwh	33 mTons	0.55 Million Gallons
Total	**703.6 MWh**	**6,008 mTons**	**99.9 Million Gallons**

Based on **prioritized implementation** plan:

Identify long-range Greenhouse Gas **emissions** reductions

Calculate **air pollution** reductions

Estimate community **water footprint** reductions

Estimate total **social benefit**

Case Studies Power

Section 08

Conclusions and Next Steps

Conclusions and Next Steps

Project Ownership and Financing Scenarios

The Village has multiple ownership and project financing options available. paleBLUEdot recommends the exploration of the following options:

Village Direct Purchase/Owned Solar PV

Under this option, the solar arrays developed are purchased in full from the project contractor at the completion of the array construction and commissioning. The direct purchase can be a cash purchase, or a financed purchase. Should the Village desire a direct purchase option on each site, there are several options for structuring the financing, including:

Issue Tax Exempt Bonds.

For most government entities, securing up-front capital through bonds is how public renewable energy projects have traditionally been financed. Prior to issuing a tax exempt bond, research will be required to verify that solar pv projects are qualified for issuance of this bond type.

Apply to the IRS for a Clean Renewable Energy Bonds allocation

CREBs may be issued by electric cooperatives, government entities (states, cities, counties, territories, Indian tribal governments or any political subdivision thereof), and by certain lenders. The bondholder receives federal tax credits in lieu of a portion of the traditional bond interest, resulting in a lower effective interest rate for the borrower. The issuer remains responsible for repaying the principal on the bond. For approved applicants, the federal incentive CREBs can be a valuable source of low-cost financing, if steps are taken to reduce the high transaction costs associated with their issuance.

Bond-PPA Hybred

The hybrid model is a financing option by which a government entity issues a government bond at a low interest rate and transfers that low-cost capital to a developer in exchange for a lower PPA price. Under the model, a government entity (the administrator) issues a request for proposals (RFP) seeking a solar developer to build, operate, and own a solar project or portfolio of projects on public buildings (local hosts). The administrator sells bonds to finance the development costs of the PV installation. The administrator then enters into both a lease-purchase agreement with the winning bidder and a PPA (on behalf of the local hosts) to buy the electricity from the PV system. Careful consideration and definition of the status of renewable energy credits should be made (see Section 1).

Third-Party Engagement Options.

The Federal Tax Incentive program for solar PV, as well as the accelerated depreciation available for solar equipment (MACRS) are very significant opportunities to reduce the up-front costs of solar pv installations through 2021. Third-party engagement options allow mechanisms for Tribal government entities to capture the value of these federal tax incentives. The third party engagement options paleBLUEdot recommends for the Village include:

Solar Lease or Power Purchase Agreements

Under this approach, the project development team retains ownership of the solar array and charges a monthly fee to the site owner. The monthly fee is either a set dollar value for the use of the solar equipment ("solar lease"), or a varying monthly fee based on the total electricity produced by the solar array ("Power Purchase Agreements"). In both approaches, the site owner incurs no "up front" costs and typically experiences a reduction in their monthly electricity expenses of perhaps 10%. Both of these options typically include a purchase clause which enables the site owner to purchase the system at fair market value at a future date (year 7, 10, 15, etc).

Village Direct Purchase with Reverse ITC Lease

This approach enables a site owner to own the solar array, usually with no up front costs, while empowering the solar project development team to receive the ITC and MACRS tax benefits. This approach is particularly effective for Tribal, Government, or non-profit entities who wish to claim ownership of the array while leveraging the value of the tax benefits through reduced project costs. Under this scenario, the site owner purchases the array at the completion of the project installation and commissioning, usually under a financed purchase whose terms are identical to a typical PPA or Solar Lease, and then executes a reverse lease granting the tax benefit ownership rights to the project development team.

9 - 2 La Farge Critical Facilities Solar Feasibility paleBLUEdot llc

Conclusions and Next Steps

Federal Solar PV Investment Tax Credit (ITC)

For solar technologies, the ITC provides a significant investment tax credit for qualified commercial, utility, and residential solar projects. Projects that qualify for the ITC receive their total qualifying tax credit in 1 to 5 years depending on the entity's tax liability.

Only entities with a tax liability can take advantage of the reduction to solar PV system costs that the ITC allows. As just outlined, third party engagement project delivery methods may enable LLBO to leverage a portion of these savings.

The total ITC value, expressed as a percent of the total solar project cost, is scheduled through 2021 as illustrated to the right:

Potential Economic Benefits of Project Ownership Scenarios - Critical Facility Sites

As outlined in earlier sections of this report, the solar arrays recommended in this report represent economic benefits in the form of long-range cost savings as well as potential employment/economic development. For the building site projects, the total potential economic value of each of the Project Ownership options outlined on the previous page :

Direct Purchase/Owned Solar PV

Initial Investment (may be financed):	$1,415,200
Estimated Total 30 Year Value (excluding ITC):	$2,213,641
Estimated Year 1 Savings:	$0
Estimated Village Resident Training/Employment Investment (construction):	$240,000
Estimated Village Resident Training/Employment Investment (Annual long-term):	$30,000 (including induced)

Third-Party Engagement Options

Solar Lease or Power Purchase Agreements

Initial Investment (may be financed):	$0
Estimated Total 30 Year Cost Savings (excluding ITC):	$200,000
Estimated Year 1 Savings:	$7,500
Estimated Village Resident Training/Employment Investment (construction):	$240,000
Estimated Village Resident Training/Employment Investment (Annual long-term):	$30,000 (including induced)

Pre-Paid PPA with 50% ITC Sharing

Initial Investment (may be financed):	$1,202,920 (assumes ITC Sharing)
Estimated Total 30 Year Value (excluding ITC):	$2,425,912
Estimated Year 1 Savings:	$0
Estimated Village Resident Training/Employment Investment (construction):	$240,000
Estimated Village Resident Training/Employment Investment (Annual long-term):	$30,000 (including induced)

paleBLUEdot llc La Farge Critical Facilities Solar Feasibility 9-3

Conclusions and Next Steps

At the completion of this effort, the city has:

- a solid understanding of the underlying energy grid vulnerabilities
- Identification of sites to provide community energy resilience.
- Procurement tools and options including "no cost" approaches

Contact

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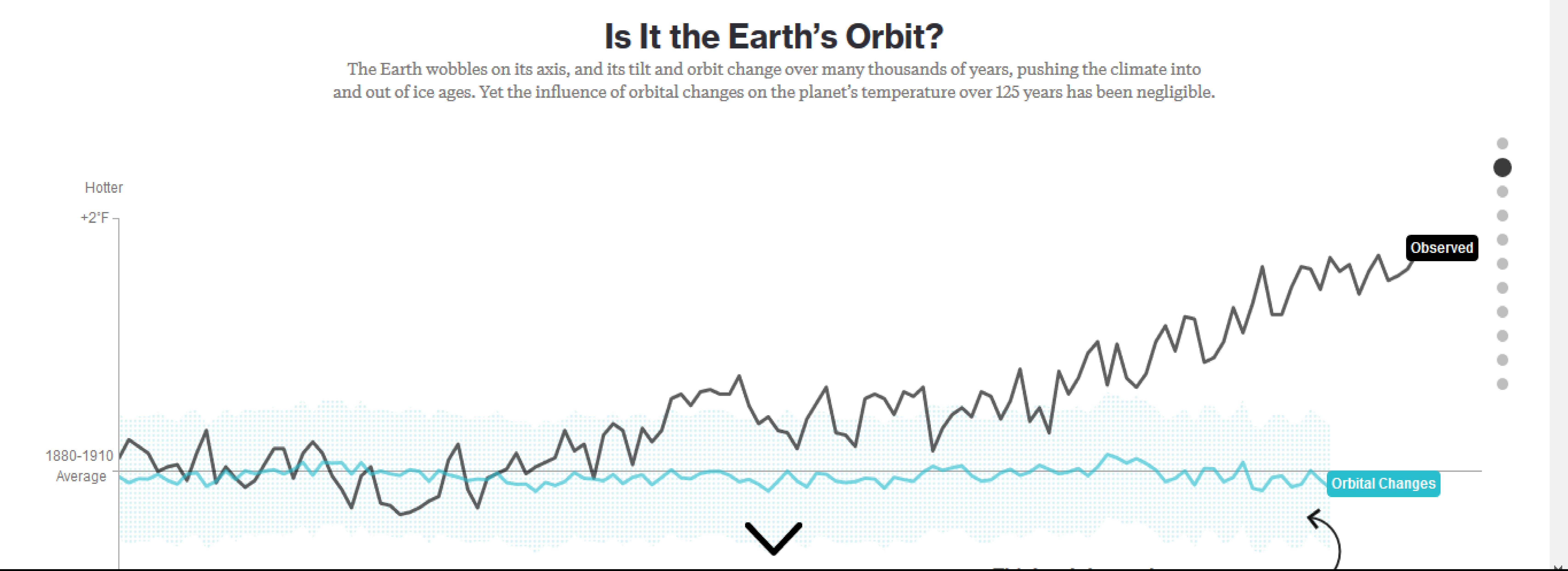
Thank you!

FAQ’s – Earth’s Orbit

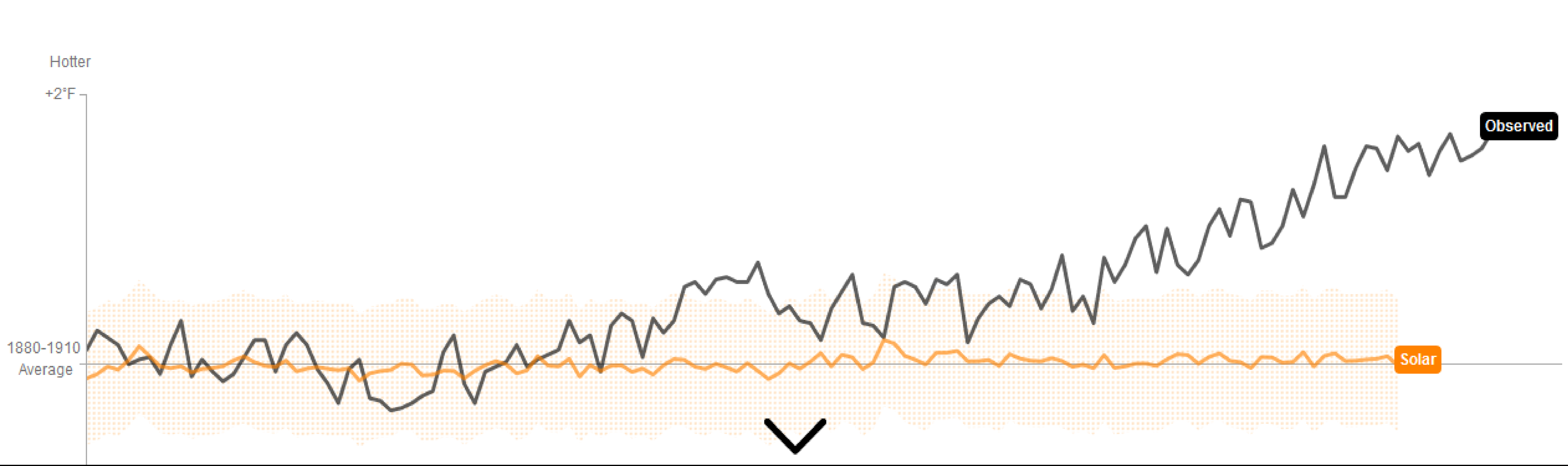


Source: Bloomberg Businessweek

FAQ's – The Sun

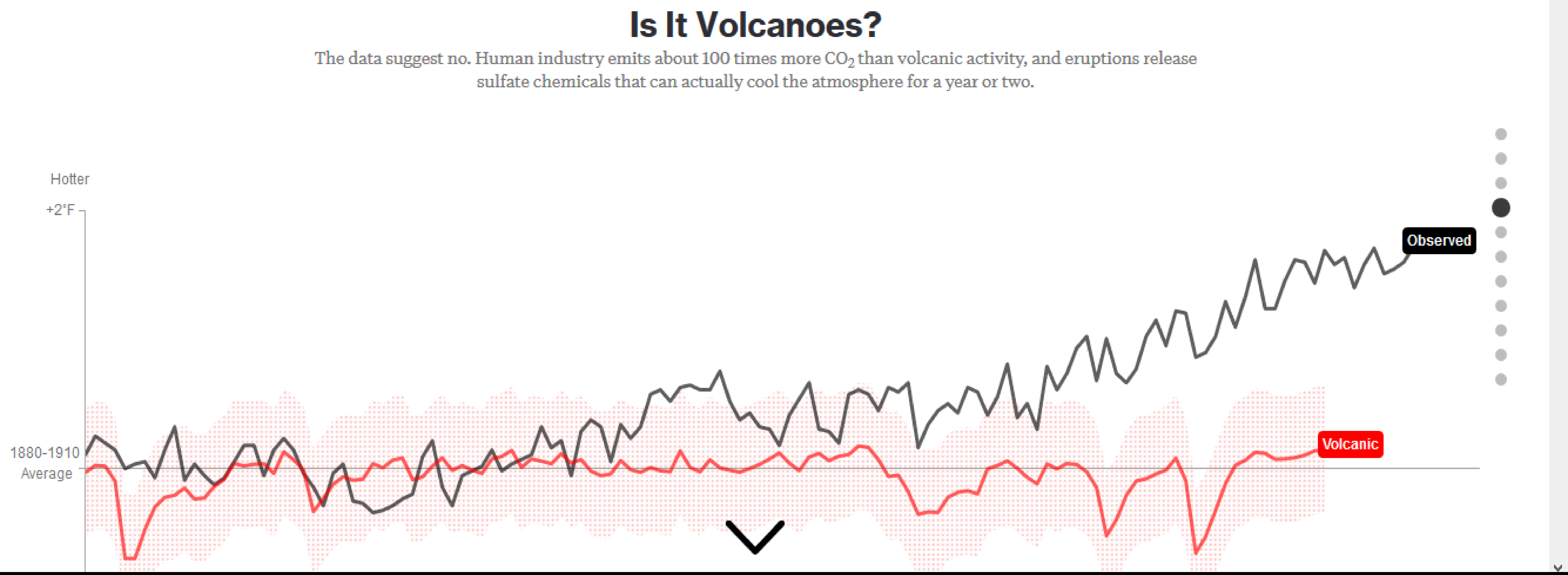
Is It the Sun?

The sun's temperature varies over decades and centuries. These changes have had little effect on the Earth's overall climate.



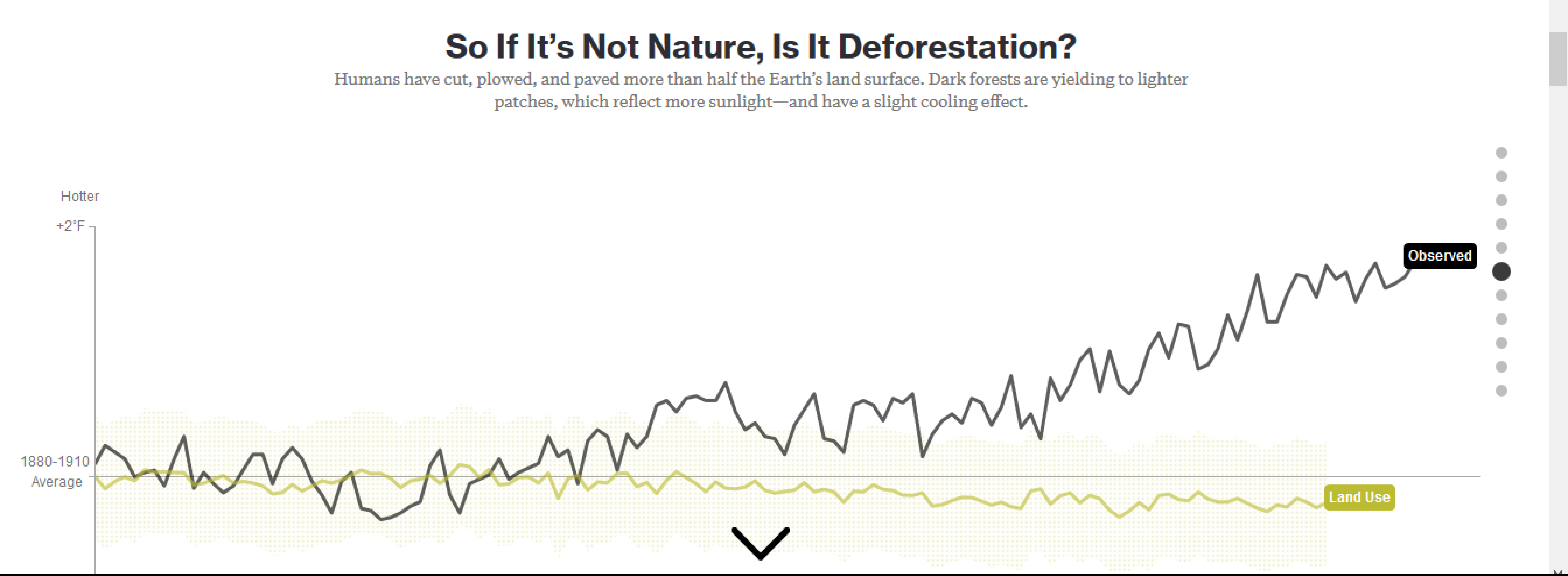
Source: Bloomberg Businessweek

FAQ's – Volcanoes



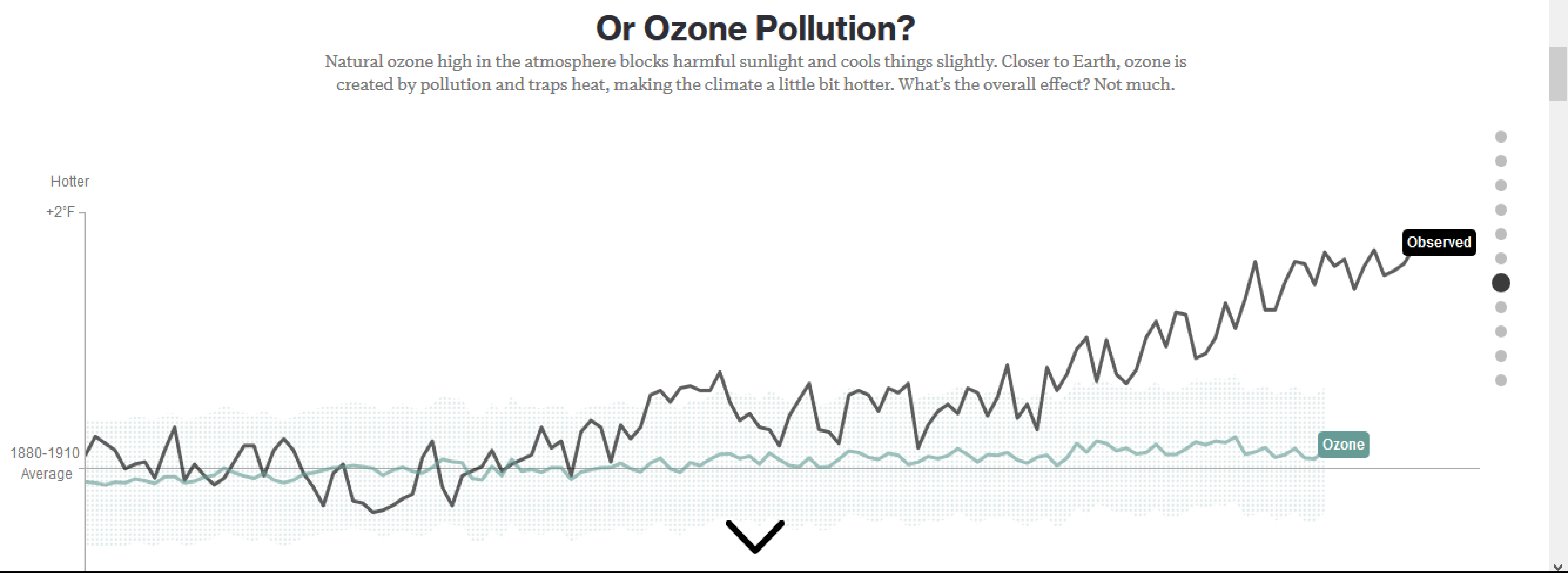
Source: Bloomberg Businessweek

FAQ's –Deforestation



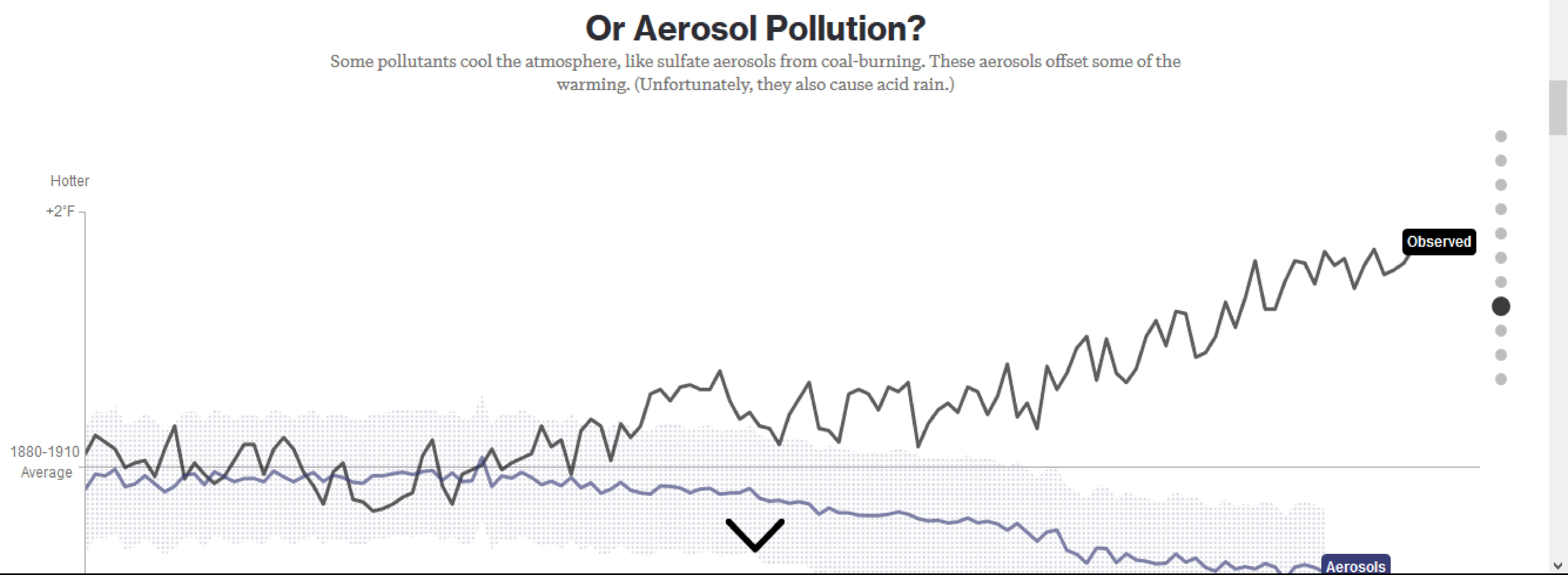
Source: Bloomberg Businessweek

FAQ’s –Ozone Pollution



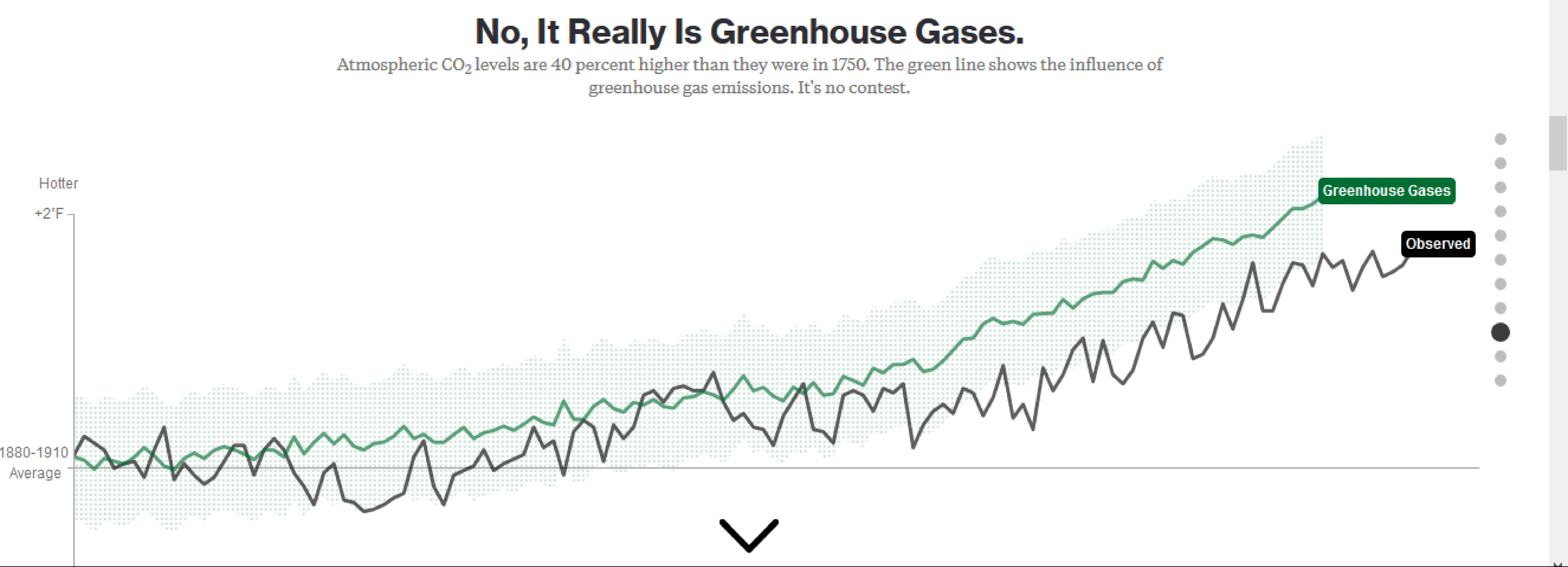
Source: Bloomberg Businessweek

FAQ’s – Aerosol Pollution



Source: Bloomberg Businessweek

FAQ’s – Greenhouse Gases



Source: Bloomberg Businessweek