Dangerous Inheritance

The Hotter, More Extreme Climate that We're Passing Down to America's Young

ENVIRONMENT OREGON
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FRONTIER GROUP

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Executive Summary

As a result of global warming, young Americans today are growing up in a different climate than their parents and grandparents experienced. It is warmer than it used to be. Storms pack more of a punch. Rising seas increasingly flood low-lying land. Large wildfires have grown bigger, more frequent and more expensive to control. People are noticing changes in their own backyards, no matter where they live.

Pollution from burning coal, oil and gas is the primary cause of global warming. Without urgent action to reduce global warming pollution, children born today will grow up in a more dangerous world.

We can protect our children from the most harmful impacts of global warming by reducing carbon pollution and shifting to cleaner sources of energy. The United States has a critical window of opportunity to lead the world in this effort.

It is warmer than it used to be.

- When Baby Boomers were entering adulthood in the 1970s, the national average temperature was 52 degrees Fahrenheit (°F). So far, this decade has been 1.6 °F warmer across the contiguous United States. To put that into context, Rhode Island's average temperature today is comparable to that of West Virginia in the 1970s; New Jersey's average temperature to that of 1970s Missouri; and Delaware's average temperature to that of 1970s Tennessee.

Generations of Change

To evaluate how different generations of Americans have experienced the changing climate, we reviewed climatic data for four generations of Americans, and projections of future trends for a fifth, as defined in the table below.

Table 1: Generations Defined

Generation Name	Born	Entering Adulthood (Turning 18)
The Baby Boomers	1946 – 1964	The 1970s
Generation X	1965 – 1980	The 1980s
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Generation Z	1995 – 2009	The late 2010s
Generation Alpha (Today's Children)	2010 – 2025	The 2030s

- The Millennial Generation entered adulthood during the hottest 10-year period in the last 100 years.
- In every state, young adults in the Millennial generation and Generation Z are experiencing warmer average temperatures than young adults in the Baby Boomer generation. (See Figure ES-2 and Appendix B for state-by-state data.)

The biggest storms are getting bigger.

- The biggest rain and snow storms produce 10 percent more rainfall in 2011 than they did in 1948.

Figure ES-1: Each Generation Has Grown Up in a Successively Warmer Climate

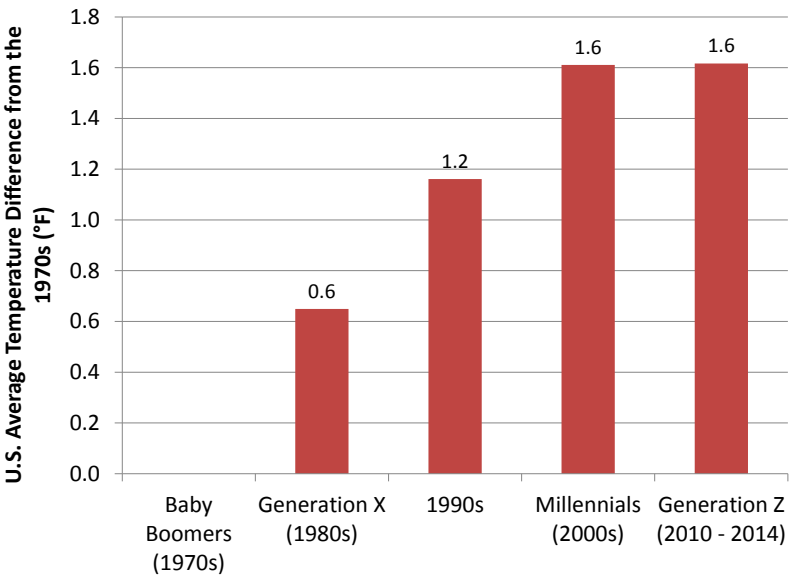
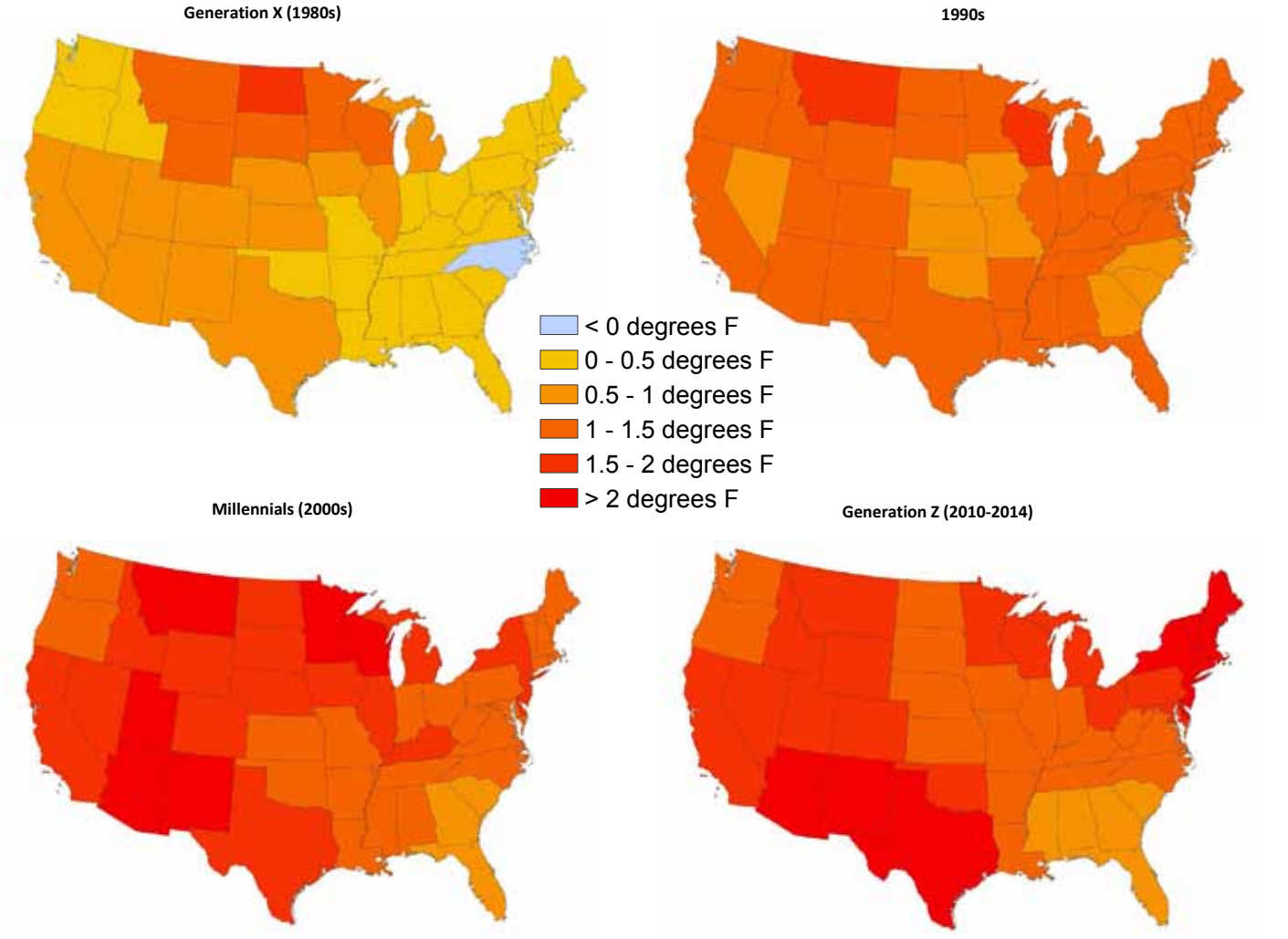


Figure ES-2: Higher Temperatures Are Affecting Generations Across the Country (Temperature Difference Since the 1970s) (°F)

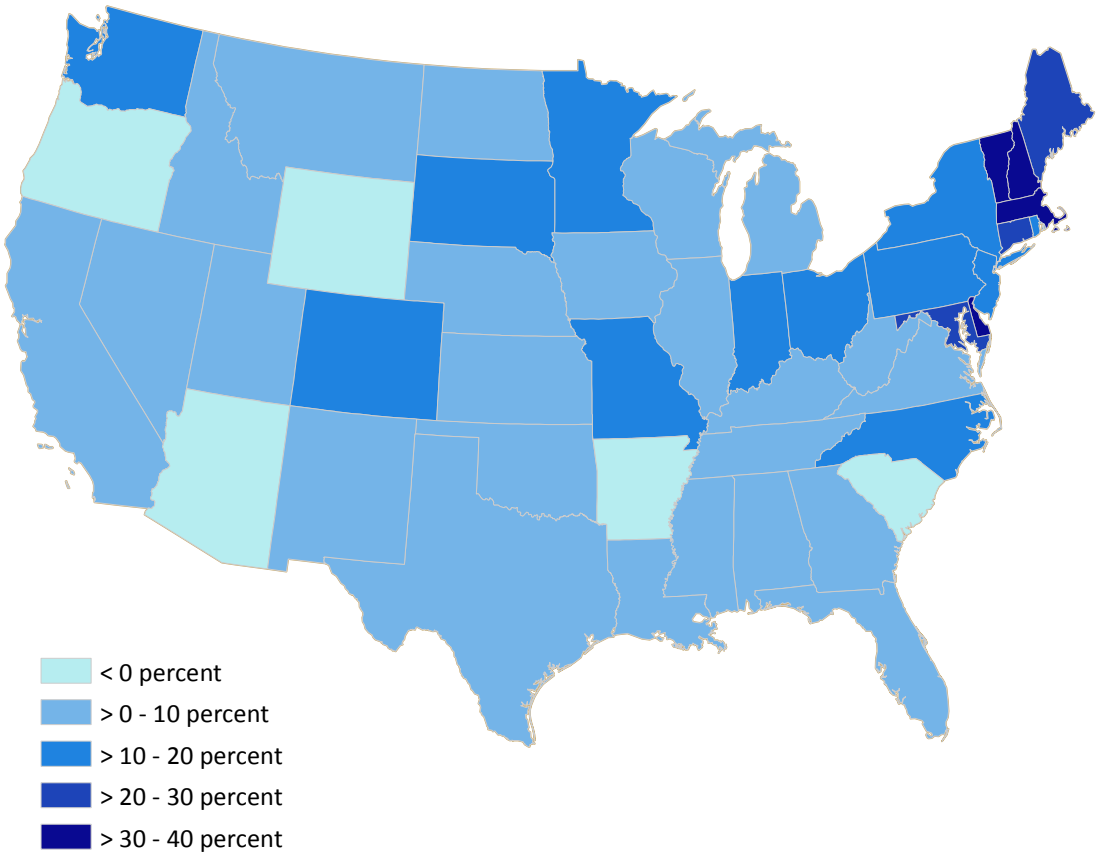


- Young members of Generation Z are experiencing bigger extreme storms than Baby Boomers did as young adults.* (See Figure ES-3 for state trends in the size of the biggest storms between 1970 and 2011.)
- Increases in extreme precipitation have been particularly pronounced in New England since 1970: in New Hampshire, members of Generation Z experience 40 percent more precipitation on average in the biggest rainstorms and snowstorms, and members of Generation Z in Massachusetts experience 34 percent more precipitation on average in the biggest storms.

Sea level is rising as global warming heats up the oceans and melts glaciers and ice caps.

- Globally, sea level has risen 8 inches since the 1880s – rising at a faster rate than at any point in the last 2,000 years.
- U.S. coastal cities are experiencing sea level rise: in New York, Millennials came of age with seas 3.4 inches higher than in the 1970s. As a result, coastal flooding has become more frequent. Small floods that occurred every one to five years in the 1950s now are expected every 3 months on average at most tide gauges in the United States.

Figure ES-3: The Biggest Storms are Getting Bigger (Percent Increase in Maximum Annual 24-hour Precipitation Totals by State, 1970 to 2011)



* Based on a linear regression trend analysis of the largest annual 24-hour precipitation total from 1970 to 2011 at 3,700 weather stations across the contiguous United States. See the Methodology section for details.

- Coastal Louisiana is experiencing significant land subsidence, which is accelerating relative sea-level rise to rates higher than anywhere else in the world. Between rising seas, sinking land and other human-caused disturbances, Louisiana has lost 1,880 square miles of coastal land since the 1930s.

Warming threatens our health and safety and puts our children at risk.

- The warming that has happened over the past four decades has increased the risk of heat-related illness, floods, drought, crop failure, wildfires and infrastructure damage. If the United States and the world continue to emit more carbon pollution, by the end of the century (when today's children will be reaching retirement age) temperature will have risen 5-10 °F, greatly magnifying the risks we face.

- Scientists predict with "a high degree of certainty" that the United States will be more frequently impacted by heavy precipitation events as the world continues to warm, putting today's children at risk of floods, waterborne disease and crop failure.

- Global sea level could rise 1.9 to 3.6 feet by 2100, with some parts of the U.S. coast experiencing faster rates of sea-level rise. Sea-level rise and land subsidence put more than $1 trillion worth of U.S. coastal buildings at risk of flooding in the next century, and the National Flood Insurance Program predicts that the number of flood insurance policyholders will increase by 80 percent by 2100.

To protect our children from the worst impacts of global warming, the United States must cut its overall emissions of global warming pollution by at least 80 percent below 2005 levels by 2050, as part of global action to dramatically reduce carbon emissions. This will require action at all levels of government. In particular:

- The **federal government** should: finalize the Clean Power Plan to limit carbon pollution from power plants (the single largest source); secure a bold international climate agreement at the 2015 United Nations Climate Change Conference in Paris; and accelerate our transition to clean energy, including by adopting a national renewable electricity standard and measures to get America off of oil.

- **State policymakers** should implement the Clean Power Plan, going above and beyond individual state targets and maximizing the role of renewable energy and energy efficiency. State governments should also adopt or strengthen complementary policies, including renewable electricity and energy efficiency standards, and ensure that new state policies do not hinder the ability of regulators to comply with the Clean Power Plan. Finally, states should reduce transportation pollution through policies that reduce dependence on oil, including measures to accelerate the market for zero-emission vehicles and expand access to public transportation and other low-carbon forms of transportation.

Introduction

The orange and black Baltimore oriole is one of the most distinctive American birds. In summers, Marylanders hear the orioles' chirps as the birds flutter around small towns, or spot their bag-shaped nests in backyard elm trees.

The Baltimore oriole has been a regular sight in Maryland as long as people can remember. And since the Baltimore oriole became the Maryland state bird in 1947 – and the namesake of Baltimore's Major League Baseball team in 1953 – the small and colorful songbird has become synonymous with an entire region.[1]

Soon, however, the very name of the Baltimore oriole may be an anachronism. The bird is slowly shifting its summer habitat northward, to compensate for the rising temperatures caused by global warming. By 2080, orioles may be gone from Baltimore.[2] They are not alone. The National Audubon Society estimates that 314 North American bird species may lose more than half of their current ranges by 2080.[3]

Older Americans who grew up in the 1960s or 1970s are noticing climate change in their backyards. Birds are beginning to migrate earlier and earlier each year.[4] In some Northern states, the ice on frozen lakes breaks up a week or two earlier than it did two generations ago.[5] Plants that might have thrived in a backyard garden several decades ago might not anymore, while other plants can survive in places where they were once absent, due to the shifting of plant distributions as the nation has warmed.[6] Tree species are also on the cusp of change – a hike through the woods in the northern forests of the United States will look very different in the coming decades, with oaks and maples replacing spruces and firs.[7]

The same climatic forces that are driving changes in our local environments are also creating dire public health risks. Rising temperatures have loaded the dice in favor of more extreme heat events, which can be deadly; for example, between June 30 and July 13, 2012, a U.S. heat wave was linked to 32 deaths in Maryland, Virginia, Ohio and West Virginia.[8] Extreme precipitation events have increased in size and frequency across the country with dire consequences for life and property – a rainfall event with the statistical likelihood of occurring once every 1,000 years based on historical trends struck Boulder, Colorado, in 2013, killing 4 people and causing 7,600 county residents to apply for federal assistance.[9] Sea-level rise has doubled the risk of a Hurricane Sandy-level flooding event in the New York City region, putting thousands of lives and billions of dollars in property value at risk.[10]

As this report explores, each recent generation of Americans – from the Baby Boomers born right after World War II to Generation X to the Millennials – has entered adulthood in a climate different from that of the generation before. Those changes have already created additional risks for our health and safety. Allowing global warming to continue unchecked will magnify those risks and threaten our future.

To protect our children from the damaging impacts of hotter temperatures, more extreme downpours, higher sea level and more, America must take action to clean up carbon pollution and accelerate our transition to pollution-free energy, while leading the world in doing the same.

Photo: Anita Peppers, morguefile.com

Each recent generation of Americans – from the Baby Boomers born right after World War II to Generation X to the Millennials – has entered adulthood in a climate different from that of the generation before. Those changes have already created additional risks for our health and safety.

Americans Are Witnessing Changes in Climate

Our climate is changing. Many Americans have witnessed significant shifts over the course of their lifetimes – temperatures are higher, big storms are even bigger and sea level is higher along the coast. People can sense that we are shifting our climate away from recent historical norms, telling stories like: "Lake ice used to stick around longer into the spring;" "The soil never used to be this dry;" "I've never seen a storm like this."

In this report, we use data from the United States National Climatic Data Center (NCDC) and Center for Operational Oceanographic Products and Services (CO-OPS) to quantify the changes in climate that various generations of Americans have experienced in recent years, focusing on three indicators: average temperature and temperature extremes, the size of extreme rainfall events, and sea-level rise. For each indicator, we reviewed the data for a decade in which each of four generations entered adulthood, and discuss scientists' predictions of future trends.[11] Our analysis therefore extends over the past four decades and includes a look at future predictions after 2014. We also discuss these trends in the context of studies that have analyzed climatic data over longer periods of time.

Generations of Change

To evaluate how different generations of Americans have experienced the changing climate, we reviewed climatic data for four generations of Americans, and projections of future trends for a fifth, as defined in the table below. We chose a single decade to represent each generation's young adulthood.

Table 1: Generations Defined[12]

Generation Name	Born	Entering Adulthood (Turning 18)
The Baby Boomers	1946 – 1964	The 1970s
Generation X	1965 – 1980	The 1980s
Millennials (Generation Y)	1981 – 1994	The 2000s
Generation Z	1995 – 2009	The late 2010s
Generation Alpha (Today's Children)	2010 – 2025	The 2030s

Data for the 1990s – a decade that spans the early adulthood of younger Gen X'ers and the oldest Millennials – are also included for comparison.

Children born today will experience further dramatic and dangerous shifts in climate over their lifetimes without urgent action to reduce the pollution that is driving global warming.

Rising Temperatures

Temperatures are higher on average than they were when many Baby Boomers were coming of age in the 1970s. Extremely hot months are getting hotter and extremely cold months are not as cold as they used to be.

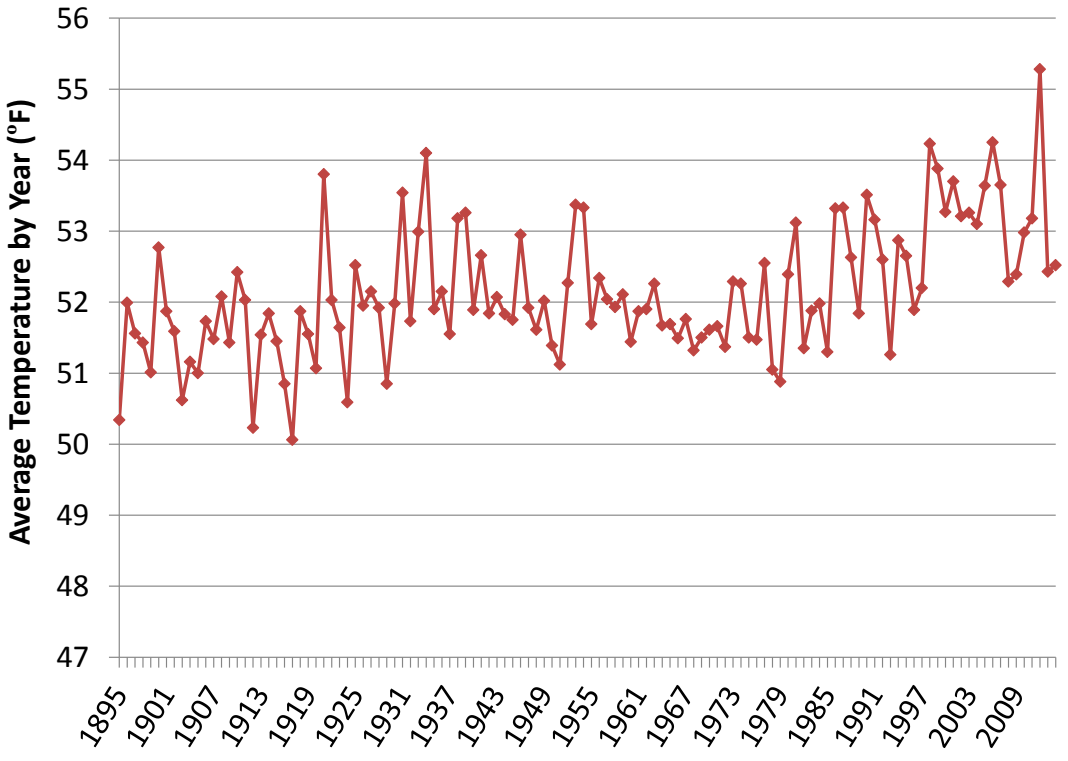
Rising temperatures increase our risk of heat-related illnesses, stress food production, worsen droughts and make large wildfires more frequent.

The Trend: The United States Is Warmer Than It Was When the Baby Boomers Were Entering Adulthood

The average temperature in the United States is increasing, and extreme heat is becoming more pronounced and more common across the country.

Global temperatures across land and ocean surfaces have been above the norm every year since 1977.[13] In other words, Millennials have never experienced a colder-than-average year. In the United States, average temperature has risen between 1.3 to 1.9 °F since 1895, and 2012 was the warmest year on record for the nation.[14] (See Figure 1 for trends in U.S. average temperature since 1895.) The Millennial generation entered adulthood during the hottest 10-year period in the last 100 years.[15]

Figure 1: Average Temperatures in the Contiguous United States by Year, 1895–2014[16]



Just as average temperatures are increasing, so are unusually high temperatures. When Millennials entered adulthood in the 2000s, the nation experienced twice as many record high temperatures as it did record low temperatures.[17] These trends are even more pronounced with the seasons: summer nights and days with unusually high temperatures have affected larger portions of the contiguous United States in the last few decades.[18]

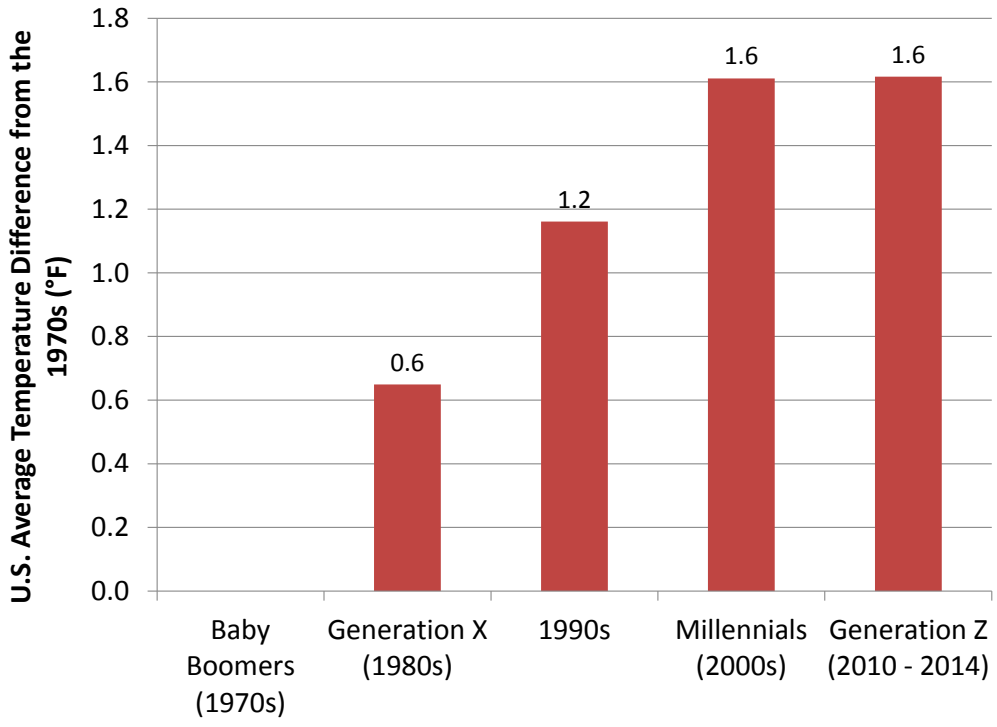
Millennials and Generation Z Are Entering Adulthood in a Warmer Climate

The last four generations have grown up in an increasingly warmer climate.

During the 1970s when the Baby Boomers were entering adulthood, the national average temperature was 51.7 °F. As members of Generation X entered adulthood in the 1980s, the national average temperature was 0.6 °F warmer than during the previous decade. (See Figure 2.) The largest increase in average temperature happened in the West North Central region of the United States, where temperatures increased 1.2 °F on average. At the state level, North Dakota, Minnesota, Montana and South Dakota experienced the largest increases in average temperature – with temperatures rising more than 1.2 °F in each state.

Average temperatures nationwide continued to increase in the 1990s and, as Millennials entered adulthood in the 2000s and members of Generation Z approached adulthood in the early 2010s, the average temperature was 1.6 °F higher nationally than it was in the 1970s. To put that into context, Rhode Island's average temperature today is

Figure 2: Each Generation Has Grown Up In a Successively Warmer Climate



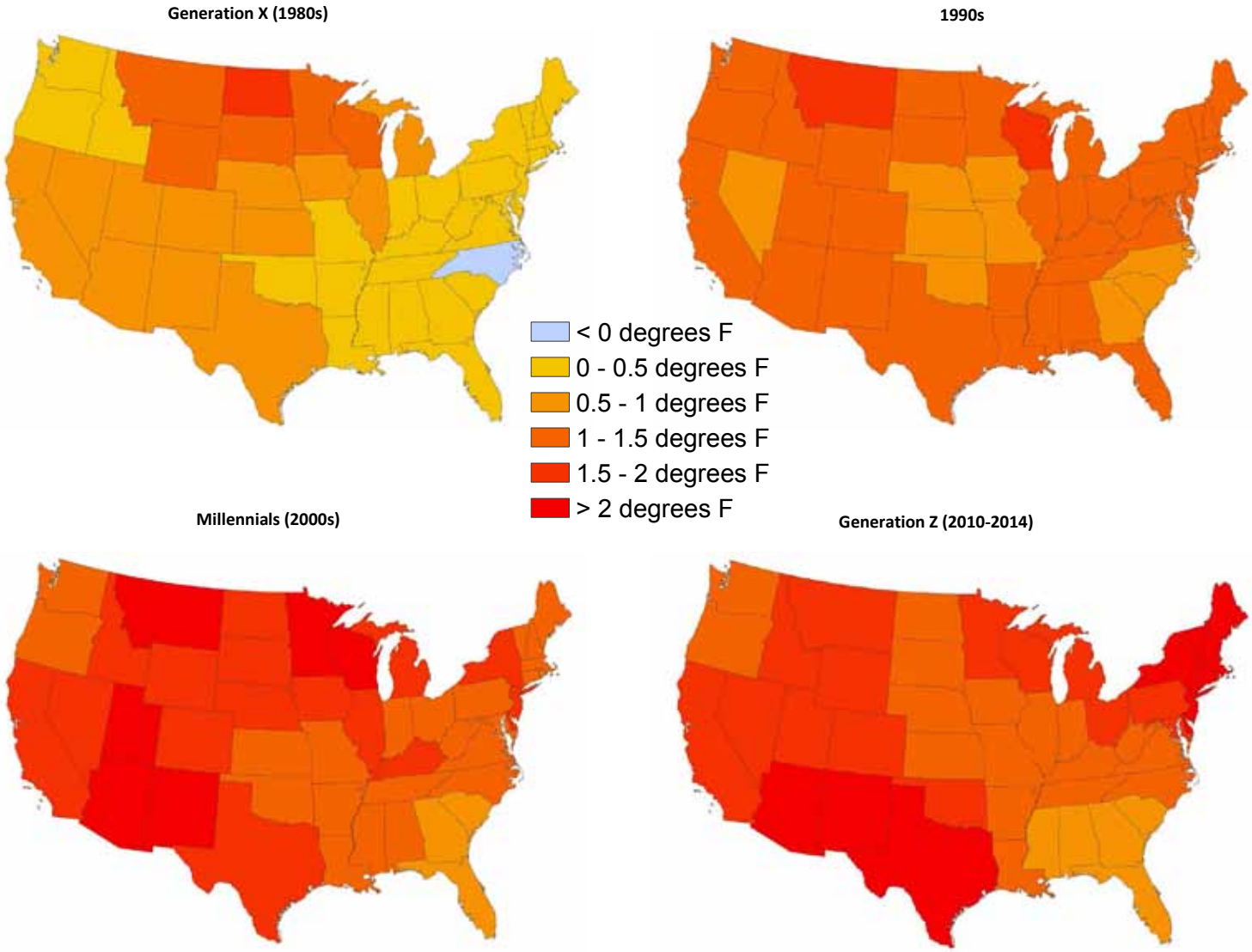
comparable to that of West Virginia in the 1970s; New Jersey's average temperature to that of 1970s Missouri; and Delaware's average temperature to that of 1970s Tennessee.

The Northeast has experienced the most dramatic increase in average temperature. In the early 2010s, average temperatures in Maine, Vermont, Massachusetts and New Hampshire were more than 2.5 °F higher than they were in those states in the 1970s. (See Figure 3.)

Temperature Extremes Are Changing, Posing a Threat to Public Health and Agriculture

Not only are average temperatures rising across the country, but temperature extremes – the hottest and coldest parts of the year – are warming even more rapidly. A comparison of the hottest and coldest months across the contiguous United States during each decade reveals that the hottest months are even warmer than they were in the 1970s, and the coldest months of the year are not as cold.

Figure 3: Higher Temperatures Are Affecting Generations Across the Country (Temperature Difference Since the 1970s) (°F)



When the Baby Boomers were entering adulthood in the 1970s, the hottest month of the decade nationally reached an average daily high of 87.5 °F and the coldest month of the decade hit an average daily low of 12.5 °F.[19]

In contrast, as Millennials came of age in the 2000s, the hottest month was 2.1 °F warmer and the coldest month was 5.8 °F warmer. For Generation Z in the early 2010s, the coldest month was 6.8 °F warmer than in the 1970s, and the hottest month was 2.5 °F warmer. (See Figures 4 and 5.)

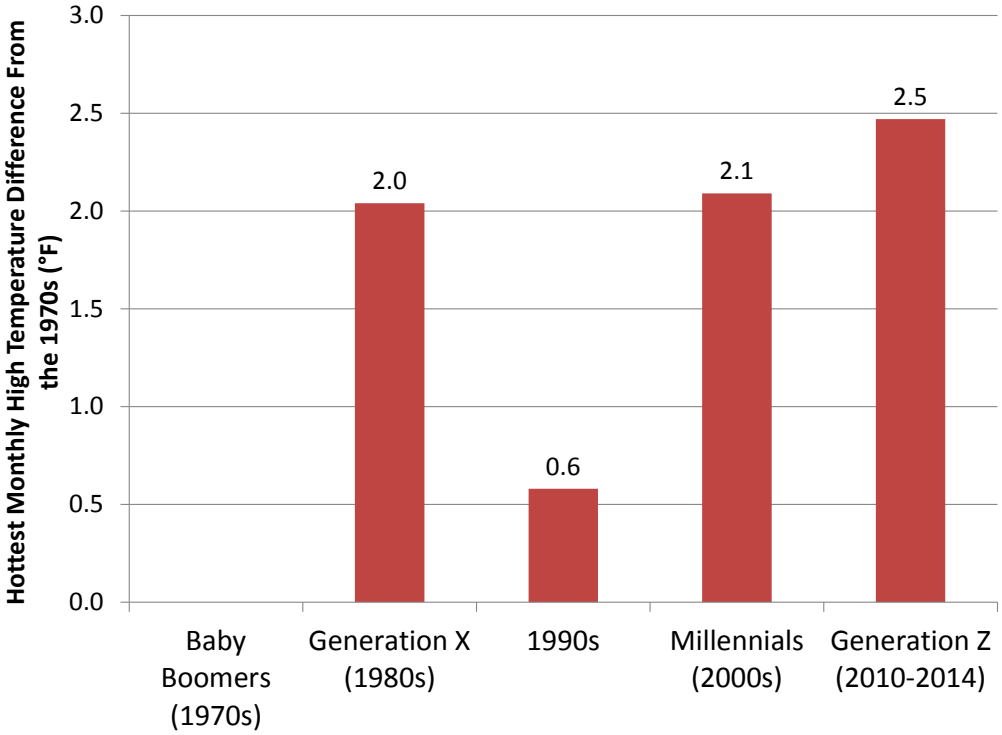
The hottest month this decade so far (through 2014) was July 2012, when the average daily maximum temperature across the contiguous United States reached 90 °F. This month broke a record set in July 1936, during the Dust Bowl, by recording the highest monthly average temperature in the history of the United States.[20]

People across the country felt the effects of this heat wave:

- St. Louis suffered from an all-time record-setting number of days above 105 °F.
- Denver experienced its warmest month on record, with seven 100-degree days.
- Washington, D.C., experienced its second-hottest July on record, during which high temperatures caused the tarmac at Ronald Reagan National Airport to melt enough to keep a plane stuck on the ground.[21]
- Farmers suffered severe losses due to the heat wave and a simultaneous drought, with 30 percent of the corn crop in "poor" or "very poor" condition.[22]

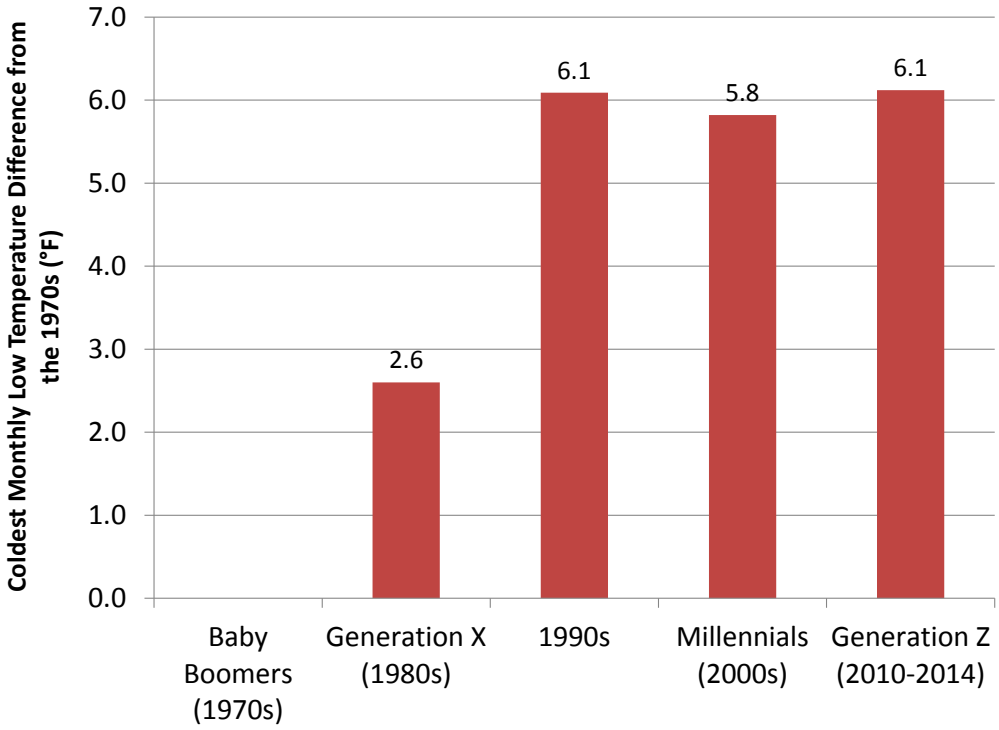
Global warming makes dangerous heat waves like this one more likely to occur.[23]

Figure 4: High Temperature Extremes Are Increasing Nationally



This chart compares high temperature extremes experienced by each generation. In this chart, "hottest month" refers to the one month of each decade with the highest average daily maximum temperature across the contiguous United States.

Figure 5: The Coldest Months Are Less Cold Nationally



This chart compares cold temperature extremes experienced by each generation. In this chart, "coldest month" refers to the one month of each decade with the lowest average daily minimum temperature across the contiguous United States.

The Impacts: Rising Temperatures and Extreme Heat Endanger Public Health, Water Availability and Food Production

Extreme heat is becoming more common across the United States, posing increased risks to public health, water availability and agriculture.

Heat waves can be deadly. The Centers for Disease Control linked extreme heat to the deaths of more than 7,800 people between 1999 and 2009 in the United States.[24] Hot and humid conditions can over-tax the human body, causing discomfort and fatigue, dehydration, heat cramps, increased visits to the emergency room and heat stroke, and they are especially dangerous to the elderly.[25] Increased days and nights with extreme high temperatures are likely to cause more heat-related deaths, especially in cities.[26] A 2015 study analyzing data from 217 cities around the world found that two-thirds of cities experienced a significant increase in the number of heat waves between 1973 and 2012.[27]

Higher temperatures contribute to the threat of large wildfires. Hot and dry conditions make the already fire-prone western United States more susceptible to large, uncontrollable wildfires that can take lives, destroy property and trigger costly fire suppression efforts.[28] Large wildfires have grown bigger and more expensive to control. The costs of fighting wildfires nearly quadrupled between 1985 and 2013 – since Millennials began entering adulthood in 2000, the United States has spent in excess of $1 billion every year to fight fires.[29] The number of large fires on federal land has increased 75 percent in western states since the 1980s, and the fire season now spans more than half the year, compared to only

five months per year in the 1970s.[30] Large wildfires are also bigger than they once were. One study showed that the total area burned by large wildfires in the western United States increased by more than 87,000 acres on average each year between 1984 and 2011.[31] Large wildfires are likely to get even worse and more expensive to control as today's children grow into adulthood.[32]

Extreme heat and rising temperatures impact water availability. In the western United States, the amount of snow that remains on the ground at high elevations during the spring determines the water resources that will be available come the heat of summer. Low snowpack reduces water availability, and unusually early spring snowmelt can disrupt the capture and distribution of precious water resources during the summer dry season.[33] High temperatures cause snowmelt to happen earlier than normal. Because of rising temperatures, spring snow cover has been decreasing in the Northern Hemisphere since the 1950s.[34] Regions dependent on snowmelt for water in the dry months have experienced shifting trends of streamflow timing between 1948 and 2008 – from late spring and summer to late winter and early spring.[35]

These changes in the availability of water supplies are challenging to water managers and a diverse group of water users.[36] Water is one of the most important inputs for agriculture. Without adequate water supplies, crops do not thrive. Growing populations will also demand more water in the western United States – the West had five of the 15 fastest-growing cities in the United States between 2012 and 2013. Nevada, Arizona, Utah and Idaho were the fastest-growing states between 2000 and 2010.[37] Changing water availability patterns contribute to an overall expectation of water stress in the western United States over the next decade. A study by the U.S. Government Accountability Office found that "40 of 50 state water managers expected shortages in some portion of their states under average conditions in the next 10 years."[38]

Rising temperatures and temperature extremes can negatively affect crop production and pose a danger to livestock production. As temperatures rise, the frost-free season increases, lengthening the growing season by 1 – 3 weeks across the country.[39] But, the challenges of warming temperatures to crop development and adaption far outweigh the benefits in many regions of the United States. For some plant species, cold days are necessary for flowering and fruit production (California's fruit and nut trees, for example); temperature increases can eliminate these cold days and threaten the healthy development of these plants.[40] If extreme heat strikes during a sensitive moment in a crop's lifecycle, such as during pollination, severe crop damage can occur.[41] Rising temperatures may also expand the reach of diseases, pests and invasive species, which can outcompete or destroy crops.[42] Extreme heat can also stress animals. For example, cattle repeatedly exposed to high temperatures show lower conception rates during the spring and summer months. Extreme temperatures also make dairy animals less productive.[43]

Pollution Is Driving Increased Temperature Extremes

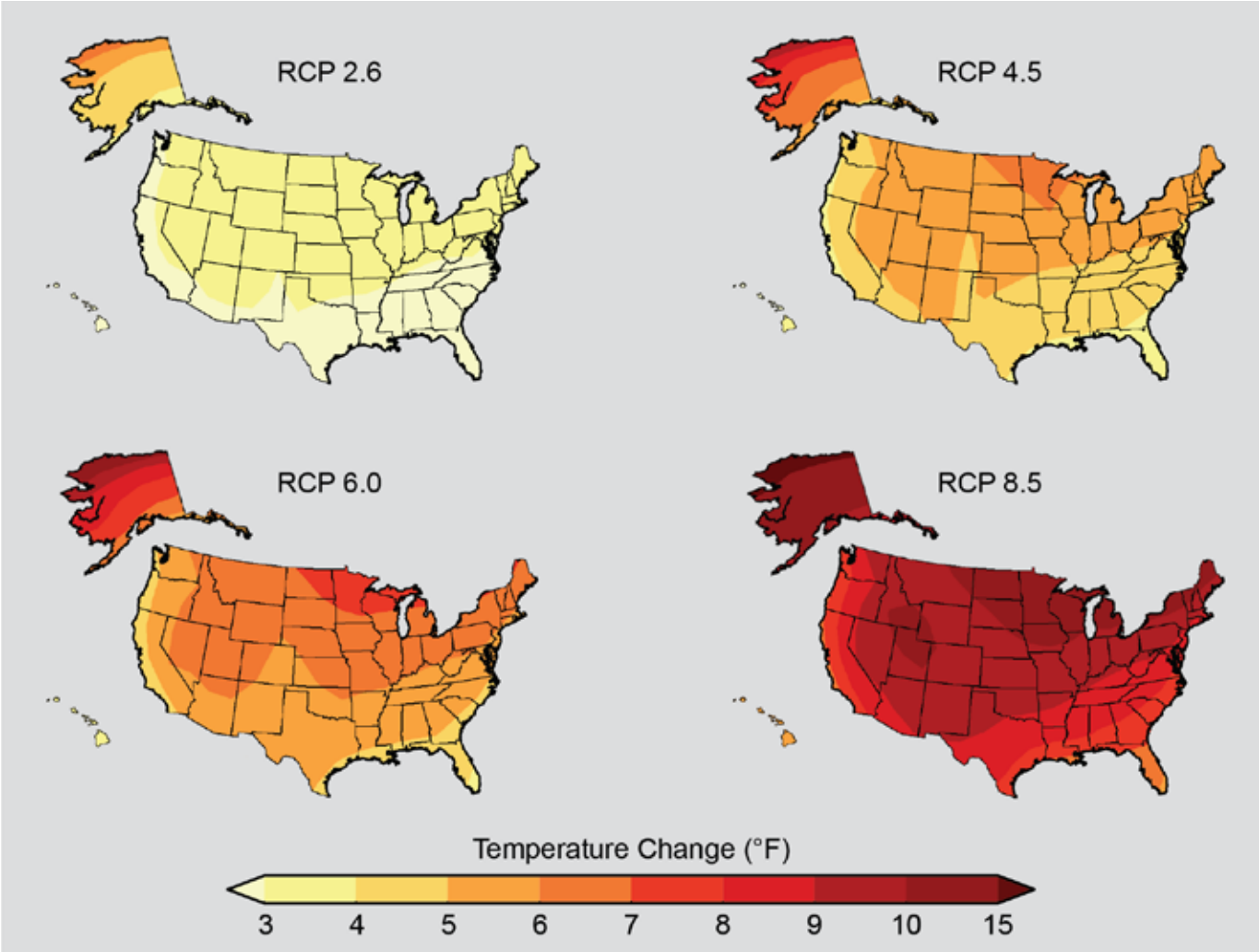
Pollution from fossil fuel combustion is largely responsible for the increase in temperatures that the United States has experienced in the last 50 years.[44] According to the National Climate Assessment, "Evidence indicates that the human influence on climate has already roughly doubled the probability of extreme heat events such as the record-breaking summer heat experienced in 2011 in Texas and Oklahoma."[45]

Children born today, who will turn 18 in the 2030s, will grow up in a warmer climate. An estimated 0.25 to 0.5 °F of global temperature increase is already "locked in" due to pollution that is already in the atmosphere.[46] The average temperature across most of the United States is projected to rise 2 to 4 °F over the next few decades.[47] The more pollution the United States and other countries around the world continue

to emit over the next few decades, the greater the temperature increases we will experience in the second half of the 21st century. If the United States and the world continue to emit more carbon pollution, by the end of the century (when today's children will be reaching retirement age) temperature will rise 5 to 10 °F, greatly magnifying the risks we face. (This scenario corresponds to RCP 8.5 scenario in Figure 6.) In contrast, if the world acts to significantly cut carbon emissions, temperature increase across the United States can be limited to 2 to 5 °F.[48] (This scenario corresponds to RCP 2.6 or 4.5 scenarios in Figure 6.)

Scientists predict that extreme high temperatures will become more common as the climate continues to warm. Climate models suggest that without action to clean up pollution, there could be 20 high temperature records for every low record by mid-century, and 50 high records for every low record by 2100.[49]

Figure 6: More Global Warming Pollution in the Atmosphere Leads to Greater Temperature Increase between 2071–2099 (Maps of Temperature Change Relative to 1970-1999 Average)[50]



These maps contain representations of temperature increase in the United States that can be expected under high and low emissions scenarios, which account for human behavior and climate policies. Scenario RCP 2.6 assumes "more than 70% [emissions] cuts from current levels by 2050 and further large decreases by 2100 – and the corresponding smaller amount of warming," and scenario RCP 8.5 "assumes continued increases in emissions (RCP 8.5) and the corresponding greater amount of warming", with scenarios RCP 4.5 and RCP 6.0 modeling intermediate emissions scenarios.[51] Reducing emissions now can reduce the threat of increased temperature rise.

When It Rains, It Pours: Extreme Storms on the Rise

Young adults in most of the country have experienced more intense extreme storms than their parents and grandparents did while growing up.[52] Heavy storms can cause hazardous flooding that threatens human life, destroys buildings and infrastructure, and impairs food production.

The Trend: Heavy Storms Are Bigger and More Frequent

Extreme storms are becoming more frequent and more intense. According to the U.S. Global Change Research Program, the increasing frequency and intensity of heavy downpours is "[o]ne of the clearest precipitation trends in the United States."[53] This trend in heavy rainfall events is much stronger than the change in average precipitation across the United States, which has decreased in some U.S. regions and increased in others since the beginning of the 20th century.[54]

An analysis of trends in extreme precipitation between 1948 and 2011 shows that the most intense rain and snowstorms have become 30 percent more frequent nationwide.[55] In New England, a storm that used to occur every 12 months in 1948 now occurs every 6.5 months.[56]

Major precipitation events are not just happening more frequently, but they are also getting bigger. The trend toward bigger rain and snowstorms has been a long-term one; an analysis of weather records during the period between 1948 and 2011 shows that the size of the largest rainstorms in the United States increased by 10 percent.[57] Another analysis of daily weather records between 1958 and 2012 supports this conclusion, showing that the Midwest and Northeast have experienced the greatest increase in the size of heavy downpours. The Northeast saw a 71 percent increase in heavy downpours between 1958 and 2012 and the Midwest experienced a 37 percent increase in heavy storms over that same period.[58]

In the following section, we look at changes in the size of extreme precipitation events that Americans have experienced over the last 40 years.

Generational Experience: Millennials and Generation Z Grow up with More Intense Extreme Precipitation Events

Extreme storms are dropping more precipitation, on average, in recent years than they did during earlier generations. An analysis of the 41-year trend in the size of the biggest storms reveals that extreme storms have grown in size in almost every state since the Baby Boomers were coming of age in the 1970s. (See Figure 7.) New England states experienced the most dramatic increase in the size of the biggest storms between 1970 and 2011:

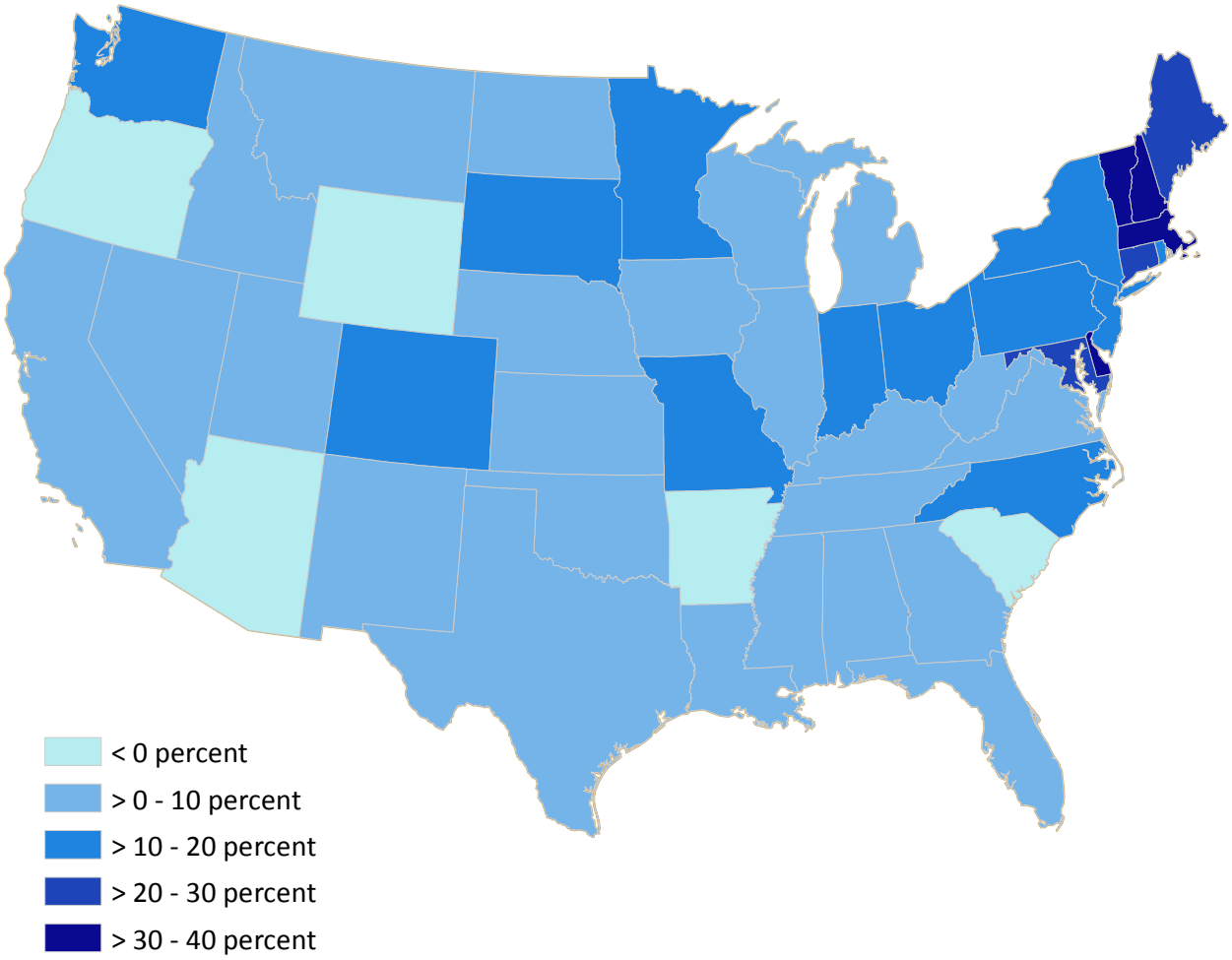
- In New Hampshire, Generation Z has experienced a 40 percent increase in the size of extreme storms.
- In Vermont, Generation Z has experienced a 37 percent increase in the size of extreme storms.
- In Massachusetts, Generation Z has experienced a 34 percent increase in the size of extreme storms.

The Impacts: Heavy Precipitation Claims Lives, Harms Crop Development and Threatens Property

More extreme precipitation can lead to more flooding, the impacts of which can include: deaths and injuries; disease triggered by contaminated drinking water sources; damaged infrastructure; and significant costs to business and the economy.[63] Increased flooding has the potential to be costly: over the last 30 years, floods in the United States have caused an average of $8.2 billion in damage per year.[64] Flooding caused by extreme precipitation can also increase the incidence of waterborne diseases, which threaten human health.[65]

Sudden downpours can have a negative effect on crop production. Heavy precipitation events can

Figure 7: The Biggest Storms are Getting Bigger (Percent Increase in Maximum Annual 24-hour Precipitation Totals by State, 1970 to 2011)



Extreme Snowfall Strikes the Northeast

Young adults living in Boston during the first few months of 2015 can testify that extreme precipitation can also mean snowfall. The city of Boston experienced 74.4 inches of snowfall in January and February 2015 – breaking all-time records for the amount of snow falling in a 14-day period, 20-day period and 30-day period.[59] These storms shut down the city's public transportation system multiple times, caused roofs to collapse under piles of snow and ice, and created costly clean-up challenges – including $33 million in snow removal – for the city to endure.[60]

This is consistent with the impacts of global warming. As the atmosphere warms, it can hold more water vapor. When that moisture falls as precipitation, it can result in more extreme rainstorms (when it is warm enough to rain), and more extreme snowfall during winter (when it is cold enough to snow).[61] Scientists have concluded that there is evidence of an increase in the frequency and intensity of winter storms in the Northern Hemisphere between 1950 and 2010, and such storms have moved northward.[62]

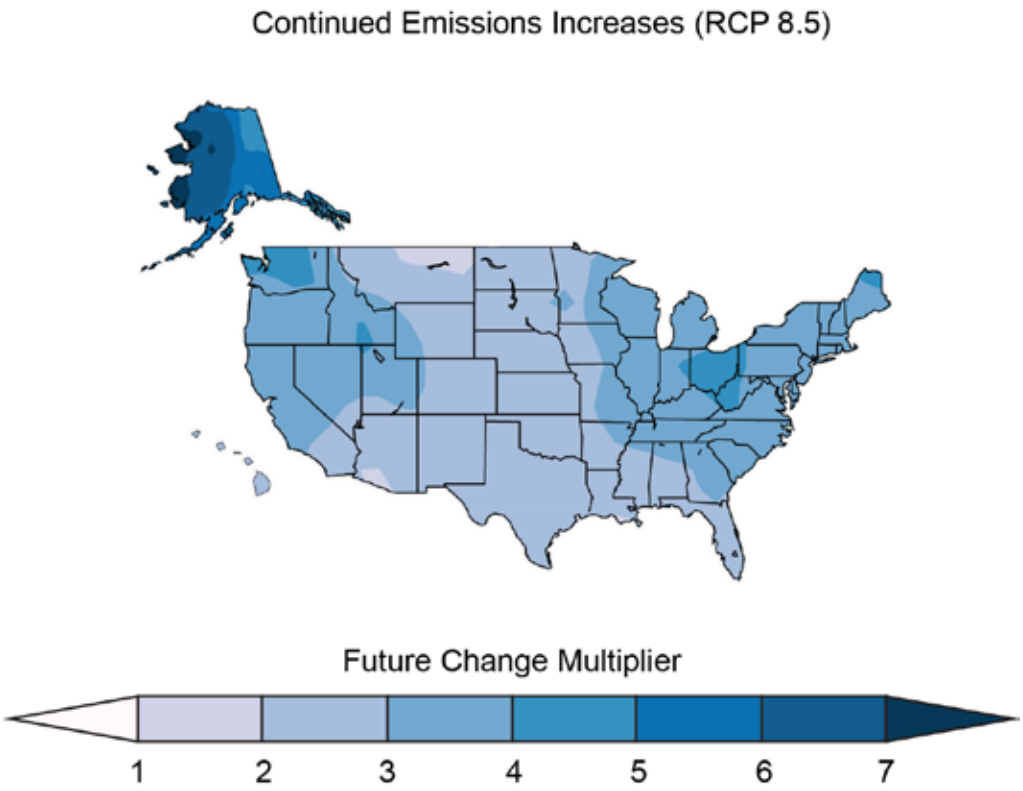
cause disease problems in the soil, increase farming costs and make it difficult for farmers to manage their crops. Flooding caused by extreme precipitation can also wash away nutrient-rich topsoil, which can compromise crop productiveness.[66]

Global Warming Will Fuel More Frequent and Heavier Storms

Scientists have linked recent increases in extreme precipitation events to global warming, because warmer air can hold more moisture than cooler air.[67] More intense precipitation events can occur even without changes in total precipitation.[68] Scientists predict with "a high degree of certainty" that the United States will be more frequently impacted by heavy precipitation events as the world continues to warm.[69] (See Figure 8.) The severity of the impact depends on how effectively humanity controls global warming pollution.

Given our current warming trend, members of Generation Alpha, today's children, will be entering adulthood as the nation is hit by larger and more frequent extreme precipitation events. Scientists have "high confidence" that extreme precipitation will increase in most regions of the United States.[72] These events threaten lives and property with flooding, negative impacts to food production, and an elevated threat of waterborne diseases.

Figure 8: Unchecked Global Warming Will Continue to Make Extreme Precipitation More Frequent[70]



This map illustrates how many times more frequently regions in the United States will experience extreme precipitation events (defined by the National Climate Assessment as "a daily amount that now occurs once in 20 years") if humans continue to produce greenhouse gas emissions at a high and increasing rate. These extreme events are predicted to occur up to five times as often in some places in the United States under this high emissions scenario (RCP 8.5).[71]

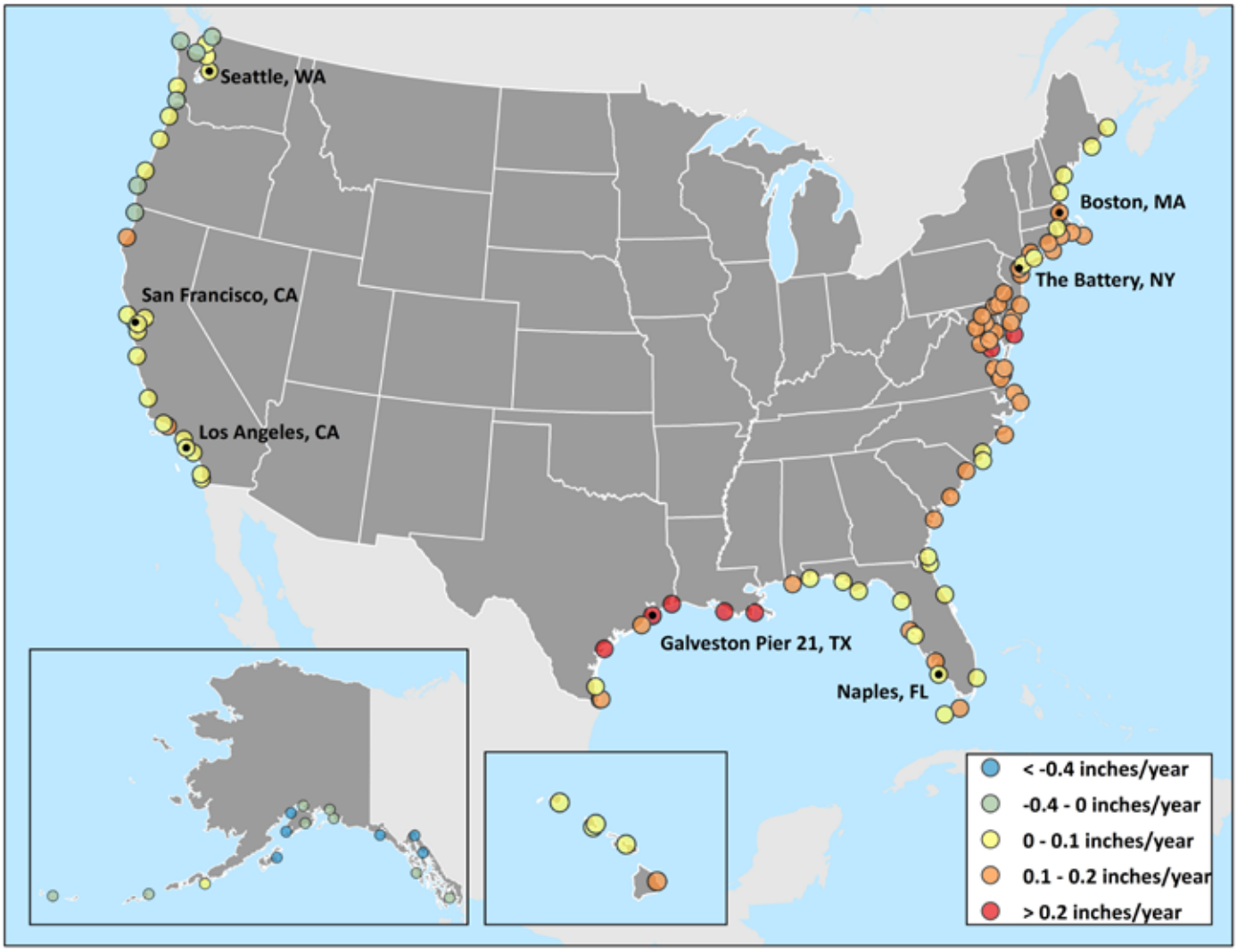
Rising Seas

Our coasts are uniquely vulnerable to the impacts of rising seas. The United States has more than 94,000 miles of coastline, and more than half of the U.S. population lives in these coastal regions.[73] About 5 million people live within 4 feet of local high tide levels.[74] Businesses are prolific in coastal areas: there are 66 million jobs located in coastal counties and workers in these communities earn on the order of $3.4 trillion in wages each year.[75]

As Baby Boomers have watched their children grow up, rising seas have begun to encroach upon coastal cities from New York to Philadelphia to New Orleans to San Francisco. Rising seas have begun to tax fishing and tourism economies dependent on a healthy ocean, and to threaten communities with significant flooding and infrastructure damage.

More changes are in store for future generations, from increased coastal flooding to impacts on marine ecosystems caused by rising temperatures and increased acidification of ocean waters.

Figure 9: Tide Gauges in the Eastern U.S. Show Trends of Sea Level Rise, as of 2013[80]



The Trend: Sea Level Is on the Rise in the United States

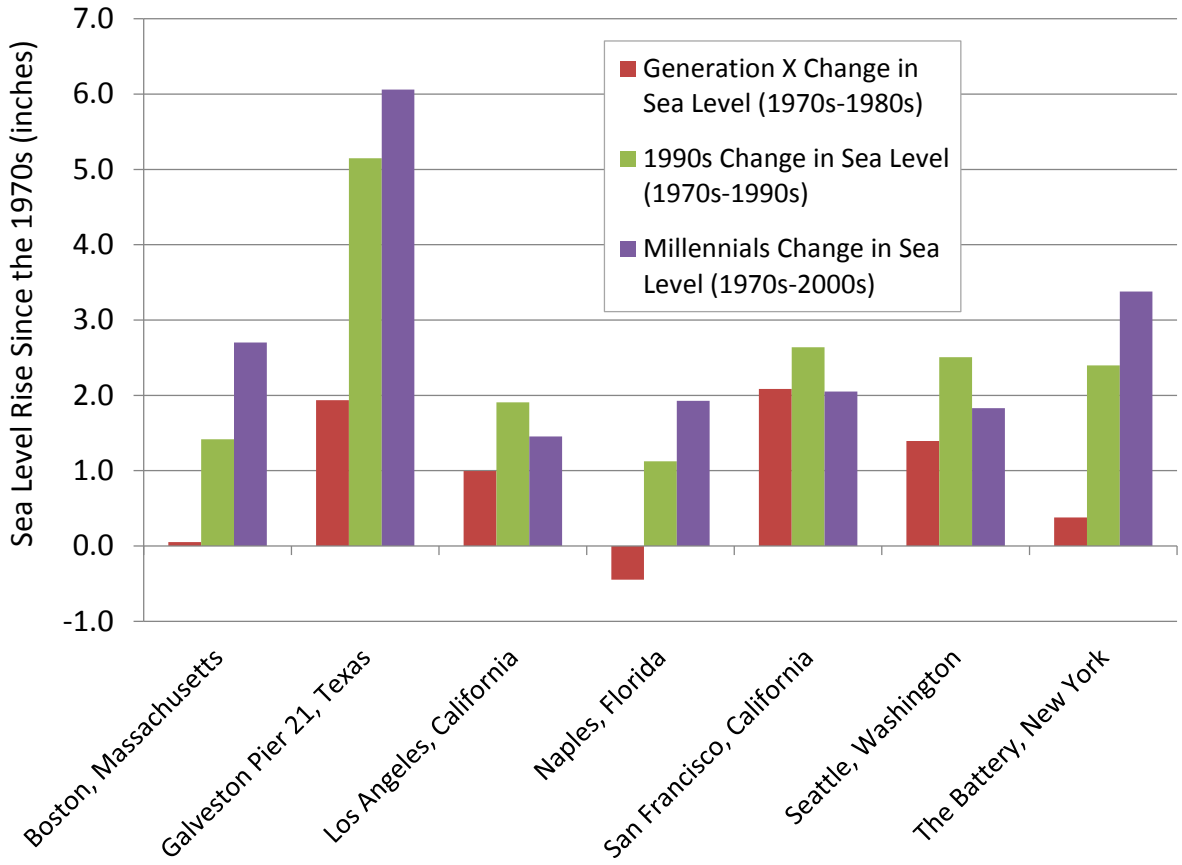
Globally, sea level has risen 8 inches since the 1880s – a faster rate than sea level has risen at any point in the last 2,000 years.[76] Vertical land motion (either land subsidence or land uplift) and seasonal ocean circulation patterns, among other factors, contribute to fluctuations in sea level, but scientists have clearly documented an overall trend of global sea-level rise during the last century.[77] Satellite data show that the rate of sea-level rise has been accelerating since 1992 to twice the rate of the last century.[78]

In the United States, the northeastern and southern regions of the United States have experienced the most dramatic sea-level rise. (See Figure 9.) Tide gauge records have been measuring mean sea level at coastal cities in the United States for the past 50 to 100 years, giving us a record of the local changes that coastal communities have undergone. In Louisiana, sea-level rise and land subsidence combine to produce the fastest relative rate of mean sea-level rise in the world; the state's southeast coast averaged 3 feet of sea-level rise during the last century.[79]

Generational Experience: Americans in Coastal Cities Have Lived Through Years of Sea Level Rise

In this section, we compare sea-level rise experienced by Americans across three generations in seven cities along the U.S. coast: Boston; New York City; Naples, Florida; Houston (near Galveston Pier); Los Angeles; San Francisco and Seattle. (See Figure 10.) We did not include the early 2010s in this comparison, due to

Figure 10: Sea-Level Rise Is Affecting U.S. Cities[82]



data limitations. Mean sea level is measured in reference to a locally designated point based on the tides at each U.S. station.[81]

Boston is experiencing relative sea-level rise at a rate of 0.11 inches per year. The city experienced sea-level rise of 2.7 inches between the young adulthood of the Baby Boomers and the 2000S, when Millennials were growing up.

Relative sea-level rise near Manhattan in New York City is also proceeding at a rate of 0.11 inches per year.[83] In the 2000s, young Millennials experienced seas 3.4 inches higher than the mean sea level that Baby Boomers grew up with in New York City.

In Naples, Florida, relative sea-level rise is occurring at a rate of 0.09 inches per year. Millennials experienced seas 1.9 inches higher than Baby Boomers did in Naples, Florida when both generations turned 18.

Sea-level rise of 0.25 inches per year is being recorded 53 miles from the center of Houston, Texas at the Galveston Pier 21 tide gauge.[84] Millennials experienced relative sea level 6.1 inches higher in the first decade of the 21st century than Baby Boomers did when entering adulthood in Houston.

On the West Coast, land uplift in Washington and Oregon is slowing the relative rate of sea-level rise, but sea level has still risen at major cities along the west coast.[85] In Los Angeles, Millennials experienced sea levels 1.5 inches higher between 2010 and 2014 than Baby Boomers did in the 1970s. In San Francisco, they experienced seas that were 2 inches higher and in Seattle, they were 1.8 inches higher.

The Impacts: High Flood Risk Endangers Life and Property Along the U.S. Coastline

Even a small amount of sea-level rise can have a dramatic impact on our coastal communities. Much of the densely populated Atlantic and Gulf Coast coastline sits less than 10 feet above sea level, and more than half of the country's economic productivity takes place in coastal zones.[86] In addition to experiencing more frequent nuisance flooding, coastal communities will be challenged to respond to major storm surges, threats to local infrastructure, and impacts on tourism and fishing economies as sea level rises.

Communities will be at a higher risk for major flooding events. Sea-level rise has been accompanied in a number of places by an increase in "nuisance flooding" – noticeable flooding with minor impacts on a community. One study of 45 U.S. tide gauges by the National Oceanic and Atmospheric Administration concludes that there has been a significant increase in nuisance flooding along the northeast Atlantic coast, due to a combination of vertical land subsidence and high rates of sea-level rise.[87] While the Baby Boomers were being born in the early 1950s, these flooding events had a probability of occurring every 1 to 5 years on average. Their children are growing up in a markedly different environment. As Generation Z neared adulthood in 2012, nuisance flooding events have a likelihood of occurring every three months on average at most tide gauges across the country.[88] Major flooding events are also more likely to occur than they were a few decades ago. One study found that, due to sea-level rise, members of Generation Z nearing adulthood in 2013 in the New York City region experience twice the risk of a Sandy-level flooding event than Americans did in 1950 when the Baby Boomers were born.[89]

A total of 8.6 million Americans live in an area classified as part of a flood hazard zone by the National Flood Insurance Program, and 1.2 million people relocate to the coasts every year.[90] The National Flood Insurance Program predicts that the number of flood insurance policies will increase by 80 percent by 2100 and the premium per policy will increase by 40 percent by 2100.[91] As flood risk increases for people living in low-lying areas – like coastal Florida or Louisiana – people will incur higher costs to maintain their homes in these areas.[92]

Sea Level Rise Is Destroying Louisiana's Wetlands

Louisiana, a state known for its coastal communities, diverse wildlife and a thriving fishing industry, is on the front lines of the fight against global warming. The state is losing its coastal wetlands at an average rate of 16 square miles per year, leaving its residents, animal population and economy vulnerable to the dangers of storm surges, water contamination and erosion.[103]

As global temperatures increase, the waters of the Gulf of Mexico expand as they get warmer and rise as glaciers and ice sheets melt—rapidly devouring the state's protective barrier islands and making their way into the thousands of acres of wetlands that protect the state from storm surge.[104] Sea-level rise along the Louisiana coast is exacerbated by canals dug through marshland and water withdrawals by the oil and gas industry, by decreased siltation from the Mississippi River, and by land subsidence.[105] The Coastal Protection and Restoration Authority estimates that the state has lost 1,880 square miles of coastland since the 1930s, and that further inaction could result in the loss of an additional 1,750 square miles in the next 50 years.[106] The rate of land loss has increased so dramatically that the National Ocean and Atmospheric Administration (NOAA) erased 30 bays, marshes and other habitats from its charts in 2013—areas that are now permanently under the sea.[107]

In an interview with *ProPublica* and *The Lens*, residents of the Louisiana coast describe how different the land is on which they are raising their children and grandchildren:

"I see what was," said Lloyd "Wimpy" Serigne, who grew up in the fishing and trapping village of Delacroix, 20 miles southeast of New Orleans. It was once home to 700 people; now there are fewer than 15 permanent residents. "People today — like my nephew, he's pretty young — he sees what is."[108]

These disappearing places are important for a variety of environmental, social and economic reasons. Barrier islands are critical to protecting mainland Louisiana from the supersized hurricanes that often plague the region. As the first points of contact during a storm, these offshore deposits of sand absorb much of the storm's energy, breaking waves and reducing wind gusts.[109] Wetlands, the second line of defense, act as the kidneys of the waterways – absorbing sediment and pollution while regulating floodwaters.[110] In addition to providing these environmental services, these habitats help the state's economy by boosting tourism and supporting the robust fishing industry.[111] And as these habitats disappear into the sea, so do the memories of generations of residents that grew up in the area.

State officials have recognized the threat posed by rising sea level in Louisiana, and have invested $50 billion into efforts to rebuild barrier islands and other lost coastal habitats.[112] While these efforts may stem the tide of sea rise, the future of the wetlands of Louisiana depends on cutting emissions to slow future increases.[113] As a Tulane University climatologist told *National Geographic*, "We're setting ourselves up for melting large parts of Greenland and West Antarctica. It may take a number of centuries for this to play out, but when those things start to happen, it's going to be game over here in New Orleans. But don't forget, it's going to be game over in New York City as well, and every other coastal city in the world."[114]

Storms become more dangerous with higher sea levels. Storm surges – rising water levels associated with a storm – are often the most destructive part of major storms. Surging waters allow waves to extend inland and damage coastal infrastructure and create currents that erode beaches and roads.[93] A 2013 study found that storms the size of Hurricane Katrina – which struck the Gulf Coast in 2005 and was one of the deadliest hurricanes to hit the United States – could strike the Gulf Coast two to seven times more frequently with each 1.8 ºF (1 ºC) increase in global temperature.[94] Storm surge flooding events that used to occur rarely – once every 100 years – will likely become more common as sea level rises.[95]

Sea-level rise threatens local infrastructure. Coastal flooding threatens to overwhelm low-lying property and infrastructure. Sea-level rise and land subsidence put more than $1 trillion in U.S. coastal buildings at risk of flooding in the next century, or sooner if sea level rises at a faster pace.[96] Local wastewater treatment facilities on the coasts could be incapacitated by higher levels of storm water and flood water. They are often located at low elevations for ease of water collection, making them vulnerable to flooding.[97]

According to a study by Climate Central, major flooding events put lives and infrastructure at risk:[98]

- A flood above 9 feet in Louisiana would put 1.4 million people, more than 600,000 homes and 4.7 million acres of land at risk.[99]
- More than 600,000 people and $90 billion in property would be threatened by a 100-year flood in New York City.[100]
- In Houston, $971 million in property would be threatened by a 100-year flooding event.[101]
- A major flooding event in Baltimore, Maryland, would put $3.1 billion in property at risk.[102]

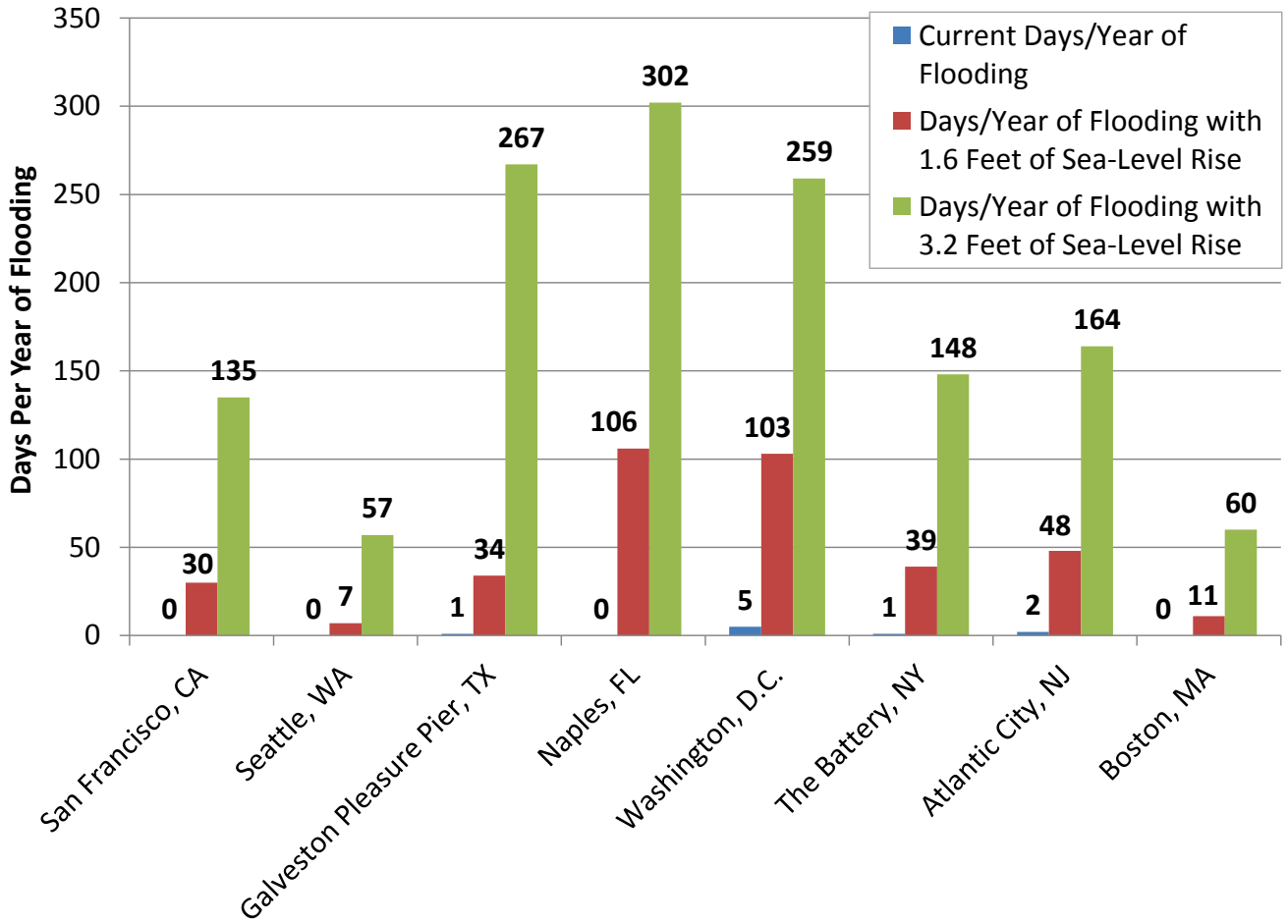
Global Warming Drives Sea-Level Rise by Melting Ice and Warming Oceans

Global warming is the primary cause of the global average sea-level rise of 8 inches from 1880 to 2009.[115] Higher sea level results from both melting land ice and thermal expansion of water as it warms. Sea-level rise will occur at a faster rate along some portions of the U.S. coastline due to higher rates of land subsidence.[116]

If the United States and the world continue to emit carbon emissions at an increasing rate, the resulting temperature rise will contribute to more global sea-level rise: 1.9 feet by 2100 in a low emissions scenario that would involve significant emissions cuts and 3.6 feet by 2100 in a high emissions scenario.[117] Some argue that if Greenland or Antarctic ice sheets melt faster, sea level could rise as much as 6.6 feet by 2100.[118] Sea-level rise on that scale would severely endanger lives, property and land area in major U.S. metropolitan areas.

Data from the National Oceanic and Atmospheric Administration show that coastal U.S. cities will experience more frequent and prolonged periods of flooding even with the low emissions scenario of sea-level rise. (See Figure 11.) The more sea level rises, the closer low-lying areas will come to permanent inundation by ocean waters.[119]

Figure 11: Many Cities Will Experience Prolonged Flooding with Predicted Sea-Level Rise[120]



Ocean Acidification Is Changing Our Oceans and Threatening Coastal Livelihoods

In addition to increasing atmospheric temperatures, emissions of carbon dioxide are increasing ocean acidity, harming ocean ecosystems. The amount of carbon dioxide in the atmosphere is increasing, and nearly a quarter of that human-emitted carbon dioxide is being re-absorbed into the world's oceans, making them more acidic. Higher ocean acid content makes it difficult for corals, zooplankton and shellfish to undergo the calcification processes necessary to form shells or corals.[121]

Ocean acidification is already harming marine ecosystems along the coast and challenging the viability of coastal businesses. Oyster farmers in the Pacific Northwest have noticed changes in ocean acidity through its impact on their shellfish businesses. Two major shellfish businesses – Taylor Shellfish in Puget Sound and Whiskey Creek in Willapa Bay, Washington – have reported that oysters have been dying before they reach maturity. On the West Coast, oyster production has an economic impact of $207 million and provides about 3,000 jobs.[122] Oysters also support the marine ecosystem in the Pacific Northwest; their disappearance would impact other species like the Pacific Salmon.[123]

In addition to damaging food production, ocean acidification is destroying coral reefs, which are important for marine ecosystem health and generate a significant amount of tourism along the coast. According to the National Climate Assessment, "75 percent of U.S. coral reefs in the Atlantic, Caribbean, and Gulf of Mexico are already in 'poor' or 'fair' condition; all Florida reefs are currently rated as 'threatened.'"[124]

If humans continue to emit high levels of carbon dioxide into the atmosphere, today's children in Generation Alpha may grow up in a world where our marine ecosystems have been significantly changed, with many coral reefs damaged and places like Puget Sound, once vibrant fisheries, unable to host shellfish.

Policy Recommendations: Reduce Pollution, Accelerate Clean Energy Adoption

Global warming poses serious threats to our civilization. Lessening these impacts will require a global effort. The United States, as the number one historical source of the pollution driving global warming in our atmosphere, has an opportunity – and an obligation – to lead the world in deploying clean energy technologies and eliminating pollution.[125]

Science tells us that developed countries must reduce emissions by at least 80 percent below 1990 levels by 2050 in order to prevent the most costly and devastating consequences of global warming.[126] Getting there will require federal, state and local action in the United States.

To protect our children and grandchildren, spur local clean energy development in our communities, and prevent the worst impacts of global warming, the federal government should:

- **Finalize a strong Clean Power Plan** (CPP). The CPP will establish the first national limits on carbon pollution from fossil fuel-fired power plants, the largest single source of pollution in the United States.
- **Secure a global agreement with strong commitments for action** at the 2015 United Nations Climate Change Conference in Paris. Regardless of the Conference's outcome, the United States should adopt and implement limits on global warming pollution capable of reducing emissions by at least 80 percent below 1990 levels by 2050.
- **Accelerate renewable energy deployment and increase energy efficiency** by renewing and extending tax credits for solar and wind installation and generation, setting bold goals for wind and solar energy adoption, developing a national energy efficiency resource standard, and working closely with state governments to encourage the construction of offshore wind farms in federal waters.
- **Invest in clean energy** rather than in dirty infrastructure projects – such as the proposed Keystone XL tar sands pipeline – that facilitate the development of fossil fuels.
- **Reduce our consumption of oil** through measures such as strengthening fuel efficiency

standards for heavy -duty vehicles and passenger cars and trucks, accelerating the deployment of zero-emission vehicles, and encouraging communities to plan for an oil-free future.

State policymakers should:

- Implement the Clean Power Plan, going above and beyond minimum targets for power plant cleanup and maximizing investments in truly clean energy infrastructure, including both renewable energy and energy efficiency.
- Establish and implement economy-wide limits on carbon pollution capable of reducing emissions to 80 percent below 1990 levels by mid-century.
- Accelerate renewable energy and energy efficiency development with standards and incentives.
- Reduce transportation pollution through policies that reduce dependence on cars and encourage low-emission forms of transportation, and speed the adoption of zero-emission vehicles.

Local policymakers should:

- Encourage local renewable energy by buying renewable electricity for municipal buildings, negotiating for renewable electricity in states that allow community aggregation or have municipal or cooperative utilities, and encouraging the installation of solar panels on local homes and businesses.
- Reduce transportation pollution by providing alternatives to driving, and by developing walkable neighborhoods that support a variety of transportation choices. Local governments can also purchase low or zero-emission vehicles for city fleets, and encourage the installation of electric charging stations on city streets.
- Encourage energy efficiency whenever possible, for example by adopting strong building codes, establishing and accelerating efficiency retrofit programs for existing buildings.

Appendix A: Methodology

This report uses climatic data from the National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC) and NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) to quantify the changes in climate and sea level that Americans are experiencing. The report focuses on three climate change indicators – extreme temperature, extreme precipitation and sea-level rise – and reviews the available data to determine how people of different generations experienced the climate during their young adulthood.

Generations

To evaluate how different generations of Americans have experienced the changing climate, we reviewed climatic data for four generations of Americans, and projections of future trends for a fifth, as defined in the table below. We chose a single decade to represent each generation's young adulthood (the middle decade if there are three, earlier decade if there are two) to reference a time period in which members of that age group could remember details of their surroundings.

Data for the 1990s – a decade that spans the early adulthood of younger Gen X'ers and the oldest Millennials – are also included for comparison.

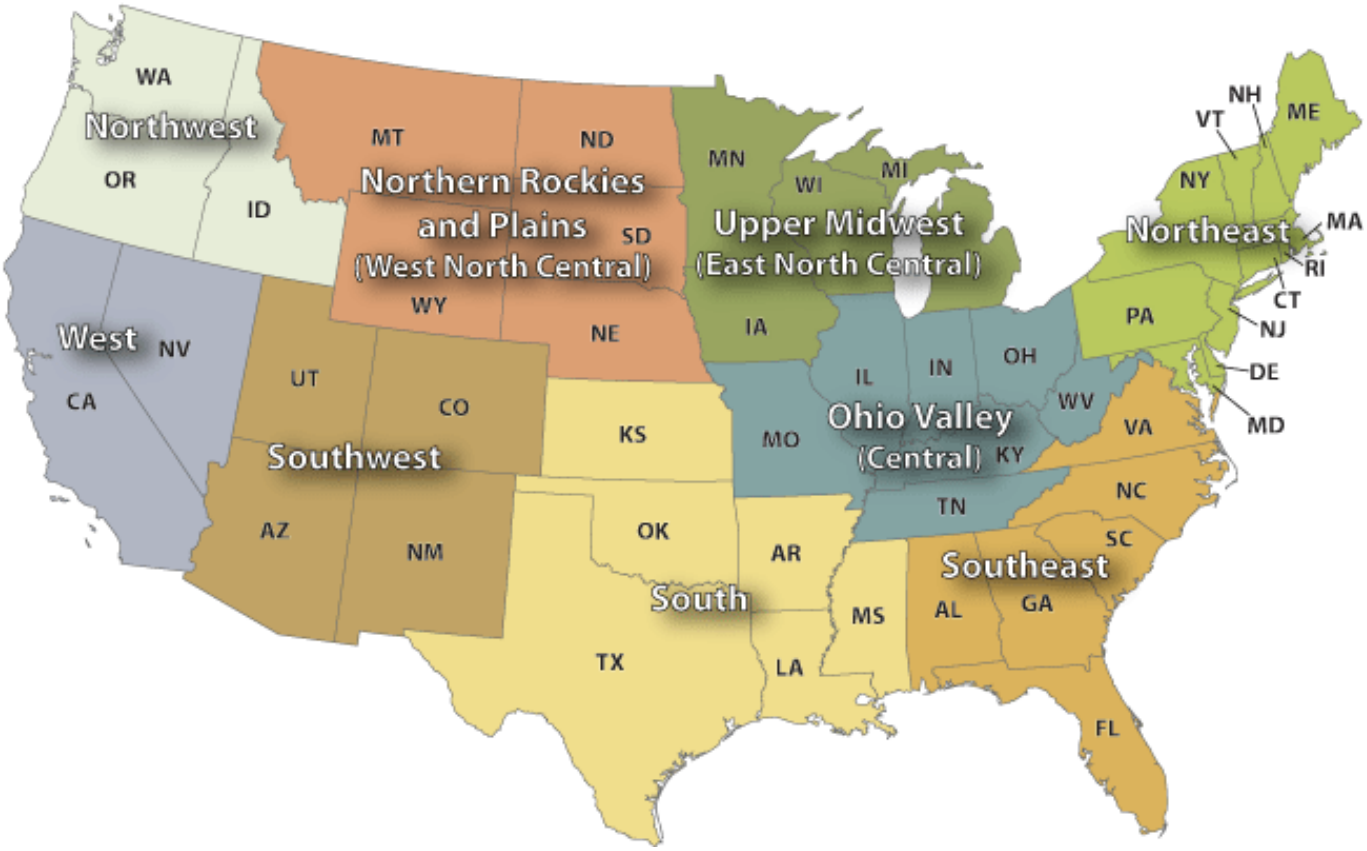
Regions

When we discuss extreme temperature trends and extreme precipitation trends in terms of regional impacts, we used the National Oceanic and Atmospheric Administration's (NOAA's) definitions of climate regions. These climate regions are defined in the map on the next page.

Table A-1: Five Generations of Americans Included in the Report[127]

Generation Name	Born	Entering Adulthood (Turning 18)
The Baby Boomers	1946 – 1964	The 1970s
Generation X	1965 – 1980	The 1980s
Millennials (Generation Y)	1981 – 1994	The 2000s
Generation Z	1995 – 2009	The late 2010s
Generation Alpha (Today's Children)	2010 – 2025	The 2030s

Figure A-1: U.S. Climate Regions[128]



Average Temperature and Extreme Temperature

We derived the temperature analysis data in this report from the National Climate Data Center's "Climate Indices" data, available at http://www.ncdc.noaa.gov/data-access/quick-links#indices. Using temperature records going back to 1895, NCDC calculated average monthly temperature composites at the national, regional, statewide and climate division level, including monthly average high temperature, monthly average low temperature, and monthly average temperature. The data includes the contiguous United States.

We aggregated these data by decade, focusing on the last 45 years, to produce this analysis. We compared average temperatures between the 1970s (1970 – 1979), 1980s (1980 – 1989), 1990s (1990 – 1999), 2000s (2000 – 2009), and 2010s to date (2010 – 2014).

We also used national composite monthly average high temperatures and monthly average low temperatures to make a comparison of the most extreme months of each decade. We defined "hottest month" as the month with the highest average maximum temperature in each decade, and compared these "hottest months" between decades. Likewise, we defined the "coldest month" of each decade as the month with the lowest average minimum temperature across, comparing between decades. Again, these data cover the contiguous United States.

Extreme Precipitation

We calculated the change in the size of the largest precipitation events by region and state using data developed for our 2012 report, *When It Rains, It Pours* (available at http://www.environmentamerica.org/

reports/ame/when-it-rains-it-pours), which analyzed daily precipitation data from more than 3,000 weather stations across the contiguous 48 states.[129]

We obtained weather data from the Global Historical Climatology Network-Daily Database maintained by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center (NCDC). The data provide daily records from more than 75,000 stations in 180 countries and territories, including 24-hour precipitation totals, in addition to geographic coordinates for the weather stations, covering varying time periods with varying degrees of completeness. The National Climatic Data Center performs quality assurance checks on the data.

For days in which a precipitation measurement was missing, yet a measurement for snowfall was recorded (a miniscule percentage of total measurements), we filled in the missing precipitation information using the 10 to 1 ratio method (i.e., precipitation was estimated at 1/10th the amount of snowfall). We discarded all observations that NCDC had flagged as having failed any type of data consistency check.

To evaluate the change in the amount of precipitation produced by the biggest annual storms from 1970 to 2011, we selected the single largest storm (in terms of 24 hour precipitation total) at each weather station in each year. We used a linear regression to analyze the trend in the size of the biggest storms by state, region and nationally. We used this trend to draw conclusions about the percent increase in the size of the biggest storms by state over that 41-year time period.

Sea-Level Rise

We downloaded data on sea-level rise at U.S. stations as of the end of 2014 from NOAA's Center for Operational Oceanographic Products and Services. Monthly sea level data and a chart of the data are available for each U.S. station, and we downloaded each for the 7 stations highlighted in this report. To determine the mean sea level for each generation, we removed "unverified" months of sea level data and averaged monthly sea level over the decade in question.[130] We did not include the early 2010s in out comparison because of the high percentage (greater than 10 percent) of monthly measurements that were missing or unverified for the stations we evaluated. Monthly values for mean sea level are relative sea level values measured in reference to the most recent 1983 – 2001 "National Tidal Datum Epoch" computed by NOAA; a tidal datum is a reference point derived locally at each station based on tide observations and used to track relative sea level trends and set marine boundaries.[131] Detailed, station-specific tidal datum information is available at: http://co-ops.nos.noaa.gov/stations.html?type=Datums. See Appendix B for NOAA's charts of sea-level rise at the stations we discuss in this report.

To construct the map of sea level trends at all U.S. stations (see page 21), we downloaded the data table "U.S. Linear Relative Mean Sea Level (MSL) trends and 95% Confidence Intervals (CI) in mm/year and in ft/century," which provided mean sea level trends for 129 U.S. Stations. Stations in the contiguous United States and Alaska and Hawaii were included.

Appendix B: Data Tables

Table B-1: 1970s Average Temperature and Average Temperature Change since the 1970s, by State (°F)

State	Average Temperature Baby Boomers (1970s)	Generation X Temperature Change (1970s - 1980s)	1990s Temperature Change (1970s - 1990s)	Millennials Temperature Change (1970s - 2000s)	Generation Z Temperature Change (Early 2010s - 1980s)
Alabama	62.3	0.3	1.0	1.1	0.9
Arizona	59.0	0.9	1.2	2.2	2.1
Arkansas	59.7	0.3	1.0	1.2	1.2
California	57.3	0.8	1.0	1.6	1.8
Colorado	44.3	0.8	1.2	1.9	1.9
Connecticut	48.2	0.3	1.4	1.3	2.4
Delaware	54.3	0.2	1.3	1.7	2.4
Florida	70.1	0.2	1.1	0.9	0.9
Georgia	63.0	0.2	1.0	0.9	0.9
Idaho	42.3	0.4	1.2	1.5	1.6
Illinois	51.1	0.6	1.2	1.6	1.4
Indiana	50.8	0.5	1.3	1.5	1.5
Iowa	47.0	1.0	0.9	1.5	1.2
Kansas	53.8	0.5	0.7	1.4	1.4
Kentucky	54.8	0.4	1.2	1.5	1.4
Louisiana	65.7	0.3	1.1	1.3	1.1
Maine	40.2	0.3	1.1	1.3	2.7
Maryland	53.7	0.2	1.2	1.5	1.9
Massachusetts	47.1	0.2	1.2	1.3	2.5
Michigan	43.4	0.7	1.3	1.9	2.0
Minnesota	39.8	1.4	1.5	2.2	1.9
Mississippi	62.9	0.3	1.0	1.2	1.0
Missouri	54.0	0.4	0.9	1.2	1.2
Montana	40.7	1.3	1.5	2.0	1.6
Nebraska	48.1	0.8	0.9	1.6	1.4
Nevada	49.4	0.6	1.0	1.7	1.7
New Hampshire	42.5	0.2	1.2	1.2	2.5
New Jersey	51.7	0.2	1.2	1.6	2.4
New Mexico	52.4	0.7	1.3	2.1	2.3
New York	44.3	0.5	1.3	1.6	2.4

Continued on page 34

Continued from page 33

State	Average Temperature Baby Boomers (1970s)	Generation X Temperature Change (1970s - 1980s)	1990s Temperature Change (1970s - 1990s)	Millennials Temperature Change (1970s - 2000s)	Generation Z Temperature Change (Early 2010s - 1980s)
North Carolina	58.3	0.0	0.9	1.1	1.1
North Dakota	39.4	1.7	1.3	1.8	1.3
Ohio	50.0	0.4	1.3	1.5	1.6
Oklahoma	59.0	0.3	0.8	1.2	1.5
Oregon	46.6	0.2	1.0	1.2	1.1
Pennsylvania	47.9	0.3	1.2	1.4	1.9
Rhode Island	49.0	0.1	1.2	1.3	2.3
South Carolina	62.2	0.1	0.9	1.0	1.0
South Dakota	44.2	1.3	1.0	1.8	1.1
Tennessee	57.0	0.3	1.0	1.3	1.1
Texas	64.0	0.5	1.3	1.7	2.1
Utah	47.3	0.7	1.3	2.1	1.7
Vermont	41.4	0.3	1.1	1.4	2.6
Virginia	54.6	0.1	1.0	1.2	1.4
Washington	46.0	0.5	1.3	1.1	1.1
West Virginia	51.2	0.2	1.2	1.3	1.3
Wisconsin	41.9	1.0	1.5	2.2	1.9
Wyoming	40.4	1.1	1.4	2.0	1.9

Table B-2: 1970s Average Temperature and Average Temperature Change since the 1970s, by Climate Region (°F)

Region	Average Temperature Baby Boomers (1970s)	Generation X Temperature Change (1970s - 1980s)	1990s Temperature Change (1970s - 1990s)	Millennials Temperature Change (1970s - 2000s)	Generation Z Temperature Change (Early 2010s - 1980s)
Northeast	45.5	0.3	1.2	1.4	2.3
Southwest	51.2	0.8	1.3	2.1	2.0
West	54.0	0.7	1.0	1.6	1.8
East North Central	42.7	1.0	1.3	1.9	1.7
South	61.5	0.4	1.1	1.5	1.6
West North Central	42.2	1.2	1.3	1.9	1.5
Central	52.9	0.5	1.1	1.4	1.3
Northwest	45.0	0.4	1.2	1.3	1.3
Southeast	62.2	0.2	1.0	1.0	1.0

Table B-3: Percent Change in 24-Hour Precipitation Produced by the Biggest Storms between 1970 and 2011, by State

State	Percent Change
Alabama	5%
Arizona	-1%
Arkansas	0%
California	5%
Colorado	13%
Connecticut	21%
Delaware	32%
Florida	9%
Georgia	6%
Idaho	10%
Illinois	7%
Indiana	20%
Iowa	6%
Kansas	6%
Kentucky	8%
Louisiana	8%
Maine	24%
Maryland	21%
Massachusetts	34%
Michigan	8%
Minnesota	15%
Mississippi	1%
Missouri	11%
Montana	1%

State	Percent Change
Nebraska	9%
Nevada	5%
New Hampshire	40%
New Jersey	11%
New Mexico	1%
New York	19%
North Carolina	16%
North Dakota	9%
Ohio	12%
Oklahoma	1%
Oregon	-2%
Pennsylvania	20%
Rhode Island	11%
South Carolina	-1%
South Dakota	11%
Tennessee	2%
Texas	4%
Utah	2%
Vermont	37%
Virginia	10%
Washington	17%
West Virginia	5%
Wisconsin	10%
Wyoming	-4%

Table B-4: Sea-Level Rise Trends at Selected U.S. Tidal Gauges[132]

Station Name	First Year	Last Year	Year Range	% Complete	MSL Trends (inches/yr)	MSL Trend (feet/century)
Boston, MA	1921	2013	92	95	0.11	0.92
Galveston Pier 21, TX	1908	2013	105	98	0.25	2.08
Los Angeles, CA	1923	2013	90	96	0.03	0.27
Naples, FL	1965	2013	48	93	0.09	0.79
San Francisco, CA	1897	2013	116	97	0.07	0.62
Seattle, WA	1898	2013	115	97	0.08	0.65
The Battery, NY	1856	2013	157	88	0.11	0.93

Table B-5: Mean Sea Level and Difference Since 1970s by Generation at Select U.S. Tidal Gauges (Inches)

Station	Baby Boomers Mean Sea Level (1970s)	Generation X Change in Sea Level (1970s-1980s)	1990s Change in Sea Level (1970s-1990s)	Millennials Change in Sea Level (1970s-2000s)
Boston, MA	-1.1	0.1	1.4	2.7
Galveston Pier 21, TX	-5.3	1.9	5.1	6.1
Los Angeles, CA	-1.4	1.0	1.9	1.5
Naples, FL	-0.7	-0.4	1.1	1.9
San Francisco, CA	-2.3	2.1	2.6	2.0
Seattle, WA	-1.9	1.4	2.5	1.8
The Battery, NY	-1.9	0.4	2.4	3.4

Table B-6: Days Per Year of Flooding with Sea-Level Rise Projections[133]

Station	Feet at Which Flooding Begins (MLLW)	Current Days/Year of Flooding	Days/Year of Flooding with 1.6 Feet of Sea-Level Rise	Days/Year of Flooding with 3.2 Feet of Sea-Level Rise
San Francisco, California Tide Gauge #9414290	7	0	30	135
Seattle, Washington Puget Sound Tide Gauge #9447130	13.5	0	7	57
Galveston Pleasure Pier Tide Gauge #8771510	4	1	34	267
Naples, Florida Tide Gauge #8725110	4	0	106	302
Washington, D.C. Tide Gauge 8594900	4.2	5	103	259
The Battery, New York #8518750	6.7	1	39	148
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