In the Path of the Storm

Global Warming, Extreme Weather and the Impacts of Weather-Related Disasters in the United States from 2007 to 2012

ENVIRONMENT
MASSACHUSETTS
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Cover photos: large photo, Union Beach, NJ, after Hurricane Sandy: Patsy Lynch, FEMA; small photos (from l): Mandeville, LA, during Hurricane Isaac: Charles Powell, FEMA; Colorado during Waldo Canyon fire: Mark Briody; Iowa corn field: Dave Kosling, U.S. Department of Agriculture.

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Table of Contents

Executive Summary **4**

Introduction **9**

Global Warming and the Future of Extreme Weather **11**

Defining Extreme Weather 11

Why Extreme Weather Matters 12

What Science Can (and Can't) Tell Us about Extreme Weather in a Warming World . . 13

Heavy Rain and Snow 14

Heat, Drought and Wildfire 16

Hurricanes and Other Coastal Storms 19

Global Warming Could Increase the Destructive Potential of Weather Events 20

Sea Level Rise 20

Changes in the Type of Precipitation and Timing of Snowmelt 23

Ecosystem Changes 24

Extreme Weather and Weather-Related Disasters: Exploring the Connections **25**

Weather-Related Disasters: A Definition 25

Why Study Weather-Related Disasters? About this Analysis 27

Weather-Related Disasters Affect Nearly Every American **28**

Weather-Related Disasters Are Common in the United States 28

Tropical Cyclones, Flooding, Tornadoes and Winter Weather Affect Tens of Millions of Americans 30

Conclusions and Recommendations **38**

Methodology **40**

Appendices **42**

Appendix A: Population of Counties with Presidentially Declared Weather-Related Disasters, by Year 42

Appendix B: Disaster Declarations for Non-County Geographies 44

Notes **48**

Executive Summary

Weather disasters kill or injure hundreds of Americans each year and cause billions of dollars in damage. The risks posed by some types of weather-related disasters will likely increase in a warming world. Scientists have already detected increases in extreme precipitation events and heat waves in the United States, and climate science tells us that global warming will likely lead to further changes in weather extremes.

Since 2007[1], federally declared weather-related disasters in the United States have affected counties housing 243 million people – or nearly four out of five Americans. The breadth and severity of weather-related disasters in the United States – coupled with the emerging science on the potential for global warming to exacerbate some types of extreme weather – suggest that the United States should take urgent action to reduce emissions of global warming pollution, while taking steps to prepare for the dangers posed by climate change.

Weather-related disasters are common in the United States, affecting people in every part of the country.

- Since 2007, weather-related disasters have been declared in every U.S. state other than South Carolina. During this period, weather-related disasters affected *every county* in 18 states and the District of Columbia. (Alabama, Arkansas, Connecticut, Delaware, Hawaii, Iowa, Louisiana, Massachusetts, Maryland, Maine, Missouri, North Dakota, New Hampshire, New

Jersey, Oklahoma, Rhode Island, Vermont and West Virginia.) (See Figure ES-1.)

- More than 19 million Americans live in counties that have averaged one or more weather-related disasters *per year* since the beginning of 2007.
- Eight U.S. counties – five in Oklahoma, two in Nebraska and one South Dakota – have each experienced 10 or more declared weather-related disasters since the beginning of 2007.
- More than 76 million Americans live in counties affected by weather-related disasters in 2012. There were at least 11 disasters in 2012 that each inflicted more than $1 billion in damage, including Hurricane Sandy, which inflicted estimated damages of at least $50 billion, making it the costliest weather disaster since Hurricane Katrina in 2005, and the costliest hurricane ever to hit the East Coast.
- As of February 2013, 705 counties housing more than 63.5 million people had been designated primary natural disaster areas as a result of drought by the U.S. Department of Agriculture.

Several extreme events in 2012 broke previous weather records.

- **The contiguous United States experienced its hottest month and hottest year in recorded history in 2012.** The United States smashed the previous record for warmest year – exceeding the previous record year (1998) by 1° F. The United States experienced its warmest

Figure ES-1. Number of Declared Weather-Related Disasters since 2007 by County

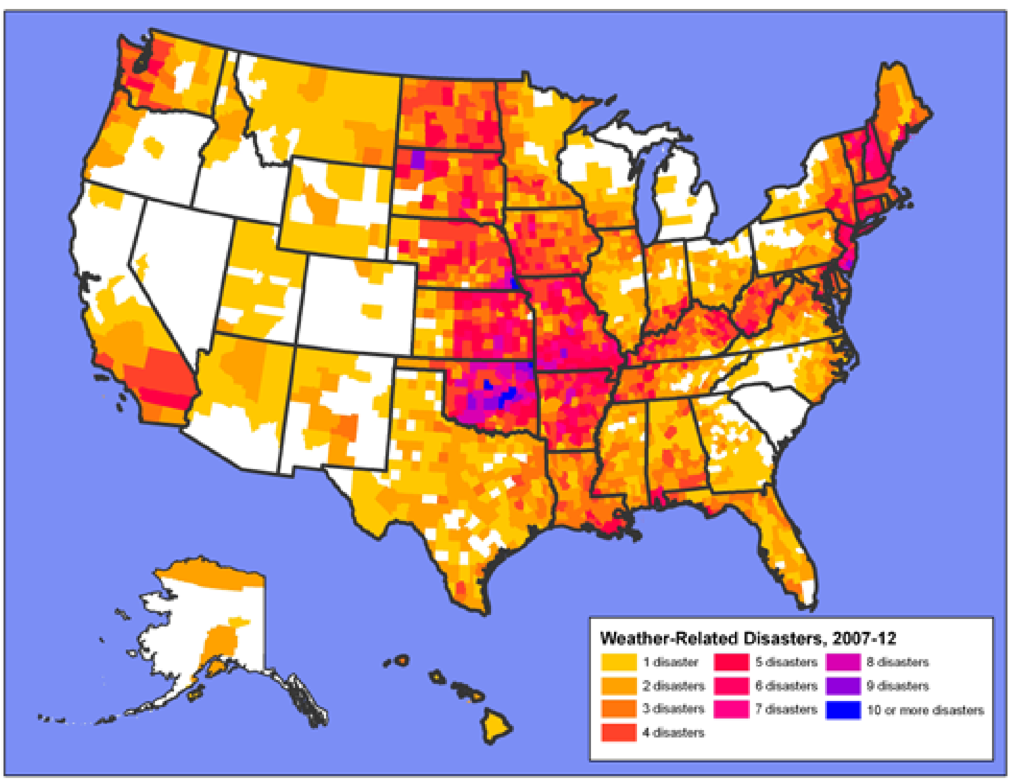
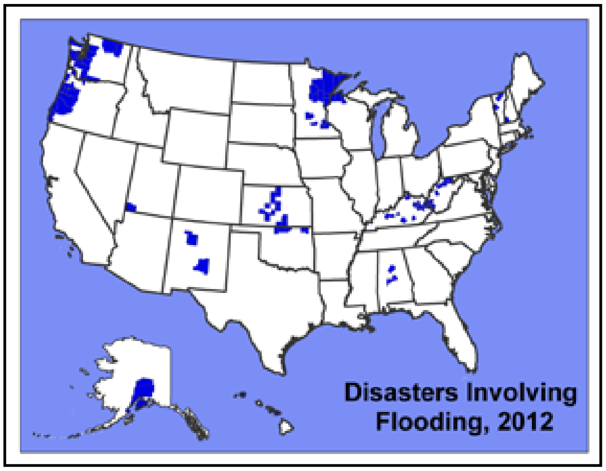
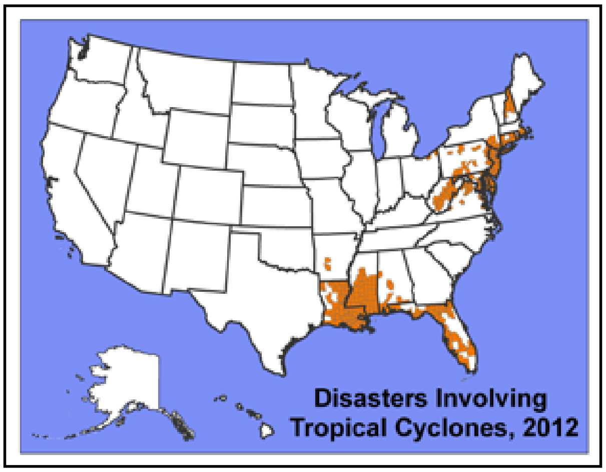


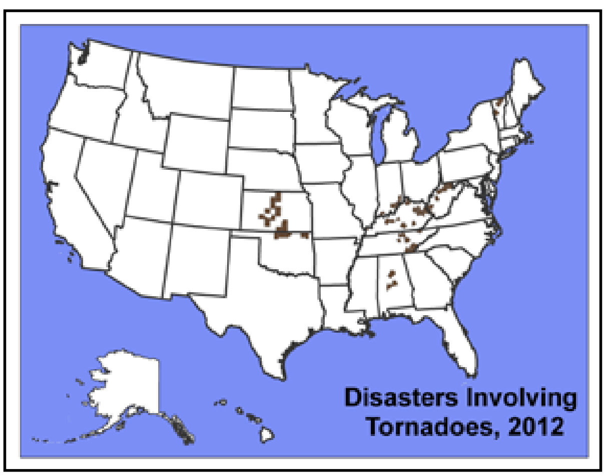
Figure ES-2 (a-e). Characteristics of Declared Weather-Related Disasters in 2012



spring, second-warmest summer and fourth-warmest winter in 2012. The nation also posted its warmest single month on record in July 2012.

- **Nebraska and Wyoming experienced their driest years on record**, while other Plains and Midwestern states experienced drier than normal conditions.
- **The U.S. experienced its most widespread drought in more than a half century** as a result of record heat and low rainfall. In July 2012, 64 percent of the nation experienced





For a breakdown of every weather-related disaster that has hit your state since 2007, visit the interactive map at www.environmentamericacenter.org.

moderate to exceptional drought, according to the National Climatic Data Center, making it the most widespread drought since at least 1956.

- **Hurricane Sandy** broke or challenged multiple records. It was the largest tropical cyclone in terms of area since modern record-keeping began in 1988, was responsible for the lowest barometric pressure ever recorded along the Northeast U.S. coast, and produced record storm tides in the New York City area.

Some types of extreme weather events have become more common or intense in recent years and may continue to become more frequent or severe in a warming world.

- **Extreme downpours.** The United States has experienced an increase in heavy precipitation events, with the rainiest 1 percent of all storms delivering 20 percent more rain on average at the end of the 20th century than at the beginning. The trend toward extreme precipitation is projected to continue, even though higher temperatures and drier summers will likely also increase the risk of drought in certain parts of the country.
- **Heat waves.** The United States has experienced an increase in the number of heat waves over the last half century. Scientists project that heat waves and unusually hot seasons will likely become more common in a warming world.
- **Hurricane intensity and rainfall.** Hurricanes may become more intense and bring greater amounts of rainfall in a warming world, even though the number of hurricanes may remain the same or decrease.
- Global warming may also make weather events more dangerous. Rising sea level, ecosystem changes, and changes in the form of precipitation could reduce the ability of natural and man-made systems to withstand even "normal" weather events.
- There is much that remains to be understood about the ways in which some forms of extreme weather – such as tornadoes, severe thunderstorms and extratropical storms – will change as a result of global warming.

The United States should reduce global warming pollution now, and plan for a future in which some types of extreme weather events are more severe and occur more frequently.

- Federal and state governments should **adopt and implement caps on global warming pollution** capable of reducing emissions by at least 35 percent below 2005 levels by 2020 and by at least 85 percent by 2050, and implement the clean energy solutions needed to make these reductions a reality. These emission reductions are broadly consistent with what science tells us is necessary to lessen the most costly and devastating consequences of global warming, including those resulting from changes in extreme weather.
- Short of economy-wide caps on global warming pollution, local, state and federal governments should **focus on capping and reducing pollution from the largest sources – most notably power plants and the transportation sector**. Regional programs such as the Northeast's Regional Greenhouse Gas Initiative can help to achieve this goal. At the federal level, the Environmen-

tal Protection Agency should use its authority under the Clean Air Act to set strong federal limits on carbon pollution from new and existing power plants.

- Decision-makers should avoid making the problem worse by **rejecting new carbon-rich fuels such as tar sands**, as well as infrastructure projects such as the proposed Keystone XL tar sands pipeline that facilitate the development of these carbon-rich fuels.
- The United States – including federal, state and local governments – should adopt clean energy solutions that reduce our dependence on fossil fuels and reduce global warming pollution. Among the most important steps are:
  - Adopting enforceable targets, financial incentives, regulatory changes and investment strategies that increase the use of **renewable energy** sources such as wind and solar power.
  - Implementing appliance standards, building codes, enforceable efficiency targets for utilities, fuel-efficiency standards for vehicles and other steps to promote **energy efficiency**.
  - Continuing to develop and implement the **fuels and technologies of the future** – from electric vehicles to energy storage devices to "smart grid" technologies and new renewable sources of energy – through government support of research, development and deployment of those technologies and the adoption of technology-forcing standards where appropriate.
- Federal, state and local officials should take steps to **prepare for a future of more frequent and severe extreme weather** and to reduce the impact of those events. Government agencies should assess the risks posed by global warming-fueled extreme weather, develop plans to protect lives and property during extreme weather events, direct public resources toward investments in infrastructure and ecological restoration that improve our resiliency in the face of extreme weather, revise policies that encourage construction in areas likely to be at risk of flooding in a warming climate, and support continued research on the implications of global warming.

Introduction

One came suddenly, inflicting devastation in a single, swift blow. The other emerged over the course of weeks and months, relentlessly spreading across the country, leaving damaged crops and scorched mountainsides in its wake.

Hurricane Sandy and the nationwide drought – the largest in more than a half-century – were the most costly and deadly extreme weather events of 2012. The damage they inflicted on the United States can be counted in the tens of billions of dollars, along with the loss of dozens of lives.

In the case of Hurricane Sandy, the storm gained strength over ocean waters that were significantly warmer than normal and its impact was made worse by the rise in sea level that has occurred over the last century as a result of global warming. Higher seas enabled Sandy's storm surge to push further inland on the coasts of New Jersey and New York, magnifying the damage to homes, businesses and infrastructure. As of the end of January 2013 – three months after Hurricane Sandy made landfall – at least 3,500 families in New York and New Jersey left homeless by the storm were still displaced and living in hotels and motels.[2]

The nationwide drought, meanwhile, came in the midst of the hottest year in the recorded history of the contiguous United States. Temperatures have been rising in the United States over the last century as a result of global warming, but never in recorded history had the nation experienced a hotter month than July 2012. The record heat that month helped fuel the spread of drought across much of the United States, resulting in the most extensive drought since at least the 1950s.

Hurricane Sandy and the crippling drought of 2012 both emerged – as all weather events now do – in a climate that has been transformed by human activities, especially the release of vast amounts of carbon dioxide and other global warming pollutants into the atmosphere. According to climate scientist Kevin Trenberth, "[g]lobal warming has fundamentally altered the background conditions that give rise to all weather. In the strictest sense, all weather is now connected to climate change."[3]

Climate science tells us that a warming world is one in which certain types of weather events that are now considered "extreme" will become increasingly common and one in which rising sea level makes coastal settlements and ecosystems more vulnerable to storm damage.

There may still be time to prevent the very worst impacts of global warming from becoming reality. And we can certainly prepare ourselves and our communities for the changes that are already underway.

Events such as Hurricane Sandy and the 2012 drought remind us that the stakes in the battle against global warming – for ourselves, our cherished natural places and ecosystems, our economy and our future – are high. The time has come for cities, states and the nation to awaken to the magnitude of the threat, and take the actions necessary to minimize the dangers.

Global Warming and the Future of Extreme Weather

Extreme weather events trigger disasters when they cause damage that outstrips a community's ability to cope. Global warming has altered the climate in ways that make certain types of extreme weather events more likely. At the same time, sea level rise and other changes brought about by global warming are diminishing the ability of natural and man-made systems to withstand extreme weather events, increasing the amount of damage they can cause.

Defining Extreme Weather

"Extreme weather" is a relative term. A storm that brings 12 inches of snow to Buffalo in January is not extreme. A storm that brings 12 inches of snow to Buffalo in early October – or 12 inches of snow to Washington, D.C., at any time of year – is extreme.

Weather or climate events, therefore, can be considered "extreme" ***in relation to the historical record at a particular location***. The Intergovernmental Panel on Climate Change (IPCC), the world's leading scientific authority on climate change, has defined a "climate extreme" as follows:

> The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable.[4]

The IPCC's definition of "climate extreme" combines both weather events, which are of short duration, and climate events, which take place over a longer period of time.[5] In this report, we use the more common and colloquial term "extreme weather" as equivalent to the IPCC's definition of "climate extreme."

Why Extreme Weather Matters

Extreme weather events have the potential to inflict massive damage to human life, the environment and the economy. In some cases, these impacts are severe enough to be considered a "disaster." Impacts include:

- **Death and injury:** Extreme weather events cause significant loss of life in the United States each year. In 2011, weather-related events killed more than 1,000 Americans and injured more than 8,800. More than half of those deaths resulted from tornadoes, with heat representing the second-deadliest type of weather event.[6]
- **Property and crop damage:** In 2012, total economic damages in the United States from the nation's 11 billion-dollar weather disasters were expected to exceed $60 billion.[7] The many smaller, less catastrophic disasters around the country imposed additional costs.
- **Emergency response expenses:** Deaths, injuries and property damage from extreme weather events would be even greater were it not for the work of emergency responders – firefighters, workers stacking sandbags alongside swollen creeks, and police and National Guard troops called upon to preserve public order. The costs of providing emergency response for extreme weather events are significant. The federal government alone, for example, spends approximately $1 billion per year on fire suppression efforts.[8]
- **Permanent changes to ecosystems and landforms:** Extreme weather events can also result in permanent changes to ecosystems and landforms. Hurricane Sandy, for example, cut new inlets in barrier islands in New York and New Jersey. The average New Jersey beach was estimated to have become 30 to 40 feet narrower.[9]
- **Economic disruption:** Natural disasters also cause temporary economic disruptions by reducing productivity, rendering transportation systems and other types of infrastructure inoperable, and forcing workers and businesses to spend time and resources recovering from dislocation and property damage.
- **Investments in preventive measures:** Another hidden cost of extreme weather is the added cost of building structures and settlements designed to withstand those extremes. Adoption of stronger building codes designed to ensure that buildings withstand high winds and floods, or relocation or fortification of public infrastructure such as roads and sewer systems, imposes major costs. For example, the federal government invested $10 billion in improved flood defenses around New Orleans in the wake of Hurricane Katrina – defenses that may have reduced the damage caused by Hurricane Isaac in 2012. (See page 26.)
- **Broader and longer-term impacts:** The costs of extreme weather events can persist long after buildings are rebuilt and things are seemingly "back to normal." During a disaster, schools and health centers may close, and close-knit communities may be torn apart through relocation, all with long-term implications for health, human development and the economy.[10]

What Science Can (and Can't) Tell Us about Extreme Weather in a Warming World

Photos: *U.S. Geological Survey*

Hurricane Sandy cut a new inlet in the barrier island housing the town of Mantoloking, New Jersey. Residents of the town were unable to return to their homes for more than three months after the storm.

Global warming is unequivocal and the bulk of the warming that has occurred over the last half-century is very likely the result of human activities.[11] Global warming has changed the conditions in which all weather events emerge in ways that make certain extreme events more likely. Not every type of extreme weather event will necessarily pose new dangers in a warming world, but some of the most damaging forms of extreme weather – including heavy rains and extreme heat – are likely to become more frequent and severe, while the connections between global warming and complex weather phenomena such as tornadoes are less clear.

In November 2011, the Intergovernmental Panel on Climate Change (IPCC) – the world's leading scientific authority on climate change – found that global warming is already shifting patterns of extreme weather worldwide. The IPCC judged it "likely" (see "Definitions of IPCC Uncertainty Terms," next page) that human-driven changes have already led to higher daily high and low temperatures and expressed medium confidence that climate change has led to the intensification of extreme precipitation.[12]

The IPCC projected that future changes in extreme weather could occur as the world continues to warm. Specifically:

- It is virtually certain that extremely hot days will become both hotter and more frequent over the course of the next century.
- It is very likely that heat waves will become longer, more frequent or more intense over most land areas of the globe.
- It is likely that heavy precipitation events will occur more frequently in many areas of the world or that the proportion of total rainfall that occurs in the form of heavy rain events will increase.
- It is likely that heavy rainfalls associated with tropical cyclones will increase and that the average maximum wind speed will increase.

Definitions of IPCC Uncertainty Terms

The Intergovernmental Panel on Climate Change uses specific terms to convey the probability that its conclusions are correct based on the current level of progress in climate science. Terms such as "likely" and "very likely," therefore, have specific meanings. As defined in the IPCC's 2011 report on extreme weather events:

- Statements defined as **virtually certain** have a 99 to 100 percent probability of being correct.
- Statements defined as **very likely** have a 90 to 100 percent probability of being correct.
- Statements defined as **likely** have a 66 to 100 percent probability of being correct.[13]

Each of these measures of probability incorporates an assessment of the **confidence** with which scientists have reached their conclusion. In some cases, the scientists who authored the IPCC report may have lower degrees of confidence in the validity of a particular finding, leading (for example) to an assertion of "medium confidence" in a particular conclusion. Unlike the IPCC's definitions of uncertainty, its declarations of confidence are qualitative rather than quantitative.[14]

- There is medium confidence that droughts will become more intense, including in central North America.[15]

While there is strong scientific understanding of future trends in heat waves and heavy precipitation in a warming world, there is far less clarity regarding how global warming will affect other types of highly destructive weather events. In some cases, historical records of weather events may be poor or inconsistent, making it difficult to determine whether trends that appear in the data are real or are the result of changes in detection methods. In other cases, scientific understanding of complex weather phenomena may be inadequate to allow for predictions of how those phenomena might change in a warming world.

In this section, we review current understanding about the links between global warming and past or future trends in various types of extreme weather events.

Heavy Rain and Snow

Global warming is widely expected to lead to more intense downpours, including heavy snowstorms in areas where it remains cold enough to snow. Warmer temperatures lead to increased evaporation and a warmer atmosphere is able to hold more water vapor, leading to bigger rainfall and snowfall events.

The United States is already receiving more of its precipitation in the form of heavy rain and snow events. Scientists have linked the increase in heavy precipitation events in the Northern Hemisphere to global warming pollution and expect that the trend will likely continue in a warming world.[16]

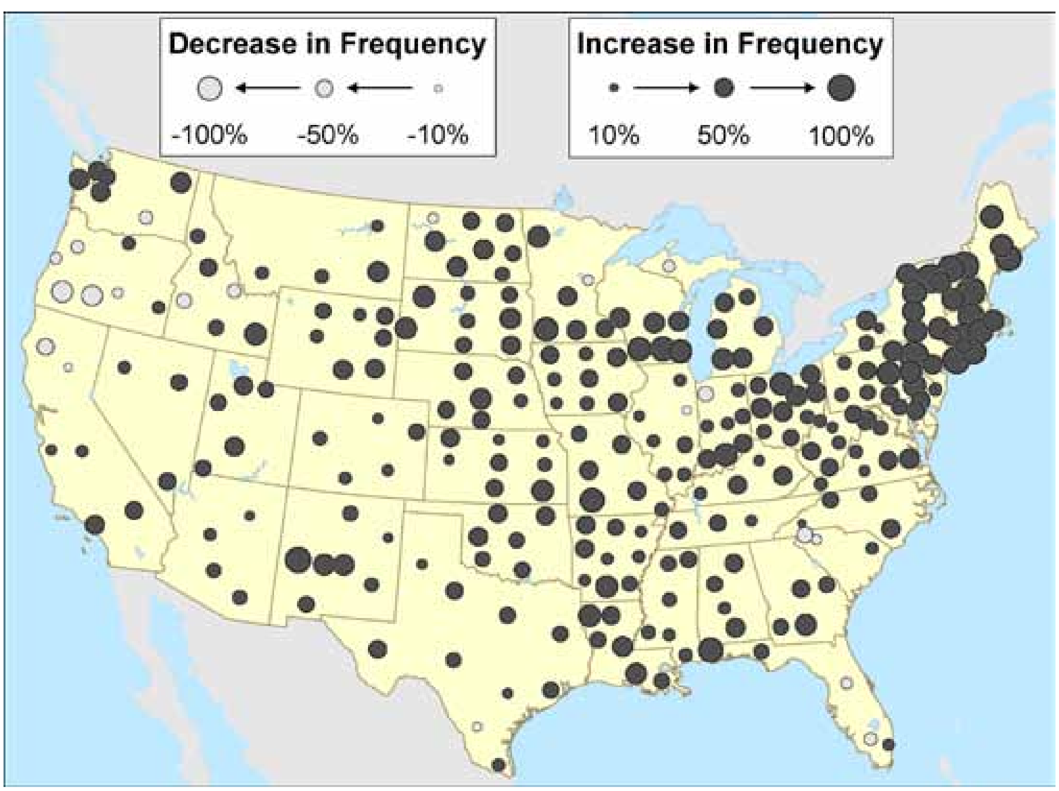
Over the last century, the amount of precipitation falling over most of the United States has increased.[17] The extra rain and snow, however, has tended to fall during heavy precipitation events. Research suggests that there has either been no change or a decrease in the number of light or average precipitation days in the U.S. during the last 30 years.[18] The amount of precipitation falling in the top 1 percent of rainfall events, however, has increased by an average of 20 percent over the course of the 20th century.[19] Severe regional snowstorms were more than twice as frequent between 1961 and 2010 as they had been during the preceding 60-year period.[20]

A 2012 Environment America Research & Policy Center analysis found that extreme precipitation events became 30 percent more common over the contiguous United States between 1948 and 2011, with the greatest increases coming in New England (85 percent) and the Mid-Atlantic region (55 percent).[21] (See Figure 1.)

Changing patterns of heavy precipitation have the potential to contribute to flooding that claims lives and damages ecosystems and property. They also have major repercussions for infrastructure planning and emergency response.

Across the United States, the amount of rainfall expected in 2-year, 5-year and 10-year rainfall events has increased, with the most significant changes in the Northeast, western Great Lakes, and Pacific Northwest regions.[23] In much of the northeastern United States, a storm that would have been expected to occur once every 50 years based on data from 1950-1979 would be expected to occur once every 40 years based on data

Figure 1. Trend in Frequency of Storms with Extreme Precipitation, 1948-2011[22]



from the 1950-2007 period.[24] The trend toward more days of heavy precipitation has even held true in the Southwest, which has experienced less precipitation overall.[25] Research suggests that the trend toward more heavy precipitation events will continue in many areas of the world.[26]

The same conditions that lead to more intense rainstorms in a warming world – including increased evaporation and the ability of warmer air to hold more water vapor – can also be expected to contribute to an increase in extreme snowstorms in places where it remains cold enough to snow.

The greatest increase in intense precipitation is projected for the Northeast and Midwest.[27] In addition, hurricanes and other coastal storms are expected to pack more precipitation – even though there is little clarity about whether the number of those storms is expected to increase or decline.[28]

Heat, Drought and Wildfire

While global warming is anticipated to lead to more intense rainstorms, it is also expected to result in higher average temperatures and more extended dry spells between rain events. The result: more heat waves and a greater potential, at least in some areas, for drought and wildfire. On the other hand, global warming may reduce certain risks from extreme cold.

The number of heat waves in the United States has increased since 1960.[40] Unlike an earlier period of extreme heat, the Dust Bowl 1930s, recent heat waves have come with marked increases in nighttime temperatures. Indeed, the share of the United States experiencing hotter nighttime low temperatures is greater than the share experiencing hotter daytime temperatures.[41] The trend in rising nighttime temperatures has been particularly marked along the Pacific coast, and in parts of the Southwest and northern Rockies.[42]

Parts of the country are also experiencing more and longer dry spells between precipitation events. Prolonged dry spells – periods of little rain lasting a month or longer in the eastern United States and two months or longer in the Southwest – are occurring more frequently, with the expected period between such episodes shrinking from 15 years to 6-7 years in the eastern United States.[43]

Hot and dry conditions – particularly when present for a long period of time – lead to drought. During the second half of the 20th century, drought became more common in parts of the northern Rockies, the Southwest and the Southeast, and less common in parts of the northern Plains and Northeast.[44] A 2012 study found that in the early 2000s the western United States experienced its most severe drought in 800 years.[45]

In parts of the United States, especially the West, water scarcity can be caused not only by a lack of rain, but also by changes in the share of precipitation that falls as rain versus snow and the timing of snowmelt. Western states often rely on melting mountain snowpack to supply human and agricultural needs during the long dry season. There has been a significant reduction in snowpack in recent years, with earlier melting and earlier peak streamflows in much of the West.[46] The recent decline in snowpack in the Mountain West has been found to be nearly unprecedented over the last millennium, caused by unusual springtime warming reinforced by climate change.[47] As snowpack declines even further, large parts of the West could find themselves under severe water stress.[48]

These trends are expected to continue and intensify in a warming world. Heat waves are projected to be more frequent,

Extreme Weather 2012: Western Wildfires

States Affected: Colorado, Montana, Oklahoma and other western states

In 2012, wildfires burned about 9.3 million acres of land in the United States— an area larger than Connecticut and Massachusetts combined, and the third-largest area burned in a single wildfire season since record-keeping began in 1960.[29]

Photo: Mark Briody

Colorado's Waldo Canyon fire was one of several severe wildfires to strike the West during 2012. It was the most destructive wildfire in Colorado history.

Wildfires were especially intense in Western states, where higher-than-normal spring and summer temperatures, extended drought, and low winter snowpack created ideal conditions for larger and more severe wildfires.[30] There were 51 fires in 2012 that burned more than 40,000 acres each – 10 more fires than the year before.[31] New Mexico experienced the largest fire in its recorded history, while two fires in Oregon ranked among that state's largest on record.[32] (See Table 1.)

More than 4,000 structures nationwide were destroyed by wildfire in 2012, well above the annual national average.[34] In Colorado, 646 homes were lost, as the state experienced a total of 4,167 wildfires in 2012, including the most destructive and second-most destructive fires in state history – the Waldo Canyon fire near Colorado Springs (18,274 acres) and the High Park fire near Fort Collins (87,284 acres).[35]

Table 1. Wildfires Larger than 100,000 Acres, 2012[33]

Fire Name	State	Total Acres	Est. Cost
Long Draw	OR	557,600	$4,360,000
Holloway	NV	460,900	$9,166,719
Mustang Complex	ID	339,400	$38,323,413
Rush	CA	315,200	$15,170,000
Whitewater - Baldy	NM	297,800	$23,000,000
Ash Creek	MT	249,600	$7,500,000
Kinyon Road	ID	234,900	$1,625,000
Halstead	ID	180,100	$26,413,932
Rosebud Creek Complex	MT	171,400	$9,000,000
Miller Homestead	OR	162,800	$6,000,000
Trinity Ridge	ID	146,800	$41,228,912
Flattop 2	ID	141,000	$600,000
Chalky	MT	131,000	$50,000
Clay Springs	UT	107,800	$6,659,000

The Waldo Canyon fire was particularly damaging, prompting the evacuation of 32,000 residents from the northwest quadrant of Colorado Springs, where 347 homes were destroyed and one person was killed. The fire caused more than $350 million in economic damages – making it the nation's costliest wildfire in 2012.[36] It also claimed a beloved local institution, the Flying W Ranch, a working cattle ranch that had been a tourist attraction since 1953.[37] The ranch offered chuckwagon suppers, cowboy sing-alongs, and western stage shows for crowds of to up to 1,000 people every night in the height of tourist season.[38] The ranch was destroyed in the blaze, but its 47 head of cattle managed to survive.[39]

more intense and last longer, with climate models projecting that the entire contiguous United States will likely experience a significant increase in the number of extreme heat days by the end of the century under a scenario in which global warming pollution continues to rise unabated.[49]

Unusually hot seasons may also become more common. One model projects that previously extreme average summer temperatures (those among the hottest 5 percent registered during the 1950-1979 period) would occur at least 70 percent of the time by 2035-2064 under a high emissions scenario.[50] A 2011 report published by the National Research Council found that global warming of 2 to 3° C (3.6 to 5.4° F), would result in "summers that are among the warmest recorded or the warmest experienced in people's lifetimes [becoming] frequent," while warming of 4° C (7.2° F) would result in about nine out of every 10 summers being hotter than the hottest recorded in the second half of the 20th century.[51] Researchers project that seasons as hot as the hottest on record for the second half of the 20th century could occur four to seven times per decade by the 2030s in much of the United States.[52]

Hotter temperatures bring with them numerous threats to public health. High temperatures – along with sunlight, nitrogen oxides and volatile organic compounds – are necessary for the creation of ozone "smog," which damages the respiratory system, reduces lung function, and aggravates asthma and other respiratory diseases.[53] The Union of Concerned Scientists estimates that, by 2020, the United States could experience more than 900,000 additional missed days of school and more than 5,000 additional hospitalizations of infants and seniors due to the additional exposure to ozone smog resulting from higher temperatures caused by global warming.[54]

Global warming can also be expected to increase the number of deaths caused by heat stress.[55] Higher temperatures may also change the patterns of occurrence of various infectious diseases. A 2009 study, for example, found a correlation between warmer temperatures and increased reports of infection by West Nile Virus.[56]

Extreme heat, coupled with longer dry spells and an expected decline in summer precipitation across most of the United States, could contribute to increased risk of drought. Climate models project that nearly the entire lower 48 states could experience more dry days by the end of the century, with strong agreement among the models across most of the country.[57] Other recent research suggests that much of the United States could experience severe and widespread drought over the upcoming century as a result of global warming.[58]

The American Southwest is likely to be hit particularly hard. A 2010 study projected that the Southwest would become drier and experience more severe drought in the decades to come. Some dry periods could last a dozen years or more.[59]

Higher temperatures, prolonged dry spells and drought are also expected to contribute to an increase in wildfire activity in parts of the country. One modeling effort projected that California would experience a 12 to 53 percent increase in the probability of large fires by the 2070-2099 timeframe under several scenarios of future climate change.[60] Another recent study projected that fire will become increasingly common in the Yellowstone region, leading to significant shifts in the composition of ecosystems in the area.[61]

The risk of damaging wildfires is not limited to the West.[62] By the end of the 21st century, the risk of fire could increase across the vast majority of the United States under a high-emission scenario, with the greatest changes taking place in the West.[63]

On the other end of the temperature scale, extreme cold is expected to become less common in a warming world. According to the Intergovernmental Panel on Climate Change, there has already very likely been a decline in cold days and nights globally, and likely a decline in North America.[64] The IPCC also concluded that it is virtually certain that there will be a decline in cold extremes during the 21st century. These declines in cold extremes will likely lead to a reduction in cold-related deaths, offsetting to some degree the increased risk of heat-related death and illness.[65]

Hurricanes and Other Coastal Storms

Global warming has the potential to make hurricanes more destructive. Hurricanes and other coastal storms are likely to deliver more rainfall in a warmer world for the same reasons that global warming contributes to bigger rainstorms: increased evaporation and the ability of a warmer atmosphere to hold more water vapor. Global warming may fuel more powerful hurricanes by making ocean waters – which are the source of energy for hurricanes – warmer. There is little clarity about whether hurricanes will become more or less frequent in a warming world. Regardless, all hurricanes and coastal storms could become more damaging in years to come as a result of sea level rise that puts human settlements and coastal ecosystems at risk.

There has been an observed increase in the number of Category 4 and 5 hurricanes in the Atlantic Ocean since 1980.[66] Measurements that aggregate the destructive power of tropical storms – in terms of their intensity, duration and frequency – over entire storm seasons have shown a marked increase in the Atlantic since the 1970s.[67] Other research has found that both the energy of and amount of precipitation in tropical cyclones in the Atlantic has increased in recent years, with an abrupt, step-wise increase in cyclone energy and precipitation occurring in the mid-1990s.[68] Another recent paper found that there has been a significant increase in "moderately large" storm surge events caused by landfalling hurricanes in the United States since the 1920s, and that those events have been more common in warm years than in cold ones.[69]

An expert team convened by the World Meteorological Organization (WMO) concluded in 2010 that hurricane activity could change in important ways by the end of this century if global warming continues unabated:

- The number of tropical cyclones is projected to decrease globally by an estimated 6 to 34 percent, but with great potential variation in trends for specific ocean basins.
- Average maximum wind speeds are projected to increase globally by 2 to 11 percent.
- The number of intense hurricanes is projected to increase.[70]
- Tropical cyclones are projected to bring more rainfall, with a projected average increase of about 20 percent.[71]

These global trends are likely to vary by region. Five of seven climate models in one recent study pointed to an increase in the aggregate power of hurricanes in the Atlantic by the end of the next century, with an average increase in power across all models of 10 percent.[72] Another recent modeling effort projected that the number of severe Category 4 and 5 hurricanes could be expected to double in the Atlantic over the course of the 21st century as a result of global warming.[73]

Research by scientists at the Massachusetts Institute of Technology suggests that global warming could increase the amount of property damage caused by hurricanes along the Atlantic Coast in upcoming decades – though, notably, the study did not factor in the impacts of higher sea level or freshwater flooding from increased precipitation.[74]

Residents of the West Coast do not generally have to be concerned with hurricanes, but they do experience intense winter storms. Parts of the Pacific Ocean off the West Coast have experienced increasing numbers of intense winter storms since the middle of the 20th century.[75] One clue to the increase in the power of winter storms has come from the measurement of wave heights off the coast of the Pacific Northwest. Researchers have found that waves off the Oregon coast are higher than they were 35 years ago, with the greatest increase coming in the largest waves.[76] As recently as the early 1990s, scientists estimated that the height of a "100-year wave" (one expected to occur only once every century) to be 33 feet; now it is estimated to be 46 feet.[77] The study also found that the increases in wave height have been greatest off the coast of Washington and northern Oregon, and less in southern Oregon. The study is consistent with other research that suggests an increase in the height of the highest waves along the West Coast, particularly in the Pacific Northwest.[78]

There is little clarity regarding the potential impacts of global warming on extratropical storms – storms that form in the mid-latitudes, as opposed to the tropics, such as the "Nor'easters" that are common along the East Coast. One clear conclusion of the research is that extratropical storms – like tropical storms – are likely to deliver increased precipitation, leading to increased potential for flooding rains and major snowfall.[79]

Global Warming Could Increase the Destructive Potential of Weather Events

In addition to its potential to increase the number or severity of extreme weather events, global warming will likely also lead to changes that could make extreme weather events – and even some routine events – more destructive, increasing the potential for disaster.

Sea Level Rise

Global warming is likely to raise sea level, both because of the thermal expansion of sea water as it warms and because of the melting of glaciers and ice caps.[96] Rising seas put America's coastal communities, ecosystems and infrastructure at risk.

It is hard to overestimate the importance of America's coasts to the nation. About 8.6 million people live in coastal areas within the Federal Emergency Management Agency's 100-year coastal flood zone.[97] Seven of America's 10 largest metropolitan areas – including world centers of government, finance and culture – sit along the coastlines or along tidally influenced rivers.[98] Critical highways, airports, seaports and rail lines all sit in close proximity to coastal waters.

Global warming has already begun to accelerate the rise in sea level and is projected to lead to even greater increases in the years to come. Sea level has risen by nearly 8 inches (20 cm) globally since 1870, with the rate of sea level rise increasing in recent years.[99] Sea level rise is not experienced the same way at all points along the coastline. Land along

Extreme Weather 2012: Hurricane Sandy

States Affected: Connecticut, Florida, Delaware, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island and West Virginia[80]

Coming just a year after 2011's Hurricane Irene deluged parts of the Northeast with torrential rains, wiping out roads and bridges and isolating entire communities, Hurricane Sandy proved to be even more devastating.

Hurricane Sandy – which made landfall as a "hybrid" bearing characteristics of both a tropical and an extra-tropical storm – broke or challenged several meteorological records. It was the largest tropical cyclone in terms of area since modern record-keeping began in 1988. Tropical storm-force winds extended at one point over a 900-mile span – a distance greater than the width of Texas.[81] Sandy also was responsible for the lowest barometric pressure ever recorded along the Northeast U.S. coast, and produced record storm tides in the New York City area.[82] New York, New Jersey and Connecticut bore the brunt of the storm's coastline impacts in the U.S. – the water rose as much as 13 feet above normal tide levels in New York, as much as 9 feet in New Jersey, and close to 10 feet in Connecticut.[83]

Photo: Patsy Lynch, FEMA

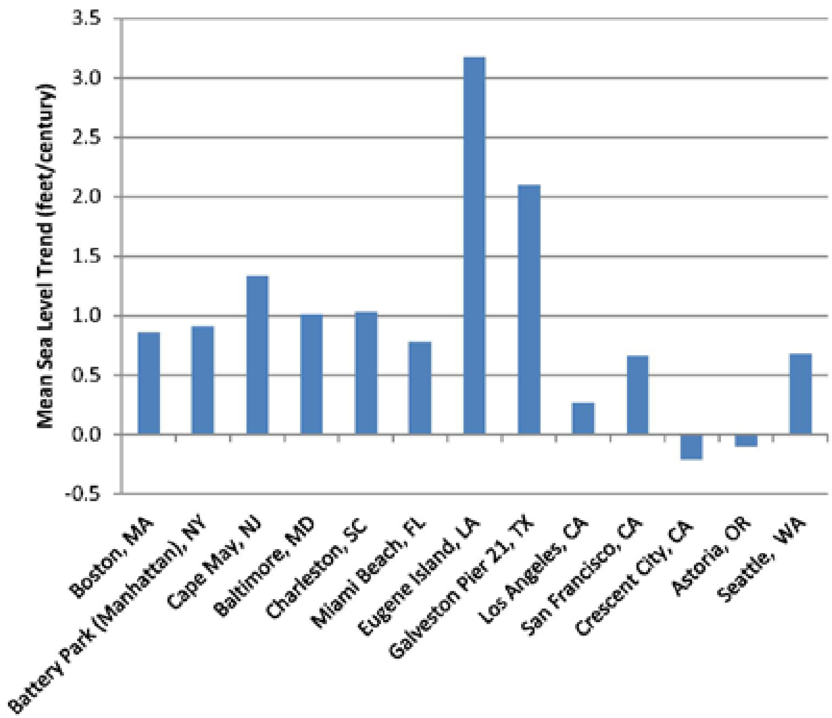
This home in Union Beach, NJ, was one of tens of thousands in the Northeast damaged or destroyed by Hurricane Sandy's record storm surge. The impacts of Sandy were likely magnified by the rise in sea level that has occurred globally since the late 19th century.

In New York, Hurricane Sandy inflicted more than $32 billion worth of damage, destroying or damaging more than 300,000 homes and disrupting the state's transportation network.[84] In New Jersey, Sandy was the state's worst-ever natural disaster, destroying or inflicting structural damage on more than 30,000 homes and businesses and causing $29 billion worth of damage.[85] Connecticut experienced $360 million worth of damage due to Sandy, with Massachusetts and Rhode Island also sustaining significant impacts.[86] Communities in the Appalachian Mountains of Maryland, Pennsylvania and West Virginia were buried under more than two feet of snow, leaving some without power for a week.[87] In the Northeast and Mid-Atlantic regions, 72 people lost their lives as a direct result of Hurricane Sandy, making it the deadliest tropical cyclone to hit the region in at least four decades.[88]

More than 8.5 million people lost power, with some not regaining it for weeks.[89] In New York City, the Metropolitan Transit Authority alone was faced with storm damage around $5 billion.[90] In both New York and New Jersey, gas rationing was imposed in the weeks following the storm, as stations were unable to pump gas without electricity back online, hindering residents' efforts to get their lives back on track.[91]

Hurricane Sandy caused an estimated $65 billion in damage in the U.S., the Bahamas, the Caribbean, and Canada,[92] making it the costliest disaster in the world in 2012.[93] There were 1.8 million claims on damaged structures, the most of any disaster event in 2012.[94] Even months after the storm, thousands of people remained displaced.[95]

Figure 2. Measured Rise in Mean Sea Level along the U.S. Coast (from the beginning of record-keeping at each station to 2006) in Feet per Century[101]



the coast is rising or falling as a result of long-term geological processes (and, in some cases, such as along the Gulf Coast, by the drawdown of underground reserves of fossil fuels or fresh water). In addition, global warming is likely to cause sea level to rise more in some locations than others, due to associated changes in ocean circulation patterns.

Figure 2 shows the relative rise in average sea level at various points along the U.S. coast from the beginning of record-keeping at each station to 2006. Relative sea level rise has been greatest in areas that are experiencing simultaneous land subsidence, such as in the Mid-Atlantic and along the Gulf Coast. The combination of land subsidence and rising seas has contributed to the loss of 1,900 square miles of coastal wetlands in Louisiana.[100]

Global warming will likely bring higher seas as glaciers and ice caps melt and sea water continues to expand as it warms. A 2012 report for the National Climate Assessment estimates that sea level will likely rise by at least 8 inches by the end of the century, and possibly by as much as 6.6 feet.[102] The high end of the estimate assumes significant losses of glaciers and ice sheets – which have been melting at an accelerated pace over the past 20 years.[103]

What would such an increase mean for America's coastline? In the Mid-Atlantic region from New York to North Carolina, approximately 1,065 square miles of dry land, as well as vast areas of wetland, are less than 3.3 feet (1 meter) above the spring high water mark. (See Table 2.)[104]

While many of these areas will be at risk of inundation, rising sea level will also increase the destructive power of coastal storms by driving storm surge further inland. A 2009 New York City report estimated that 1-in-100-year coastal floods could be expected to occur once every 15 to 35 years by the end of the century.[105] In California, sea level rise will place thousands more people at risk during flood events. Currently, a 100-year flood places 140,000 people at risk. A three-foot rise in sea level – well within the range of projections – will jeopardize 420,000 people.[106]

In the portion of the Gulf Coast stretching from Galveston, Texas, to Mobile, Alabama, more than half of the highways, nearly half of the rail miles, 29 airports and almost all port infrastructure will be vulnerable to flooding in the future due to the combination of higher sea levels and hurricane storm surge. Much of this infrastructure is at risk even in the absence of storm surge due to projected sea level rise.[107] In coastal regions of Alabama, Mississippi, Louisiana and Texas, six inches of sea level rise and a 3 percent increase in hurricane wind strength could cause $5 billion of damage annually by 2030 – damage in addition to the coastal flooding and storm damage the region already experiences.[108]

In the Mid-Atlantic region, a one-meter sea level rise could result in the breakup or migration of barrier islands, and convert vast areas of wetland to open water. In areas like the New York City metropolitan area, sea level rise coupled with storm surge from coastal storms could result in severe damage to transportation infrastructure, as occurred during Hurricane Sandy.

Making matters worse for residents of the northeastern United States is evidence suggesting that sea level rise in that region could be greater than the global average, due to global warming-induced changes in ocean circulation patterns. The result could be an additional 8 inches of sea level rise in cities such as Boston, New York and Washington, D.C., atop the roughly three feet that could occur globally, further magnifying the damage caused by even routine coastal storms.[109]

Changes in the Type of Precipitation and Timing of Snowmelt

As described above, global warming is anticipated to make precipitation – whether it comes in the form of rain or snow – more intense. However, a growing share of precipitation in some parts of the country has begun to fall in the form of rain, rather than snow.[110] Should this shift continue – as would be expected in a warming world – it could mean trouble for areas, particularly the West, that currently rely on snowpack to store water for gradual release during the spring months.

The implications of changing precipitation and snowmelt patterns can be complex. For example, snowmelt in the West now occurs earlier in the year, a change that has been linked to global warming.[111] Climate science projects that spring snowmelt will likely occur earlier in the Pacific Northwest, while precipitation could increase in the winter but decrease during the summer.[112] The result is projected to be a shift toward higher river flows during the winter

Table 2. Land Area Less than One Meter in Elevation above Spring High Water, Mid-Atlantic Region (sq. mi.)

	NY	NJ	PA	DE	MD	DC	VA	NC	TOTAL
Dry Land	63	106	9	49	174	2	135	528	1,065
Non-Tidal Wetland	4	66	1	12	47	0	57	1,193	1,381
All Land	91	551	13	199	652	2	817	2,212	4,536

and spring months.[113] A 2008 study of the potential for flooding in major river basins worldwide under an extreme climate change scenario projected that the Columbia River could experience what is now a "100-year flood" as frequently as once every three years by the end of the 21st century.[114]

However, the increased risk of major flooding in the Columbia basin is expected to occur at the same time that the region *also* becomes more susceptible to summertime drought, due to reduced summer precipitation, a reduction in the availability of water from snowmelt, and higher temperatures. Indeed, the same study that projected a dramatic increase in the frequency of severe floods also projected that the Columbia basin could experience triple the number of drought days and lower total discharge from the Columbia over the course of the year under a scenario marked by dramatic increases in global warming pollution.[115]

Earlier snowmelt in the West may also contribute to increased wildfire risk by leaving forests devoid of moisture for longer periods of the summer. Large wildfire activity in the American West has increased significantly since the mid-1980s, with the greatest increases happening in northern Rockies forests.[116]

Ecosystem Changes

Global warming could make America's ecosystems less resilient and increase the risk that extreme weather events will trigger disasters.

Global warming is expected to bring major changes to America's forests. Tree species are expected to move toward the north and upslope, while there are already signs of increasing destructive impacts from invasive species and insect pests, some of which may be linked to rising temperatures.[117] In recent years, for example, the worst bark beetle outbreak in recorded history has damaged or destroyed trees on at least 41.7 million acres of land in the West.[118] Warmer temperatures have enabled mountain pine beetles to survive in once-inhospitable areas and have changed the beetle's life cycle, even, in some cases, allowing two generations of beetles to exist per year rather than one.[119]

Global warming-induced shifts in pest populations and invasive species – as well as shifts in forest species composition – may further alter fire risk. The invasion of non-native grassland species in arid portions of the West is expected to increase fire risk in these regions.[120]

Extreme Weather and Weather-Related Disasters: Exploring the Connections

Scientific evidence suggests that certain types of extreme weather events will likely become more frequent and more severe as a result of global warming – potentially triggering an increase in the number and impact of weather-related disasters in the years to come.

Science can tell us whether a given weather event is statistically "extreme," but not whether the impacts of that event amount to a "disaster." The degree to which an extreme event causes a disaster depends greatly on the context in which it occurs.

Weather-Related Disasters: A Definition

The Stafford Act, which governs disaster response in the United States, defines a "major disaster" as "any natural catastrophe … or, regardless of cause, any fire, flood, or explosion … which in the determination of the President causes damage of sufficient severity and magnitude to warrant major disaster assistance…."[133]

In short, for an event to be a "disaster," three things must occur:

Extreme Weather 2012: Hurricane Isaac

States affected: Louisiana, Mississippi, Alabama and Florida

On August 28, 2012 – seven years minus a day after the arrival of Hurricane Katrina along the Gulf Coast – Hurricane Isaac made landfall at Plaquemines Parish, Louisiana. While the scale of damage from Isaac was not nearly as great as that from Katrina (in part due to investments in improved levees around New Orleans), it did destroy property and cause injury and loss of life along the Gulf Coast.[121]

Isaac took its toll slowly and steadily. Moving northwest at just six miles per hour, the Category 1 storm sat mercilessly over the coastal towns of Louisiana and Mississippi, deluging the area with torrential rain and building up a substantial storm surge that caught residents by surprise.[122]

In Louisiana's Plaquemines Parish, a 12-foot storm surge overcame an eight-foot levee, flooding houses up to their roofs in scenes reminiscent of Katrina.[123] A father-son team from the area took it upon themselves to rescue their neighbors stranded in attics and on rooftops.[124] Elsewhere, New Orleans reported up to 20 inches of rainfall and three-quarters of the city lost power; 30 miles to the west, in St. John the Baptist Parish, authorities scrambled to evacuate 3,000 people from rising floodwaters.[125] Statewide, Isaac damaged 59,000 homes.[126]

Photo: Charles Powell, FEMA

Hurricane Isaac caused storm surge flooding that, in some locations, rivaled that of Hurricane Katrina seven years earlier. Here, storm surge waters wash over land near the Lake Pontchartrain Causeway in Mandeville, Louisiana.

In Mississippi, 70 coastal roads closed and 31,000 homes lost electricity.[127] In Biloxi and other coastal communities, flooding was widespread and severe: water stood two to three feet deep over parts of U.S. Highway 90 where it runs past Mississippi's casinos. In Hancock County, bordering Louisiana, homes in low-lying areas also became submerged.[128] With rainfall rates of up to three inches per hour and a storm surge along the coast of up to 10 feet, the mayor of Biloxi later said that he regretted not ordering an evacuation of his city.[129]

All told, Hurricane Isaac killed seven people – five in Louisiana and two in Mississippi – and cost billions.[130] According to estimates released in the days following the storm, damage to residential and commercial property, as well as interruptions to energy production and other business, was valued at as much as $1.5 billion.[131] As of February 2013, the Federal Emergency Management Agency (FEMA) reported that state and federal recovery assistance had topped half a billion dollars.[132]

- It must ***cause damage***.
- It must "warrant … assistance"; that is, it must ***outstrip a community's immediate ability to cope***.
- It must be ***recognized*** as a disaster. While some have suggested quantifiable definitions for the term "disaster" based on the number of deaths, injuries or economic damage inflicted, the term remains inherently subjective.

In this report, we define "weather-related" disasters as presidentially declared major disasters in categories with a plausible connection to weather or climate events. For example, we consider wildfires to be "weather-related" disasters even if they were started deliberately or accidentally by humans, because few forest fires rise to the level of disasters without the proper weather or climate conditions to fuel their spread.

Why Study Weather-Related Disasters? About this Analysis

This analysis does not examine *trends* in the number or severity of weather-related disasters. Because declarations of disasters rely so much on the context in which they occur, examining trends in disaster declarations is a very imperfect measure of how the climate is changing.

Similarly, this analysis does not claim that any single event – or any disaster that resulted from a single event – occurred solely because of climate change. *All* weather events are now shaped by the combined influence of natural variability and a warming climate.

Rather, this analysis is intended to ***highlight the degree to which weather-related disasters are already a common and costly fact of life for people throughout the United States.*** By encouraging greater understanding of the fact that weather-related disasters are not unusual, that they affect people in every region of the country, and that scientists warn that global warming will increase the severity and/or frequency of certain types of extreme weather events, we hope to encourage the public and decision-makers to explore in greater detail what changes in extreme weather might mean for their specific states or regions in the future, and to take action now to prepare for those changes.

Weather-Related Disasters Affect Nearly Every American

Each year, a series of high-profile weather disasters captures the attention of the media and the public. In 2012, there were 11 individual billion-dollar weather disasters. While the number of billion-dollar disasters had fallen from 2011's record 14, 2012's disasters imposed a greater economic toll, inflicting at least $60 billion in damage.[134]

Weather-related disasters can strike anywhere in the United States. With global warming threatening to increase the severity and frequency of some extreme weather events – while simultaneously weakening the ability of our infrastructure and ecosystems to cope with those events – Americans need to understand the degree to which extreme weather puts our public safety and all of our communities at risk.

Weather-Related Disasters Are Common in the United States

Since the beginning of 2007, weather-related disasters have been declared in counties housing 243 million people in the United States – or nearly four out of every five Americans.

On average, weather-related disasters struck counties housing 88.5 million people annually between 2001 and 2012, or more than one out of every four Americans every year.

Approximately 77 million Americans live in counties that experienced presidentially declared, weather-related disasters in 2012. Geographically, weather-related disasters affect every part

Extreme Weather 2012: Drought

States Affected: Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Iowa, Missouri, Nebraska, Nevada, New Mexico, North Carolina, Oregon, South Carolina, Tennessee, Texas, Utah, Wyoming and others

The contiguous United States experienced its hottest month and hottest year in recorded history in 2012. The U.S. smashed the previous record for warmest year – exceeding the previous record year (1998) by 1° F.[135] The nation experienced its warmest spring, second-warmest summer and fourth-warmest winter in 2012 and posted its warmest single month on record in July 2012.[136] At the same time, much of the country was unusually dry. Nebraska and Wyoming experienced their driest years on record, while other Plains and Midwestern states experienced drier than normal conditions.[137]

By July, hot, dry conditions had driven 64 percent of the nation into moderate to exceptional drought, according to the National Climatic Data Center, making the drought of 2012 the most widespread since at least 1956.[138] In much of the country, drought conditions were severe: the area of the country experiencing "extreme" or "exceptional" drought – indicating widespread crop failure and pasture losses, and water shortages in reservoirs, streams, and wells – reached 22 percent in July 2012.[139]

The drought, which continues in many parts of the country as of this writing, has extended one of the nation's worst wildfire seasons. (See "Western Wildfires" on page 17.) In December 2012, peaks normally covered by snow near Estes Park, Colorado, were ablaze with a 3,700-acre wildfire that burned at elevations of 8,000 feet to 10,000 feet.[140] The fire burned for two months in an area had hadn't been burned for centuries, and forced the evacuation of 600 residents.[141]

Photo: Dave Kosling, U.S. Department of Agriculture

The 2012 drought devastated much of the nation's corn and soybean crop, including this farm field in Iowa.

The drought also damaged or destroyed major portions of the U.S. corn and soybean crop. According to the U.S. Department of Agriculture (USDA), corn yields were down 13 percent from 2011, while soybean production was down 3 percent.[142] The sudden spread of drought conditions in the summer of 2012 dealt a particularly cruel blow to corn farmers, who, encouraged by favorable conditions in the spring of 2012, had planted the largest corn crop in 75 years.[143]

The economic impacts of the drought were widespread. As corn prices spiked, many dairy farmers were forced to cull their herds, reducing the nation's cattle herd to its smallest size since 1952, according to the USDA.[144] Taxpayers, too, took losses, as federal crop insurance – subsidized by taxpayers – paid Iowa farmers more than $933 million for corn losses.[145]

Farmers in other parts of the country had difficulty obtaining water – or were only able to do so at the expense of the long-term availability of water from aquifers. Arkansas imposed limits on municipal water usage by chicken farmers because public wells and reservoirs couldn't keep up with demand.[146] In Georgia, environmental permitting agencies granted well-digging permits to farmers who wanted to switch to irrigation farming, even while acknowledging that aquifer levels were already at 40 percent below normal levels.[147]

In still other states, the lack of water threatened the stability of the electricity supply. Low water levels left power plant intake valves high and dry, and increased water temperatures made cooling water too warm for power plants to use. In July, a grid operator for the Chicago area had to either scale back or shut down production at two power plants due to increased water temperatures or low water levels, and get special permission to continue operating a third plant.[148]

Shipping was also impacted. Parts of the Mississippi River became much shallower during the drought, causing tow operators to haul fewer barges, run them more slowly, or load them lighter, which increases costs.[149] About 60 vessels ran aground in the lower Mississippi between May and December of 2012.[150]

The total economic impact of the drought remains uncertain, as the drought continued well into 2013. In February 2013, the National Oceanic and Atmospheric Administration estimated that economic losses from the drought would likely exceed $35 billion.[151]

Figure 3 (a-e). Characteristics of Declared Weather-Related Disasters in 2012

of the United States. In 2012, weather-related disasters affected residents of 33 states and the District of Columbia. Since 2007, the only state to have not experienced a federally declared, weather-related disaster was South Carolina.

Many areas of the country have experienced more than one weather-related disaster since the beginning of 2007 – indeed, more than half of all Americans (180 million) live in a county that has experienced two or more weather-related disasters during that time. More than 19 million Americans live in counties that have averaged one or more weather-related disasters *per year* since the beginning of 2007.

From 2007 to 2012, the area of the country most prone to weather-related disasters was the Plains states, with weather-related disasters also common in the Northeast and parts of the Ohio River Valley, Gulf Coast and Pacific Northwest. Eight U.S. counties – five in Oklahoma, two in Nebraska and one in South Dakota – experienced at least 10 declared weather-related disasters between 2007 and 2012.

A detailed breakdown of the number of residents of each state living in counties with declared weather-related disasters can be found in Appendix A.

Tropical Cyclones, Flooding, Tornadoes and Winter Weather Affect Tens of Millions of Americans

Americans are affected by a wide variety of weather-related disasters. The Federal Emergency Management Agency's (FEMA) disaster declaration database shines a light on the types of weather-related disasters with the most widespread impacts.[152]

For a breakdown of every weather-related disaster that has hit your state since 2007, visit the interactive map at www.environmentamericacenter.org.

Figure 4. 2011 Population of Counties with Declared Weather-Related Disasters by Number of Disasters, 2007-2012

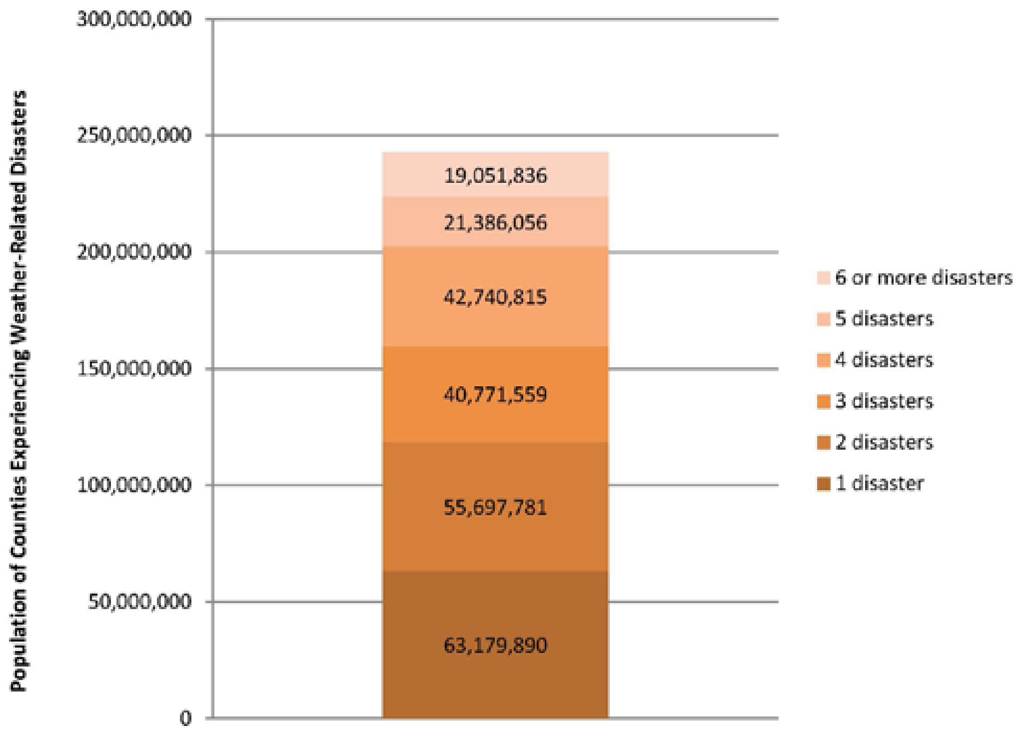
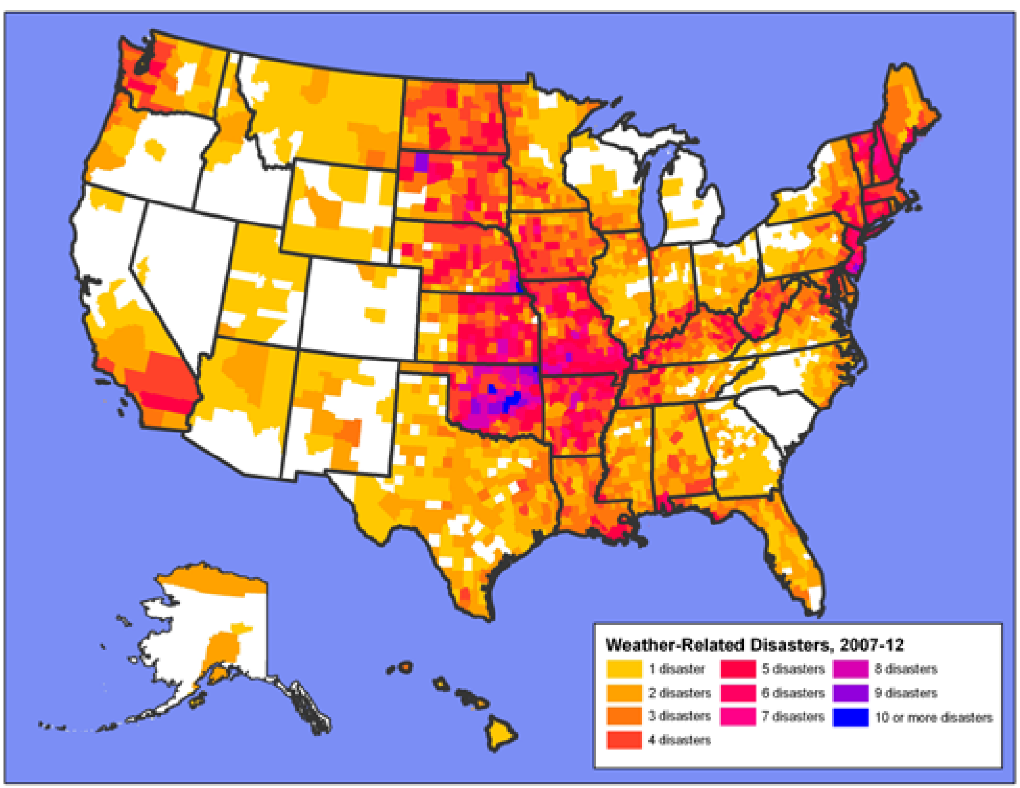


Figure 5. Number of Declared Weather-Related Disasters by County, 2007-2012



Flooding

More than half of all Americans – 176 million – live in counties that have experienced weather-related disasters involving flooding since the beginning of 2007. Flooding is the most widespread form of weather-related disaster – disasters involving flooding affected residents of 47 states between 2007 and 2012. Residents of the Plains states, the Ohio River Valley, New England and the Pacific Northwest were hit particularly frequently.

Tropical Cyclones

Nearly 102 million Americans – about one in three – live in counties that experienced a disaster involving a hurricane, tropical storm or its remnants between 2007 and 2012. Residents of 22 states and the District of Columbia experienced tropical cyclone-related disasters during that period of time, with residents of the Gulf Coast, Florida and the Northeast particularly hard hit.

Fire

Nearly 30 million Americans live in counties that experienced presidentially-declared disasters involving fire between 2007 and 2012. (See Figure 8, page 34.) Texas was by far the state that was most affected. Because federal disaster declarations are intended to provide help to communities, they fail to capture wildfires that may have done damage to forests or ecosystems but not to human settlements, resulting in some severe wildfires that affected less populated areas not appearing in the FEMA disaster database.

Tornadoes

There is little scientific clarity about how global warming may affect tornadoes, but tornadoes are a major cause of weather-related disasters in the United States, particularly in the Plains states, the Ohio River Valley and the Southeast. Nearly 82 million Americans – more than one in four – live in counties that experienced weather-related disasters involving tornadoes between 2007 and 2012. (See Figure 9, page 35.) Not all of these counties necessarily had a tornado touch down within their borders during this period – in some cases, disasters may have been declared as a result of damage caused by other aspects of a storm system (such as straight-line winds, rain or thunderstorms) that spawned damaging tornadoes in nearby counties.

Snow, Ice and Freezing

Approximately 111 million Americans – about one in three – live in areas that experienced winter weather-related disasters between 2007 and 2012. (See Figure 10, page 35.) These disasters include those involving snow storms, ice storms and freezing events, though not snowmelt-related flooding. Snow and ice-related disasters affected residents of 24 states and the District of Columbia, with residents of the central Plains, Appalachia, and metropolitan East Coast experiencing the bulk of these disasters. Interestingly, California experienced a winter weather-related disaster due to freezing during this period – a perfect example of how events that might be routine, and therefore expected, in one part of the country might result in a disaster in a portion of the country where they are rare and unexpected.

Other Severe Storms

Other types of storms that do not fit into the above categories are also capable of inducing weather-related disasters. These storms include strong coastal storms, severe thunderstorms, hailstorms and winter storms not explicitly identified in the FEMA database as producing snow

Figure 6. Weather-Related Disasters Involving Flooding, 2007-2012

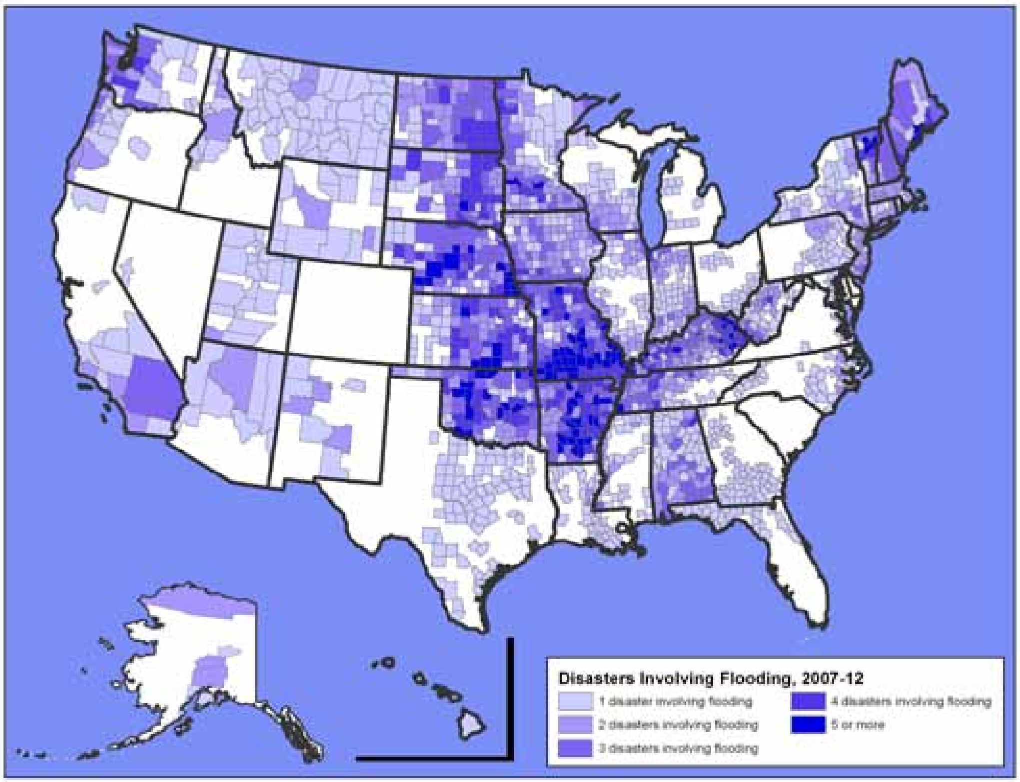
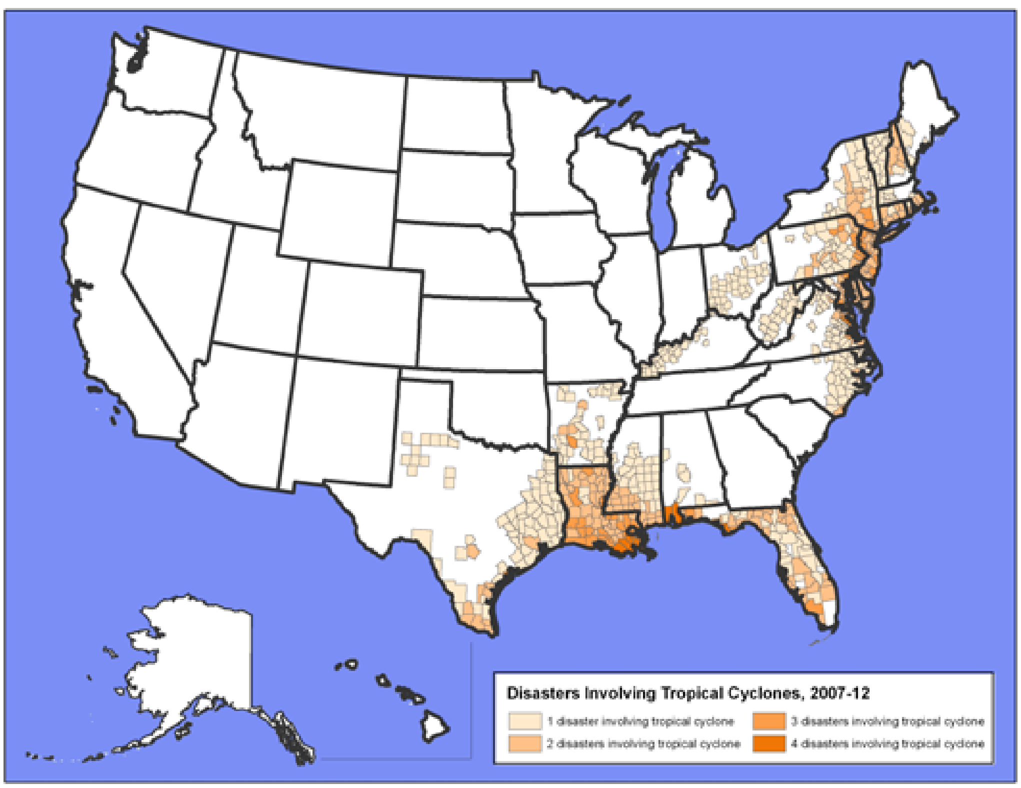


Figure 7. Weather-Related Disasters Involving Tropical Cyclones, 2007-2012



or ice. Approximately 33 million Americans live in counties that experienced a weather-related disaster triggered by these severe storms. (See Figure 11, page 36.)

Drought

Drought can be a devastating form of weather-related disaster, especially in its effects on farmers. However, presidentially declared severe disasters for drought are rare – none have been declared since 1965.

While presidential disaster declarations for drought are rare, it is quite common for the secretary of the USDA to designate counties as disaster areas as a result of drought or other weather or climate events with the potential to damage crops. These disaster designations are necessary to unlock federal financial assistance for farmers who have experienced crop or other losses.

Since 2007, drought conditions have triggered county-level USDA secretarial disaster declarations in every state other than Alaska, Connecticut, New Hampshire, Rhode Island and the District of Columbia.[153]

As of February 2013, 705 counties housing more than 63.5 million people had been designated primary natural disaster areas as a result of drought conditions.[154] (See Figure 12, page 37.)

Summary

Weather-related disasters are a fact of life in the United States. Throughout recorded history, the nation has been subjected to droughts, heat waves, tornado outbreaks, blizzards, hurricanes and floods that claim lives and damage property.

The climate is changing, however, and patterns of extreme weather are shifting in the United States and worldwide. For some types of extreme weather

(continued on page 36)

Figure 8. Weather-Related Disasters Involving Fire, 2007-2012

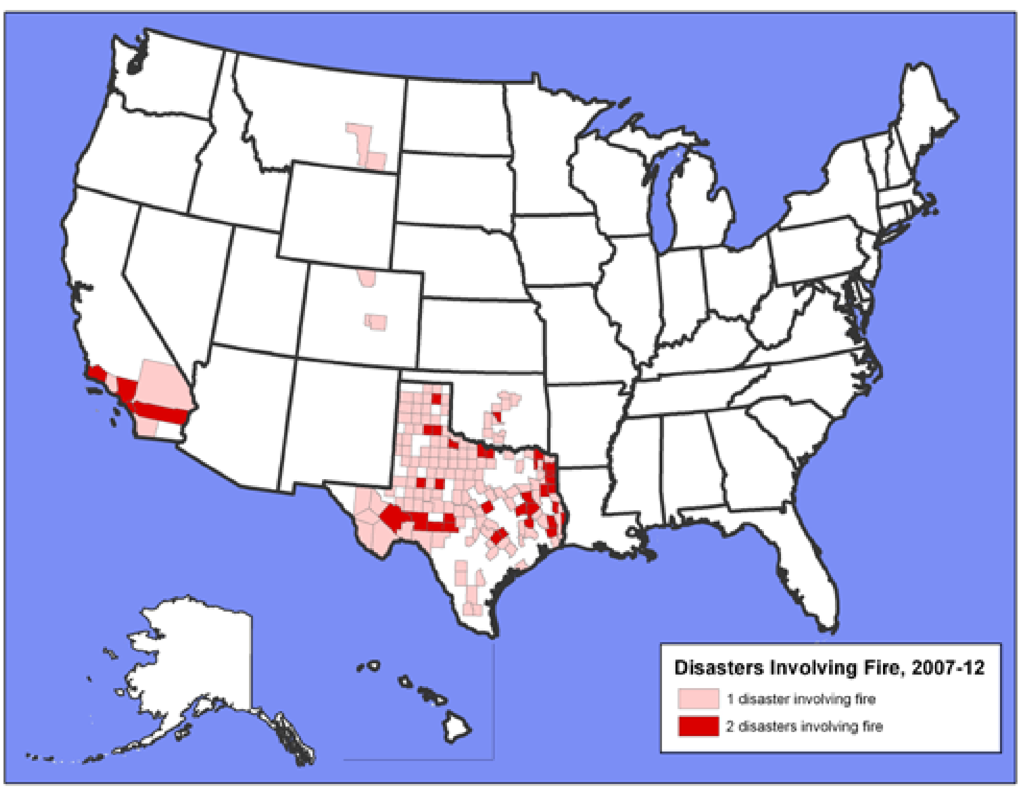


Figure 9. Weather-Related Disasters Involving Tornadoes, 2007-2012

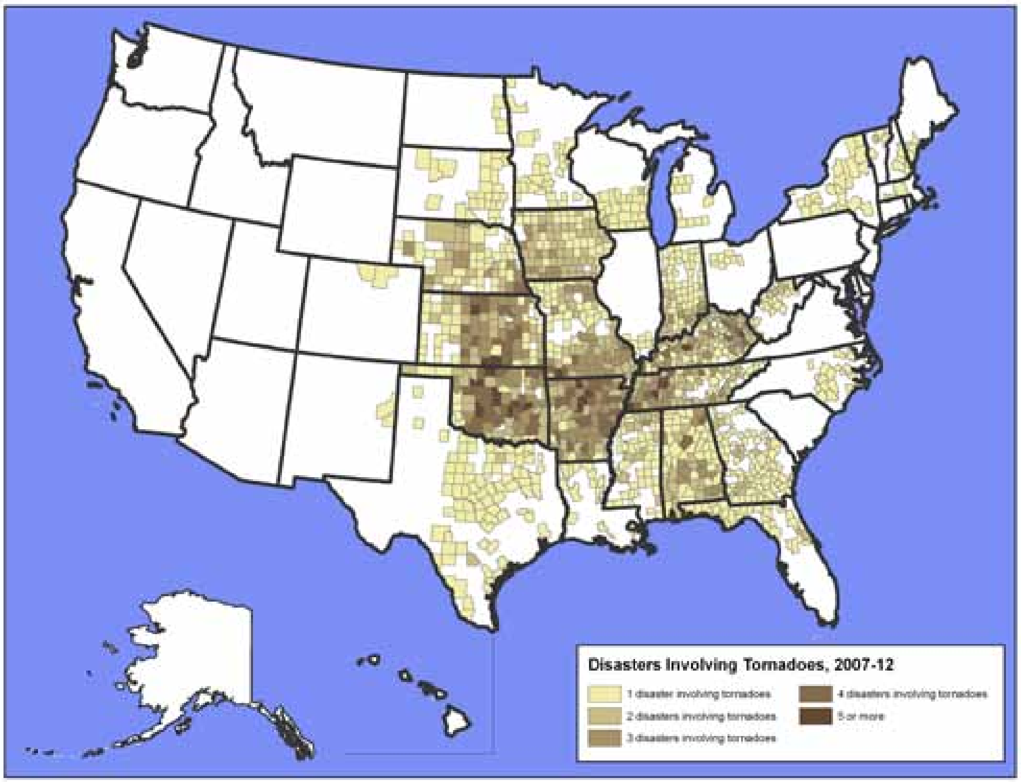
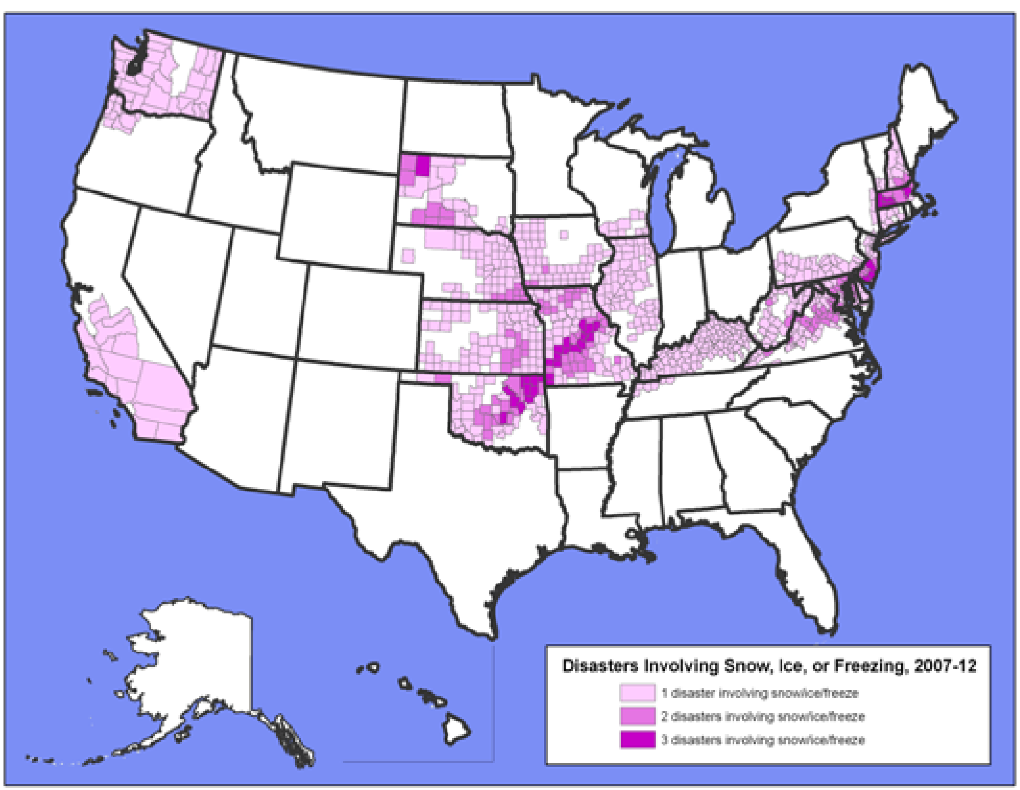


Figure 10. Weather-Related Disasters Involving Snow, Ice or Freezing, 2007-2012



events – such as heat waves and extreme downpours – the influence of global warming on current and future trends is relatively clear. For other types of destructive events – such as tornadoes and hurricanes – there is far greater uncertainty about future trends in a warming world. Regardless, climate change is likely to leave the United States more vulnerable to extreme – and even ordinary – weather events as a result of sea level rise and changes in ecosystems.

Understanding the breadth and severity of weather-related disasters in the United States can help decision-makers and the public grasp the high stakes involved in preventing the dramatic changes in weather extremes that scientists suggest are in store if worldwide emissions of global warming pollution continue to increase unabated. The time has come for the nation to take the steps needed to prevent the worst impacts of global warming and to prepare for the changes that are inevitably coming down the road.

Figure 11. Weather-Related Disasters Caused by Other Severe Storms, 2007-2012

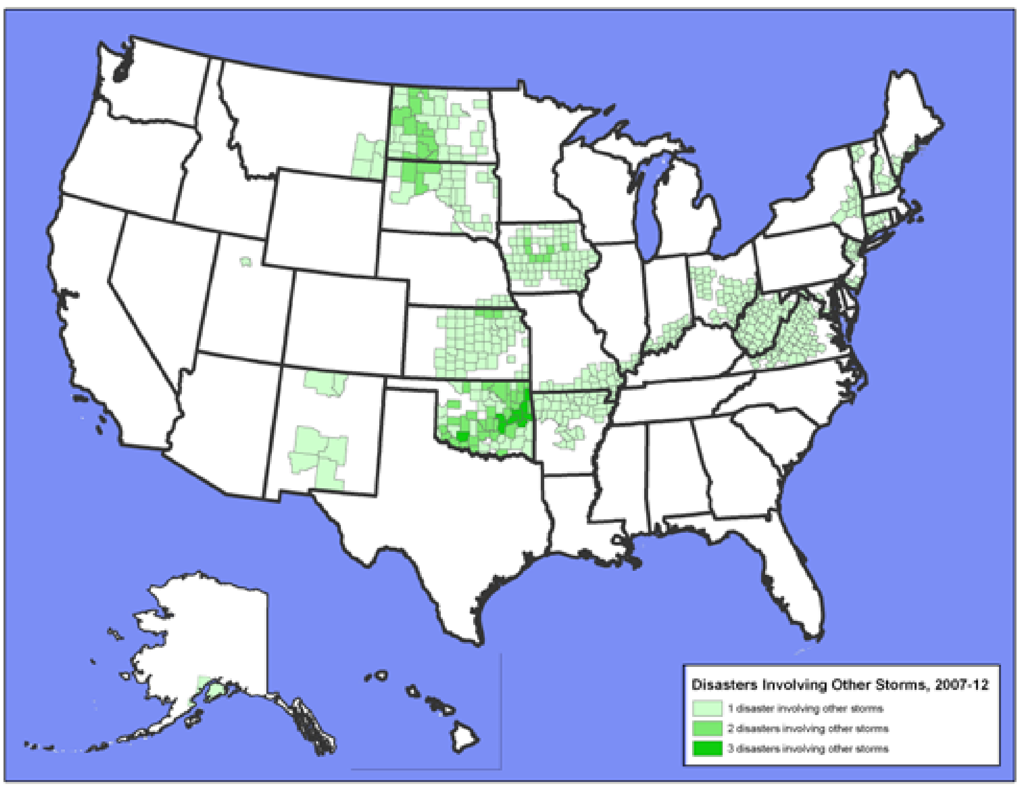
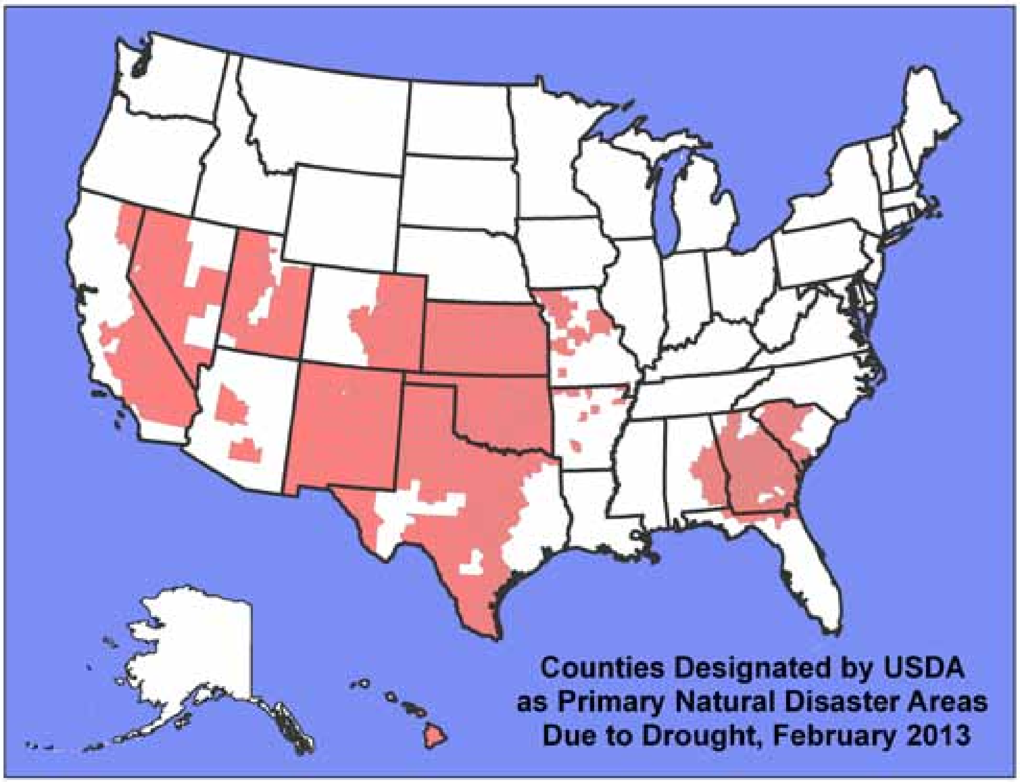


Figure 12. Counties Designated by USDA as Primary Natural Disaster Areas Due to Drought, February 2013[155]



Conclusions and Recommendations

Weather-related disasters impose massive costs on the nation and threaten the health and survival both of people affected by those events and of treasured ecosystems. Recent scientific findings about the potential impacts of global warming on extreme weather provide yet another reason for the United States and the world to take action against global warming.

Among the steps that can be taken to protect Americans from the threat of global warming-induced extreme weather events are the following:

Federal and state governments should adopt and implement limits on global warming pollution capable of reducing emissions by at least 35 percent below 2005 levels by 2020 and by at least 85 percent by 2050, and implement the clean energy solutions needed to make these reductions a reality. These emission reductions are broadly consistent with what science tells us is necessary to lessen the most costly and devastating consequences of global warming.

Federal, state and local governments should adopt and implement public policies designed to move the nation away from our dependence on fossil fuels while building momentum for future comprehensive action to curb global warming pollution. Specifically, federal, state and local governments should:

- Take strong steps to clean up existing sources of pollution. The federal government should impose strong limits on emissions of carbon dioxide and other pollutants from fossil fuel-fired power plants, while governments at all levels should work to expand and strengthen carbon cap-and-trade programs such as the pioneering Regional Greenhouse Gas Initiative in the Northeast.
- Adopt aggressive energy efficiency standards for buildings, appliances,

equipment and vehicles in order to get the most out of our current consumption of fossil fuels.

- Expand renewable electricity standards and clean fuel standards to increase the production of clean, environmentally friendly energy in the United States.
- Increase investment in clean transportation options, such as public transportation, as well as in research, development and deployment of new clean energy technologies.
- Reject the use of carbon-rich fuels such as tar sands, as well as infrastructure projects such as the proposed Keystone XL tar sands pipeline that facilitate the development of these carbon-rich fuels.

Environment America Research & Policy Center's 2011 report, *The Way Forward on Global Warming*, found that local, state and federal level policies could reduce carbon dioxide emissions from fossil fuel use in the United States to as much as 34 percent below 2005 levels – even without adoption of comprehensive climate and energy legislation in the United States Congress.

As the United States curbs emissions, we also need to **prepare for a future of more frequent and severe extreme weather** and take steps to reduce the impact of those events. Government agencies should assess the risks posed by global warming-fueled extreme weather, develop plans to protect lives and property during extreme weather events, direct public resources toward investments in infrastructure and ecological restoration that improve our resiliency in the face of extreme weather, revise policies that encourage construction in areas likely to be at risk of flooding in a warming climate, and support continued research on the implications of global warming.

Methodology

Data on federal disaster declarations were obtained primarily from the Federal Emergency Management Agency's (FEMA) *Disaster Declarations Summary*, last updated in December 2012. We supplemented this dataset by manually appending information for additional disasters that occurred in 2012 but had not yet been added to the FEMA database. As a result, the data presented in this report include all presidentially declared weather-related disasters that began prior to the end of 2012 and were declared through March 5, 2013. Because the disaster declaration process often takes time, there may be additional disasters that occurred in 2012 for which disaster declarations had not been issued as of March 5, 2013. These disasters are not included in this report.

A full county-by-county listing of federally declared weather-related disasters for 2007-2012 can be found through an interactive online map at www.environmentamericacenter.org.

Disasters were classified by year based on the date on which the weather event precipitating the disaster began – not the year on which the disaster was formally declared. "Weather-related" disasters were assumed to include all disasters whose primary characteristic ("incident type" in the FEMA database) was listed as coastal storm, fire, flood, freezing, hurricane, severe ice storm, severe storm, snow or tornado. (We reclassified one 2012 Utah incident, described as "other" in the incident type field, as a "severe storm" based on the contents of the title field.)

To streamline data processing and representation, only declarations for counties and county equivalents (such as parishes in Louisiana or boroughs in Alaska) are included in our totals. Declarations listed as being "statewide," for Indian reservations, for non-standard geographies, or for county-level jurisdictions that no longer exist were excluded from the totals in this report (though declarations for these geographies are listed separately in Appendix B).

All county population totals for 2011, 2012 and 2007-2012 are based on 2011 county population estimates from the U.S. Census Bureau. All data for previous individual years are based on population estimates for that year from the U.S. Census Bureau.

To identify the type(s) of weather events that took place in each disaster, we used a combination of FEMA's "incident type" (which is based on the disaster assistance request filed by the state governor) and the more detailed information about disaster events provided in the "title" field of the FEMA database.

Incident types are broad categories (e.g., "severe storms") that are either vague or describe only the most prominent aspect of the disaster. For example, a disaster may have an incident type of "tornado," but also include damage caused by heavy rains, flooding or straight-line winds. As a result, the "incident type" field is of limited usefulness in describing the extent to which flooding, for example, was a common element of weather-related disasters across the country. To provide additional detail about the breadth of impact of several types of weather events, we performed a text search of the "title" field in the FEMA database, which includes more descriptive information about the various events. Counties were identified as having experienced disasters "involving" flooding, snow or ice storms, etc., if these components were identified in the "incident type" field or if the following words (or near variants) appeared in the "title" field:

- Disasters involving flooding:
  Incident type: "flooding"; Title: "flood"
- Disasters involving tropical cyclones:
  Incident type: "hurricane"; Title: "tropical", "hurricane"
- Disasters involving tornadoes:
  Incident type: "tornado"; Title: "tornado"
- Disasters involving snow and ice:
  Incident type: "snow", "severe ice storm", "freezing"; Title: "snow" (with an exclusion for "snow pack"), "blizzard"

Appendices

Appendix A: Population of Counties with Presidentially Declared Weather-Related Disasters, by Year

State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2007-2012	% of population in counties affected by disaster, 2007-12
AK	0	249,654	388,693	7,397	15,606	132,723	0	105,196	100,390	0	65,796	150,094	272,661	37.7%
AL	2,018,325	2,796,995	3,480,393	4,530,729	3,353,587	0	1,106,840	585,023	2,601,391	231,333	4,802,740	1,462,773	4,802,740	100.0%
AR	834,676	471,448	839,589	806,211	0	199,972	0	2,786,692	2,469,402	0	2,460,999	626,440	2,937,979	100.0%
AZ	0	340,228	885,893	715,818	4,251,107	1,411,962	0	0	0	807,500	0	0	810,718	12.5%
CA	0	0	17,087,688	21,358,162	29,807,596	5,585,443	24,890,301	15,218,311	0	22,619,205	0	0	25,956,454	68.9%
CO	302,606	4,378,254	0	0	0	0	0	535,092	0	0	0	965,844	1,224,482	23.9%
CT	0	0	0	0	1,599,950	0	3,377,552	0	0	2,339,974	3,580,709	2,686,004	3,580,709	100.0%
DC	574,504	0	568,502	0	0	0	0	0	592,228	604,453	617,996	617,996	617,996	100.0%
DE	0	0	818,003	518,944	0	182,390	0	0	0	899,769	365,164	907,135	907,135	100.0%
FL	2,413,762	0	3,907,247	17,415,318	10,327,541	494,748	1,284,516	10,939,352	2,398,019	0	0	9,770,356	14,548,816	76.3%
GA	0	0	0	5,011,324	0	0	448,261	2,464,240	5,589,259	0	1,355,287	0	6,976,805	71.1%
HI	0	0	0	907,997	0	990,419	390,235	999,283	0	0	0	224,375	1,374,720	100.0%
IA	770,724	974,844	0	2,517,732	0	0	2,352,202	2,716,443	663,952	1,963,075	621,798	0	3,062,309	100.0%
ID	0	0	0	0	49,064	0	0	148,658	0	83,348	118,171	0	326,284	20.6%
IL	383,502	2,475,687	437,628	830,828	0	1,422,785	7,685,252	10,184,700	307,075	6,659,907	11,438,775	0	12,283,808	95.5%
IN	0	3,175,683	4,426,498	4,946,140	6,171,403	725,000	493,403	6,016,997	2,498,110	0	1,412,795	284,987	6,110,790	93.8%
KS	27,771	1,939,795	533,586	755,532	1,634,560	531,675	1,954,377	799,907	2,076,457	554,749	537,298	582,753	2,303,690	80.2%
KY	430,532	1,439,182	2,697,175	3,538,835	77,510	0	243,023	2,701,813	3,983,955	2,277,539	2,907,859	633,944	4,315,248	98.8%
LA	2,846,384	3,784,585	0	3,649,604	4,576,628	1,450,515	752,844	4,435,586	491,528	0	1,845,765	4,175,575	4,574,836	100.0%
MA	5,334,311	0	0	4,310,772	6,155,849	2,873,175	2,274,950	3,824,868	0	5,490,296	6,577,394	2,020,110	6,587,536	100.0%
MD	0	238,758	5,496,269	0	0	990,383	0	0	3,824,264	5,708,070	4,181,516	4,851,060	5,828,289	100.0%
ME	573,682	937,456	348,457	0	856,973	197,635	1,084,437	1,031,912	358,920	764,436	320,864	0	1,328,188	100.0%
MI	0	147,655	0	7,642,841	0	0	0	1,161,297	0	0	0	0	1,161,176	11.8%
MN	4,538,620	484,253	0	294,975	111,399	166,616	319,355	136,496	459,723	1,870,165	3,602,338	1,027,002	5,145,593	96.3%
MO	0	3,667,012	4,547,169	1,587,978	0	3,376,056	4,801,142	4,925,603	2,064,785	1,270,553	3,634,843	0	6,010,688	100.0%
MS	2,302,606	797,310	1,409,769	1,829,566	2,905,943	0	0	1,169,978	318,462	469,346	1,522,937	1,939,551	2,861,071	96.1%
MT	187,371	42,853	0	0	0	0	0	17,250	0	21,955	799,080	11,117	799,080	80.1%
NC	0	5,520,096	4,851,024	4,727,778	695,655	0	0	387,279	715,400	971,955	3,945,305	0	4,704,966	48.7%
ND	493,047	115,360	11,199	217,400	464,511	279,911	294,758	0	656,179	622,861	642,953	0	683,932	100.0%

Appendix A: Population of Counties with Presidentially Declared Weather-Related Disasters, by Year

(continued)

State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2007-2012	% of population in counties affected by disaster, 2007-12
NE	185,753	0	614,149	1,369,669	409,197	541,053	349,010	1,558,065	1,595,047	1,631,665	1,035,398	0	1,834,345	99.5%
NH	0	0	118,225	0	808,124	1,153,521	1,312,540	1,315,906	0	1,098,839	1,241,276	349,855	1,318,194	100.0%
NJ	0	0	0	1,703,913	3,681,115	750,942	7,039,278	0	2,415,545	8,543,671	8,821,155	8,821,155	8,821,155	100.0%
NM	0	0	0	686,299	0	778,822	55,584	82,956	0	251,928	369,475	172,935	634,787	30.5%
NV	0	0	0	55,995	2,324,381	0	0	52,156	0	0	0	0	51,871	1.9%
NY	946,515	0	3,278,901	19,171,567	3,127,468	4,239,289	9,400,040	1,090,617	4,103,282	11,750,688	16,856,805	13,093,372	18,038,396	92.7%
OH	1,399,698	4,270,769	6,884,760	11,452,251	0	2,759,881	499,947	5,551,020	0	0	1,801,635	4,506,096	8,400,900	72.8%
OK	1,830,746	2,650,011	1,804,404	0	3,548,597	67,713	3,500,595	1,192,740	3,447,819	2,688,269	1,912,346	413,856	3,791,508	100.0%
OR	0	617,535	2,655,317	0	1,375,208	448,442	920,132	2,214,293	0	0	617,025	1,288,269	3,114,909	80.4%
PA	1,739,762	0	1,425,730	12,410,722	1,895,861	5,279,964	0	0	0	8,038,405	8,538,243	4,294,871	11,361,524	89.2%
RI	0	0	0	0	0	0	82,881	0	0	1,052,886	1,051,302	424,593	1,051,302	100.0%
SC	0	973,632	0	3,540,191	1,151,882	0	0	0	0	0	0	0	0	0.0%
SD	214,003	0	0	213,145	247,708	45,308	193,693	218,626	186,292	585,713	333,250	0	712,929	86.5%
TN	1,214,803	1,966,457	5,219,173	707,177	0	1,234,195	0	1,813,993	1,754,217	3,764,269	4,858,051	696,277	5,860,748	91.5%
TX	5,991,837	10,493,963	937,171	0	22,778,123	748,254	13,826,761	11,151,515	0	2,052,011	5,995,685	0	21,337,307	83.1%
UT	0	0	0	0	331,950	0	0	0	0	150,801	2,555,572	141,666	2,709,639	96.2%
VA	293,350	656,254	7,086,145	1,544,250	0	2,417,011	0	0	4,893,152	3,346,797	4,720,558	3,448,192	7,831,286	96.7%
VT	0	132,869	168,039	360,358	0	0	378,363	379,855	0	229,129	626,431	88,616	626,431	100.0%
WA	0	0	4,288,008	0	0	4,961,836	3,457,583	6,137,334	4,987,984	0	2,241,186	4,122,846	6,683,958	97.9%
WI	1,366,910	888,005	0	4,748,231	0	0	1,474,913	3,871,096	0	1,473,050	2,263,665	75,346	4,399,974	77.0%
WV	982,396	466,563	1,717,547	1,264,390	162,080	0	466,109	362,264	735,800	1,188,480	0	1,687,164	1,855,364	100.0%
WY	0	0	0	0	37,888	0	0	0	0	48,916	292,711	0	292,711	51.5%
Total	**40,388,582**	**57,093,166**	**88,932,351**	**147,350,039**	**114,934,464**	**46,437,639**	**96,710,877**	**110,284,412**	**56,288,637**	**104,126,006**	**123,490,151**	**76,562,225**	**242,827,937**	

Appendix B: Disaster Declarations for Non-County Geographies

Note: Some Indian reservations extend across state lines.

State	Beginning date of disaster	Disaster type	Disaster description	Affected area
SD	5/4/2007	Severe Storm(s)	Severe Storms, Tornadoes and Flooding	Crow Creek Indian Reservation
SD	5/4/2007	Severe Storm(s)	Severe Storms, Tornadoes and Flooding	Lake Traverse Sisseton Indian Reservation
SD	5/4/2007	Severe Storm(s)	Severe Storms, Tornadoes and Flooding	Pine Ridge Indian Reservation
OR	12/1/2007	Severe Storm(s)	Severe Storms, Flooding, Landslides and Mudslides	Coos, Lower Umpqua and Siuslaw Indian Reservation
OR	12/1/2007	Severe Storm(s)	Severe Storms, Flooding, Landslides and Mudslides	Grand Ronde Indian Reservation
OR	12/1/2007	Severe Storm(s)	Severe Storms, Flooding, Landslides and Mudslides	Siletz Indian Reservation
SD	6/2/2008	Severe Storm(s)	Severe Storms and Flooding	Cheyenne River Indian Reservation
SD	6/2/2008	Severe Storm(s)	Severe Storms and Flooding	Crow Creek Indian Reservation
SD	6/2/2008	Severe Storm(s)	Severe Storms and Flooding	Lower Brule Indian Reservation
AK	7/27/2008	Severe Storm(s)	Severe Storms, Flooding, Landslides and Mudslides	Yukon Koyukuk Regional Educational Attendance Area
SD	11/5/2008	Snow	Severe Winter Storm and Record and Near-Record Snow	Cheyenne River Indian Reservation
SD	11/5/2008	Snow	Severe Winter Storm and Record and Near-Record Snow	Pine Ridge Indian Reservation
SD	11/5/2008	Snow	Severe Winter Storm and Record and Near-Record Snow	Rosebud Indian Reservation
SD	11/5/2008	Snow	Severe Winter Storm and Record and Near-Record Snow	Standing Rock Indian Reservation
ND	3/13/2009	Severe Storm(s)	Severe Storms and Flooding	Lake Traverse Sisseton Indian Reservation
ND	3/13/2009	Severe Storm(s)	Severe Storms and Flooding	Spirit Lake Reservation
ND	3/13/2009	Severe Storm(s)	Severe Storms and Flooding	Standing Rock Indian Reservation
ND	3/13/2009	Severe Storm(s)	Severe Storms and Flooding	Turtle Mountain Indian Reservation
MN	3/16/2009	Severe Storm(s)	Severe Storms and Flooding	Red Lake Indian Reservation
MN	3/16/2009	Severe Storm(s)	Severe Storms and Flooding	White Earth Indian Reservation
AK	4/28/2009	Flood	Flooding and Ice Jams	Alaska Gateway Regional Educational Attendance Area
AK	4/28/2009	Flood	Flooding and Ice Jams	Kuspuk Regional Educational Attendance Area
AK	4/28/2009	Flood	Flooding and Ice Jams	Lower Kuskokwim Regional Educational Attendance Area
AK	4/28/2009	Flood	Flooding and Ice Jams	Lower Yukon Regional Educational Attendance Area
AK	4/28/2009	Flood	Flooding and Ice Jams	Yukon Flats Regional Educational Attendance Area
AK	4/28/2009	Flood	Flooding and Ice Jams	Yukon Koyukuk Regional Educational Attendance Area

Appendix B: Disaster Declarations for Non-County Geographies (continued)

State	Beginning date of disaster	Disaster type	Disaster description	Affected area
AK	4/28/2009	Flood	Flooding and Ice Jams	Yupiit Regional Educational Attendance Area
SD	3/11/2009	Severe Storm(s)	Severe Storms and Flooding	Cheyenne River Indian Reservation
SD	3/11/2009	Severe Storm(s)	Severe Storms and Flooding	Standing Rock Indian Reservation
NC	12/18/2009	Severe Storm(s)	Severe Winter Storms and Flooding	Eastern Cherokee Indian Reservation
ND	1/20/2010	Severe Storm(s)	Severe Winter Storm	Standing Rock Indian Reservation
SD	12/23/2009	Severe Storm(s)	Severe Winter Storm and Snowstorm	Pine Ridge Indian Reservation
SD	12/23/2009	Severe Storm(s)	Severe Winter Storm and Snowstorm	Rosebud Indian Reservation
SD	1/20/2010	Severe Storm(s)	Severe Winter Storm	Cheyenne River Indian Reservation
SD	1/20/2010	Severe Storm(s)	Severe Winter Storm	Lake Traverse Sisseton Indian Reservation
SD	1/20/2010	Severe Storm(s)	Severe Winter Storm	Standing Rock Indian Reservation
AZ	1/18/2010	Severe Storm(s)	Severe Winter Storms and Flooding	Gila River Indian Reservation
AZ	1/18/2010	Severe Storm(s)	Severe Winter Storms and Flooding	Hopi Indian Reservation
AZ	1/18/2010	Severe Storm(s)	Severe Winter Storms and Flooding	Navajo Nation Reservation
AZ	1/18/2010	Severe Storm(s)	Severe Winter Storms and Flooding	San Carlos Indian Reservation
AZ	1/18/2010	Severe Storm(s)	Severe Winter Storms and Flooding	Tohono O’odham Reservation and Trust Lands
AZ	1/18/2010	Severe Storm(s)	Severe Winter Storms and Flooding	White Mountain Apache Tribe
MN	3/1/2010	Flood	Flooding	Prairie Island Community Indian Reservation
MN	3/1/2010	Flood	Flooding	Upper Sioux Community Indian Reservation
ND	4/1/2010	Severe Storm(s)	Severe Winter Storm	Standing Rock Indian Reservation
ND	2/26/2010	Flood	Flooding	Spirit Lake Reservation
MT	6/15/2010	Severe Storm(s)	Severe Storms and Flooding	Rocky Boy’s Indian Reservation
WY	6/4/2010	Flood	Flooding	Wind River Indian Reservation
SD	6/16/2010	Severe Storm(s)	Severe Storms, Tornadoes and Flooding	Cheyenne River Indian Reservation
NM	7/25/2010	Flood	Severe Storms and Flooding	Navajo Nation Reservation
NM	7/25/2010	Flood	Severe Storms and Flooding	Pueblo of Acoma
AZ	7/20/2010	Severe Storm(s)	Severe Storms and Flooding	Hopi Indian Reservation
SD	9/22/2010	Severe Storm(s)	Severe Storms and Flooding	Flandreau Indian Reservation
AZ	10/3/2010	Severe Storm(s)	Severe Storms and Flooding	Havasupai Indian Reservation
CT	1/11/2011	Snow	Snowstorm	Mashantucket Pequot Indian Reservation
CT	1/11/2011	Snow	Snowstorm	Paucatuck Eastern Pequot Indian Reservation
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Mescalero Tribe
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of Acoma

Appendix B: Disaster Declarations for Non-County Geographies (continued)

State	Beginning date of disaster	Disaster type	Disaster description	Affected area
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of Picuris
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of Pojoaque
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of San Felipe
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of Santa Ana
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of Santa Clara
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	Pueblo of Taos
NM	2/1/2011	Severe Storm(s)	Severe Winter Storm and Extreme Cold Temperatures	San Felipe Pueblo Indian Reservation
ND	2/14/2011	Flood	Flooding	Fort Berthold Indian Reservation
ND	2/14/2011	Flood	Flooding	Spirit Lake Reservation
ND	2/14/2011	Flood	Flooding	Standing Rock Indian Reservation
ND	2/14/2011	Flood	Flooding	Turtle Mountain Indian Reservation
MN	3/16/2011	Flood	Severe Storms and Flooding	Red Lake Indian Reservation
ID	3/31/2011	Flood	Flooding, Landslides and Mudslides	Nez Perce Indian Reservation
AK	5/8/2011	Flood	Ice Jam and Flooding	Crooked Creek ANV/ANVSA
AK	5/8/2011	Flood	Ice Jam and Flooding	Kuspuk Regional Educational Attendance Area
AK	5/8/2011	Flood	Ice Jam and Flooding	Red Devil ANV/ANVSA
MT	4/4/2011	Severe Storm(s)	Severe Storms and Flooding	Blackfeet Indian Reservation
MT	4/4/2011	Severe Storm(s)	Severe Storms and Flooding	Crow Indian Reservation
MT	4/4/2011	Severe Storm(s)	Severe Storms and Flooding	Fort Belknap Indian Reservation
MT	4/4/2011	Severe Storm(s)	Severe Storms and Flooding	Fort Peck Indian Reservation
MT	4/4/2011	Severe Storm(s)	Severe Storms and Flooding	Northern Cheyenne Indian Reservation
MT	4/4/2011	Severe Storm(s)	Severe Storms and Flooding	Rocky Boy's Indian Reservation
WY	5/18/2011	Severe Storm(s)	Severe Storms, Flooding and Landslides	Wind River Indian Reservation
MN	7/1/2011	Severe Storm(s)	Severe Storms, Flooding and Tornadoes	Mille Lacs Indian Reservation
UT	4/18/2011	Flood	Flooding	Uintah and Ouray Indian Reservation
NE	5/24/2011	Flood	Flooding	Omaha Indian Reservation
RI	8/27/2011	Hurricane	Tropical Storm Irene	Statewide
NM	8/19/2011	Flood	Flooding	Cochiti Pueblo Indian Reservation
NM	8/19/2011	Flood	Flooding	Pueblo of Acoma
NM	8/19/2011	Flood	Flooding	Santa Clara Pueblo Indian Reservation
AK	11/8/2011	Severe Storm(s)	Severe Winter Storms and Flooding	Bering Strait Regional Educational Attendance Area

Appendix B: Disaster Declarations for Non-County Geographies

State	Beginning date of disaster	Disaster type	Disaster description	Affected area
AK	11/8/2011	Severe Storm(s)	Severe Winter Storms and Flooding	Lower Kuskokwim Regional Educational Attendance Area
AK	11/8/2011	Severe Storm(s)	Severe Winter Storms and Flooding	Lower Yukon Regional Educational Attendance Area
AK	11/8/2011	Severe Storm(s)	Severe Winter Storms and Flooding	Southwest Region Regional Educational Attendance Area
MN	6/14/2012	Severe Storm(s)	Severe Storms and Flooding	Fond du Lac Indian Reservation
MN	6/14/2012	Severe Storm(s)	Severe Storms and Flooding	Grand Portage Indian Reservation
MN	6/14/2012	Severe Storm(s)	Severe Storms and Flooding	Mille Lacs Indian Reservation
MT	6/25/2012	Fire	Wildfire	Crow/Northern Cheyenne Area
WI	6/19/2012	Severe Storm(s)	Severe Storms and Flooding	Red Cliff Indian Reservation
NM	6/22/2012	Flood	Flooding	Mescalero Tribe
NM	6/22/2012	Flood	Flooding	Santa Clara Pueblo Indian Reservation
MS	8/26/2012	Hurricane	Hurricane Isaac	Mississippi Choctaw Indian Reservation
WA	7/20/2012	Severe Storm(s)	Severe Storm, Straight-Line Winds and Flooding	Colville Indian Reservation
CT	10/27/2012	Hurricane	Hurricane Sandy	Mashantucket Pequot Indian Reservation
AK	9/15/2012	Severe Storm(s)	Severe Storm, Straight-Line Winds, Flooding and Landslides	Alaska Gateway Regional Educational Attendance Area
AK	9/15/2012	Severe Storm(s)	Severe Storm, Straight-Line Winds, Flooding and Landslides	Chugach Regional Educational Attendance Area

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