

CLIMATE CHANGE and EXTREME HEAT EVENTS



**Centers for Disease
Control and Prevention**
National Center for
Environmental Health

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All scientific information in this document is derived from peer-reviewed assessments, including those published by the United States Global Change Research Program and the Intergovernmental Panel on Climate Change, from other peer-reviewed literature, or from federal government agencies.

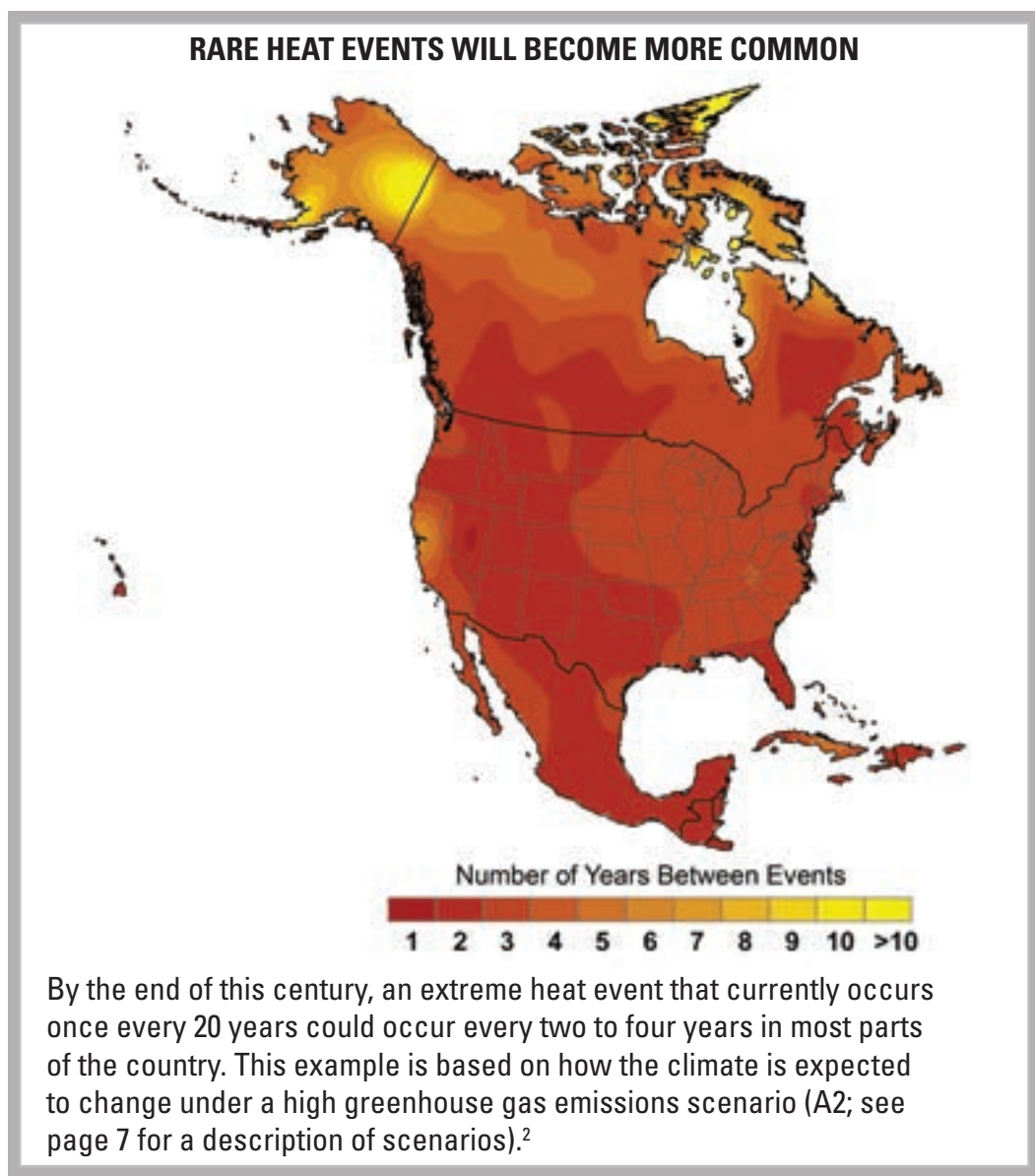
Overview

Extreme heat events pose a serious danger to people throughout the United States. Studies conducted by the Centers for Disease Control and Prevention (CDC) have shown that exposure to extreme heat can increase discomfort and fatigue, cause heat cramps, and increase emergency room visits and hospitalizations.¹ It can also kill. From 1999 through 2009, extreme heat exposure caused or contributed to more than 7,800 deaths in the United States (Kochanek et al, 2011).

Extreme heat is a real danger to human health that will become worse with time. Experts project that as our climate changes, extreme heat events in the United States will become more frequent, longer lasting, and more severe.^{2,3} By the end of this century, extremely high temperatures that currently occur once every 20 years could happen as often as every two to four years.²

Learning about how to prepare for and respond to extreme heat events will help protect our communities, especially the most vulnerable populations, from avoidable death and hardship.

This document describes extreme heat events, how an extreme heat event threatens public health, and how to prepare for and respond to such an event. It explains how the frequency, duration, and severity of extreme heat events are increasing as a result of climate change, and includes links to local programs and real-world examples from across the country.

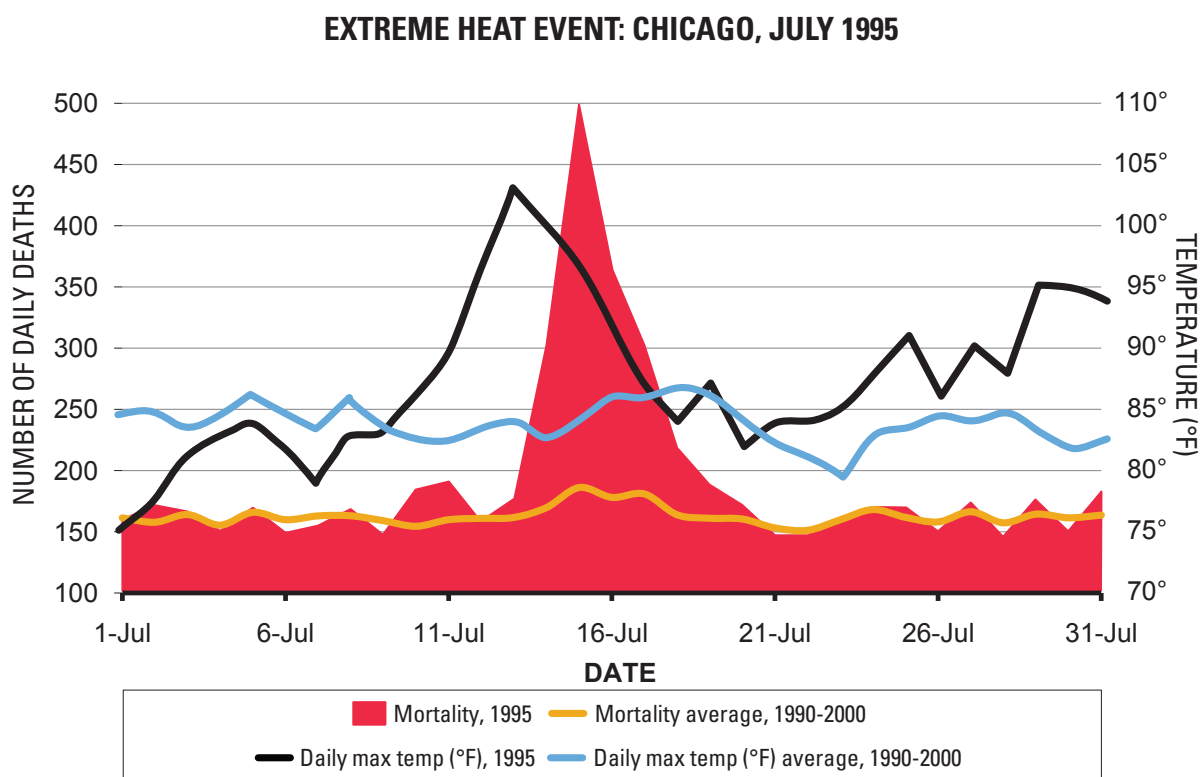


Understanding Extreme Heat Events

What Is an Extreme Heat Event?

While there is no single agreed upon definition of an extreme heat event, most definitions refer to an extended period of time (several days or more) with unusually hot weather conditions that potentially can harm human health.⁵

“ The U.S. Environmental Protection Agency defines extreme heat events as “periods of summertime weather that are substantially hotter and/or more humid than typical for a given location at that time of year.”⁴



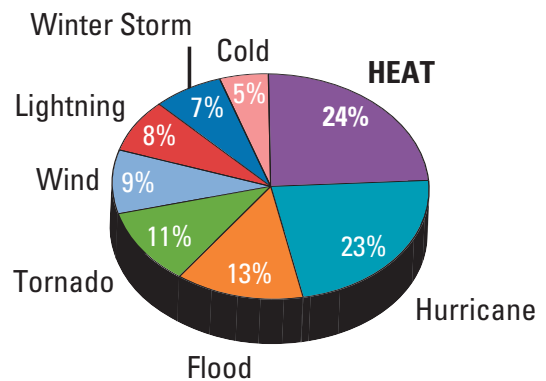
One of the most severe extreme heat events in recent U.S. history occurred in July 1995 in Chicago. During this event, the extended increase in daily maximum temperatures (black line) as compared to the average for 1990-2000 (blue line) had an estimated result of more than 650 deaths.³

Health Effects of Extreme Heat Events

Heat waves can be deadly. Extreme heat was the leading cause of weather-related deaths in the United States from 2000 through 2009.⁶ From 1999 through 2009, extreme heat exposure caused more than 7,800 deaths in the United States.²

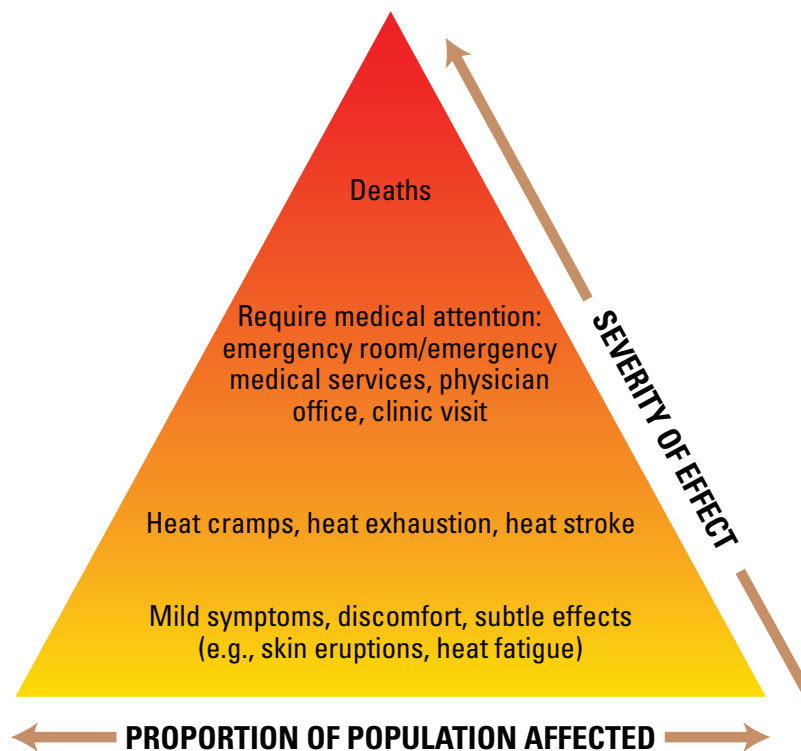
In addition to deaths, extreme heat events cause a wide range of other health problems such as rashes, cramps, heat exhaustion, and heat stroke. Extreme heat can also make existing medical conditions worse. Though harder to count than deaths, these health conditions affect far more people and lead to extra emergency room visits and hospitalizations.³

DEATHS IN THE UNITED STATES ATTRIBUTED TO WEATHER CONDITIONS, 2000–2009⁶



“Extreme heat events are a problem around the world. For example, in 2003, an extreme heat event in Europe killed 14,800 people in France alone.”

EXTREME HEAT EVENTS CAUSE A RANGE OF HEALTH PROBLEMS

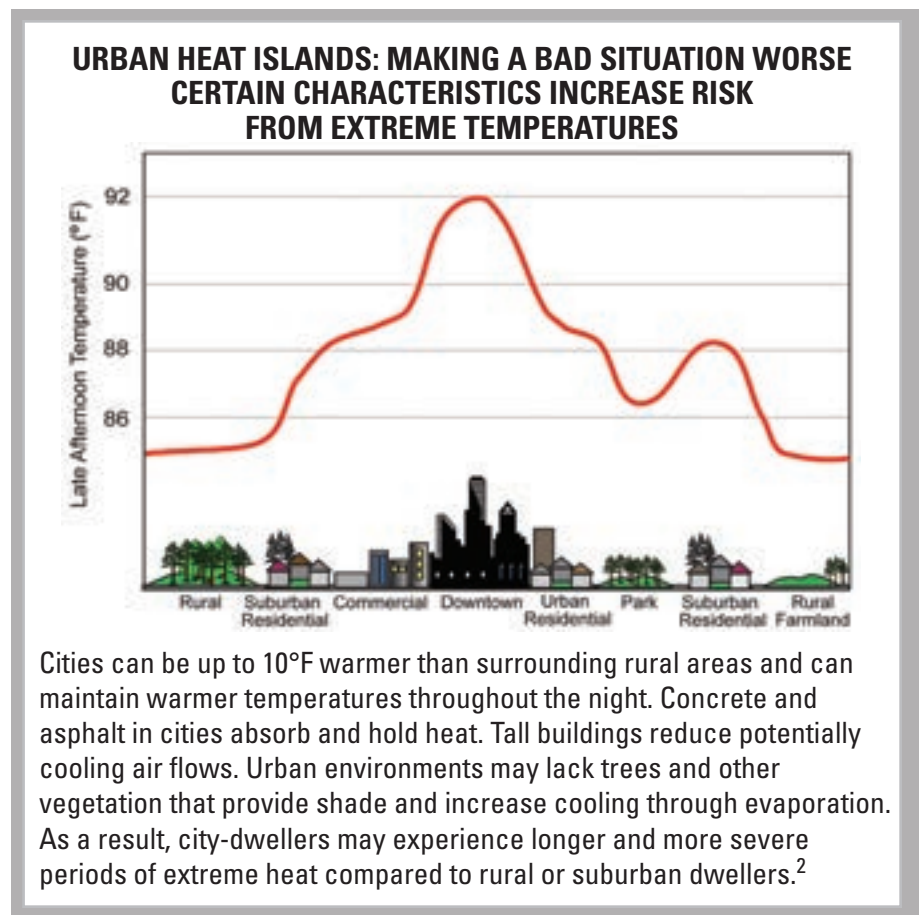
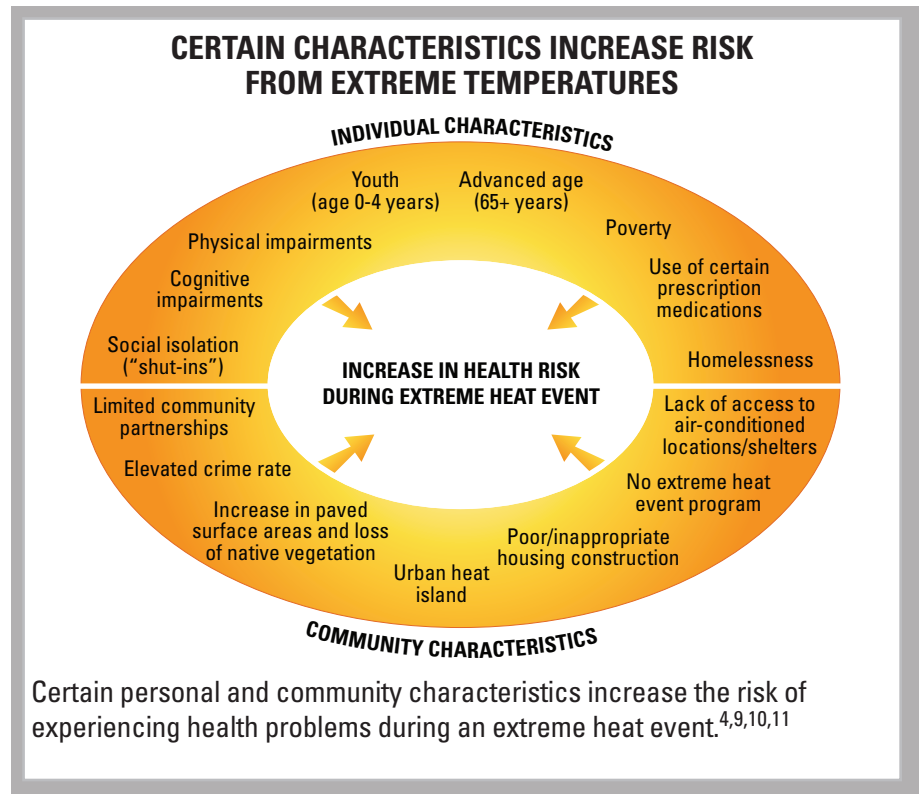


Extreme heat events cause health problems and can make other health problems worse. Mild effects are more common, but in extreme cases, people can die.⁷

Vulnerability to Extreme Heat Events

Everyone should take steps to protect themselves and their families' health during an extreme heat event, but some people are more vulnerable than others. Young children, people aged 65 and older, persons with certain disabilities, those living in poverty or social isolation, and the homeless have a much higher risk of heat-related health problems than other people living in a population.^{4,9,10,11}

If current population trends continue, the number of vulnerable Americans aged 65 and older will continue to grow.² In addition, the number of people living in urban areas may continue to increase exposing more vulnerable individuals in the future to the "urban heat island" effect (see figure at right).² Changes in health care, transportation patterns, and urban design could either increase or decrease the risk, but these changes are harder to predict than population trends.



Climate Change and Extreme Heat Events

Climate Change and a Warming World

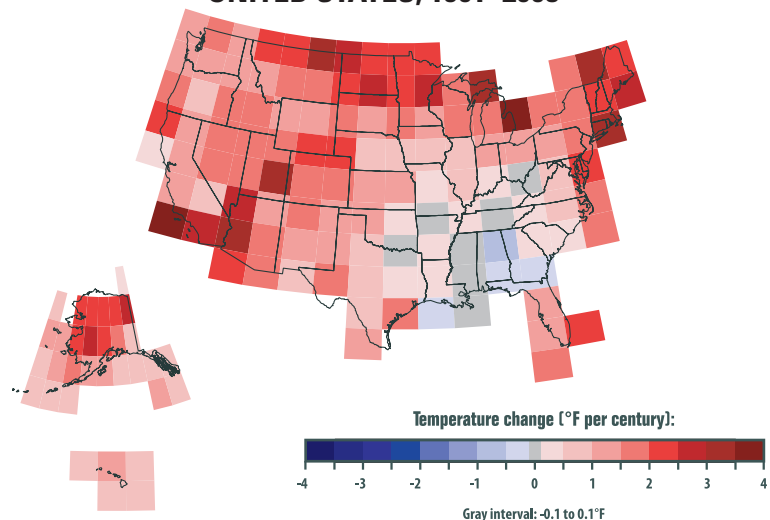
The Earth is getting warmer because people are adding greenhouse gases, such as carbon dioxide and methane, to the atmosphere. Most of these gases are being released as a result of burning fossil fuels like coal, oil, and natural gas. As these gases build up in the atmosphere, they trap extra heat and cause average temperatures to increase—a process called global warming.^{2,3,13} Warmer temperatures lead to many other changes in the atmosphere, on land, and in the oceans. Together, these changes are known as climate change.

Average temperatures around the world have become warmer since the start of the 20th century, and they have risen at a particularly fast rate during the last 50 years. Nine of the ten warmest years on record have occurred since 2000.¹⁴

Like the rest of the world, the United States has become warmer. The U.S. average temperature has risen more than 2.0°F over the past 50 years, and it is projected to rise more in the future.² Some parts of the country have experienced more warming than others (see figure).



RATE OF TEMPERATURE CHANGE IN THE UNITED STATES, 1901–2008

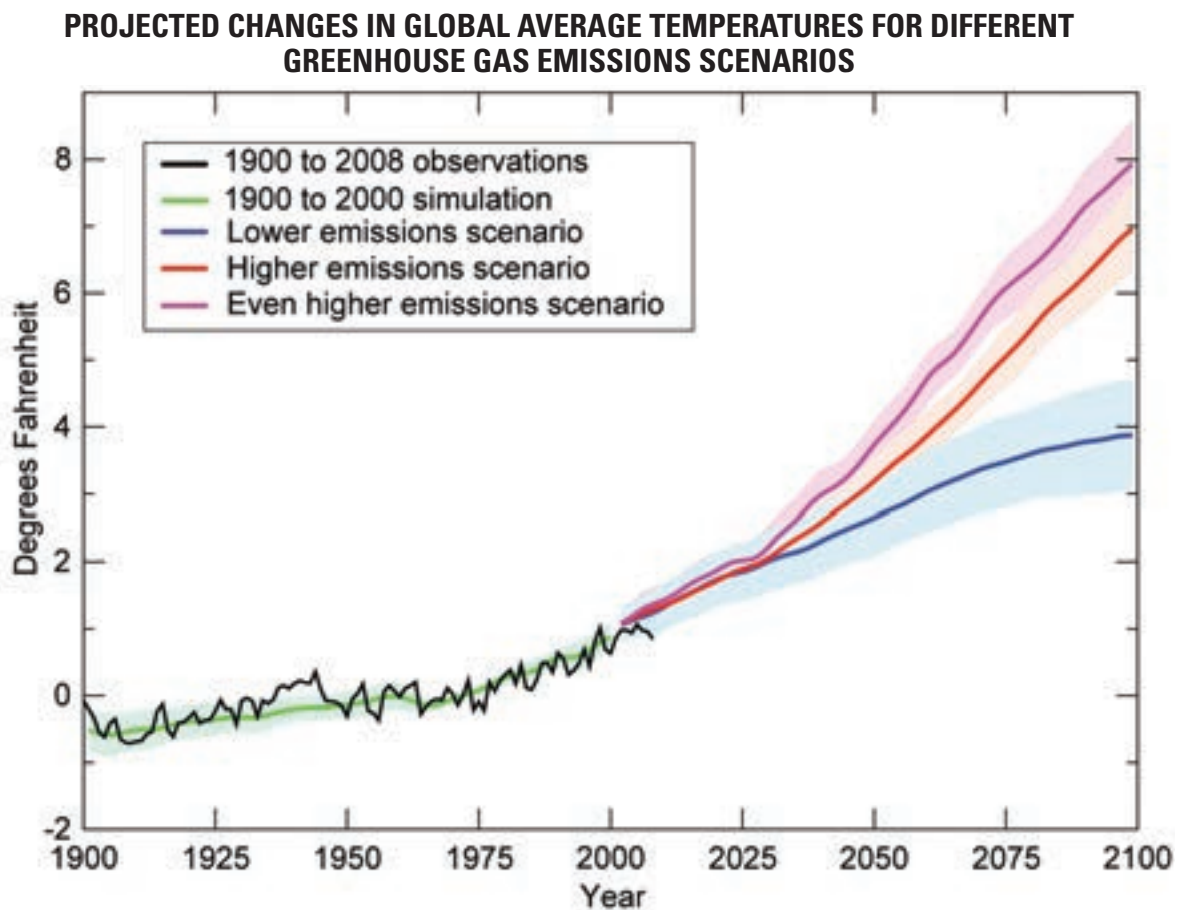


Since the early 20th century, average air temperatures have changed by different amounts in different parts of the United States.¹²

Future Climate Change

Scientists expect the Earth to keep getting warmer in the years ahead. Their projections are based on past and current observations, trends in greenhouse gas emissions, and computer models that show how additional greenhouse gases in the atmosphere will affect average climate conditions in different parts of the world. Climate models project a continued increase in the Earth's average temperature over time. The amount of warming depends on the time period under consideration, and the greenhouse gas emissions scenarios (see box below).

“Because it is difficult to project far-off future emissions and other human factors that influence climate, scientists use a range of emissions scenarios using various assumptions about future economic, social, technological, and environmental conditions.”



Scientists have modeled future temperature changes based on a variety of greenhouse gas emissions scenarios. Each scenario is based on a set of assumptions about population trends, economic development, and technology—all of which affect the amount of greenhouse gases emitted over time.¹⁵ The figure shows the best estimate (solid line) and likely range (shaded area) of how much temperature will have changed at different points in time relative to the 1960–1979 average for emissions scenarios cited in various graphics throughout this publication.^{2,17}

Extreme Heat Events Will Become More Frequent and More Severe

Scientists expect climate change to lead to longer, more severe, and more frequent extreme heat events. Even using different climate models and emissions scenarios, the results generally point to extreme heat events becoming worse in almost every regard.^{2,3}

Duration

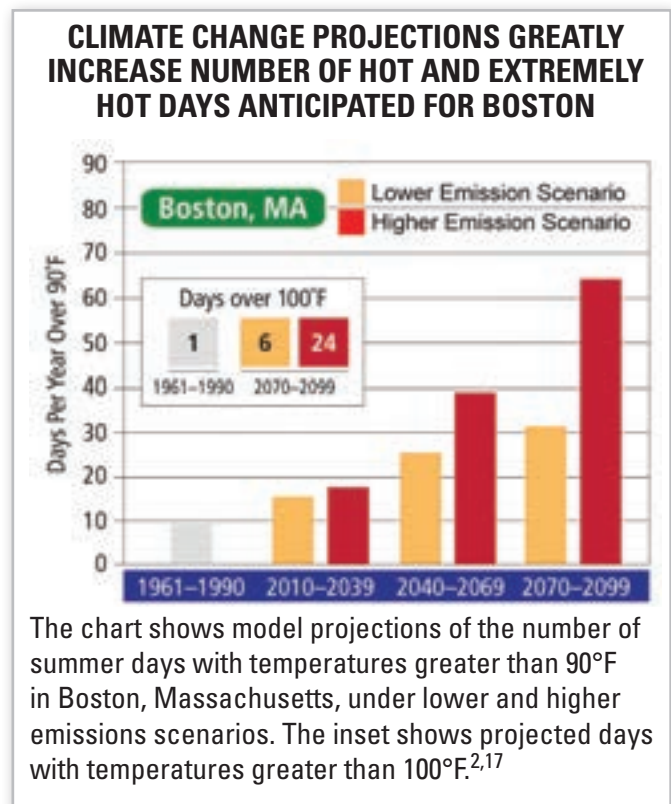
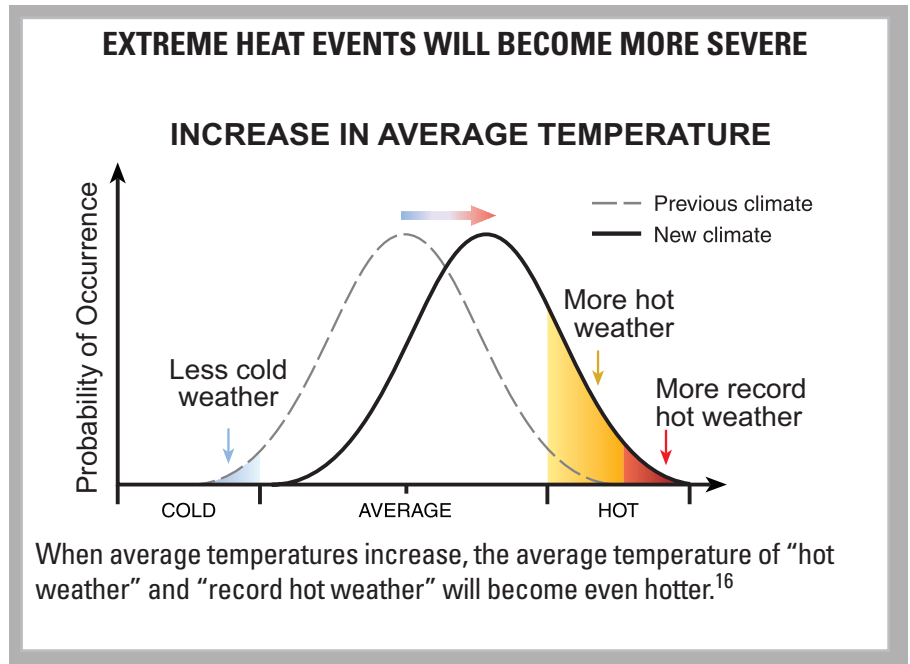
Increases in average temperatures are projected to make extreme heat events last longer. Under an emissions scenario in which average temperatures have risen 6.3°F (IPCC A2 scenario), most Americans could expect to see extreme heat events lasting 10 to 20 days longer than in the past (see page 9 first figure).³

Severity

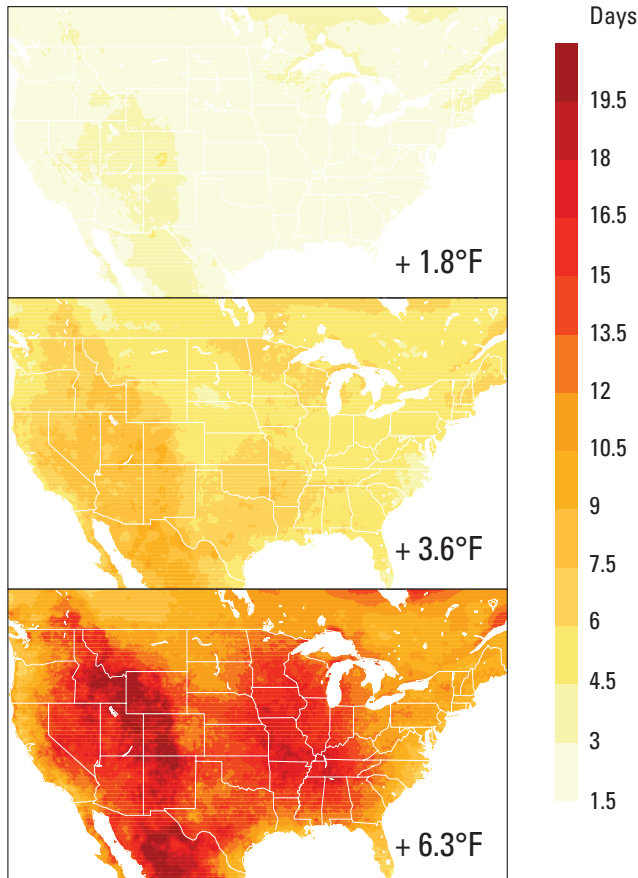
Another effect of higher average temperatures is more severe heat events. The likelihood of more hot weather and more record hot weather increases as average temperatures increase (see upper right figure).¹⁶ The box on the top of page 10 provides examples of how climate is projected to change in the United States. This particular study modeled how summertime temperatures in New Hampshire and Illinois could feel in the future. Under the higher emissions scenario, by the late part of this century, people in New Hampshire would experience a summer climate close to the current norm for North Carolina, while those in Illinois would experience a climate like that currently experienced in Louisiana or Texas.

Frequency

Climate change will also cause extreme heat events to happen more often. Studies show that by the end of this century, the number of days with temperatures reaching 100°F or more is projected to increase dramatically across the United States as a result of climate change. What the public now considers to be an exceptional event could become routine across much of the country (see page 9 second figure).²

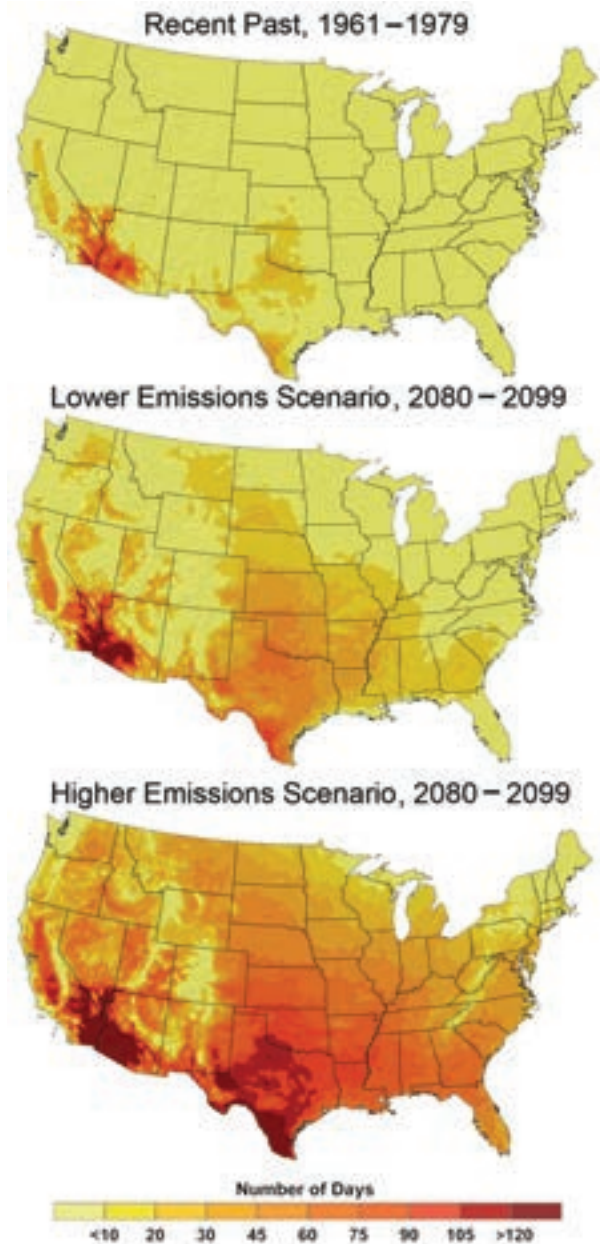


EXTREME HEAT EVENTS WILL LAST LONGER



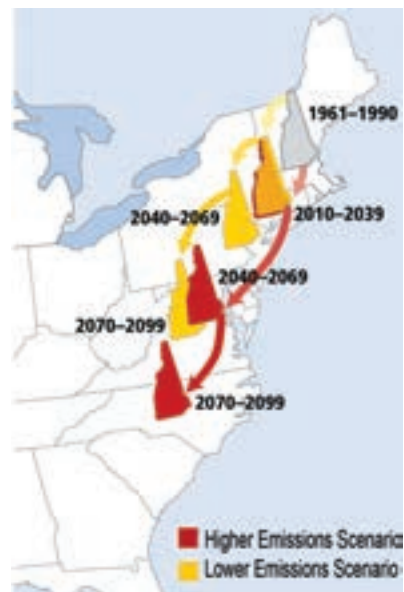
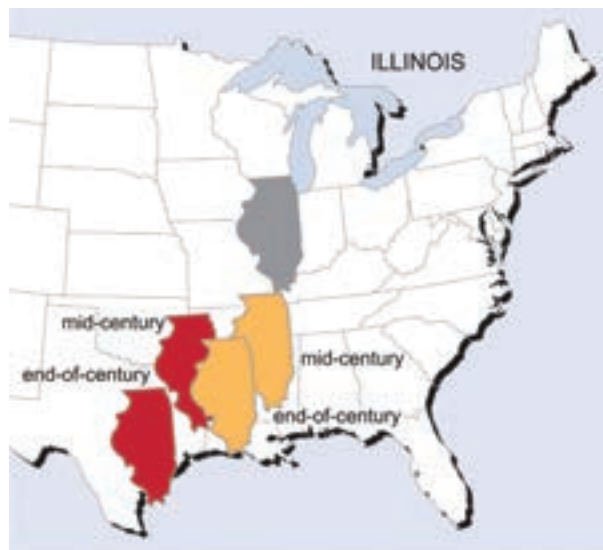
When average temperatures increase, the longest extreme heat events (here, defined as the longest event occurring in a 20-year period) will become even longer than in the past (1961–1979). In the warmest scenario, most of the country would experience an increase in its longest extreme heat event of 10-20 days.³

CLIMATE CHANGE PROJECTED TO INCREASE THE NUMBER OF 100°F DAYS



Whether using a lower or higher emissions scenario, the number and distribution of days per year over 100°F are expected to increase dramatically.^{2,17}

CLIMATE ON THE MOVE: CHANGING SUMMERS IN NEW HAMPSHIRE AND ILLINOIS



Yellow arrows track what summers are projected to feel like under a lower emissions scenario, while red arrows track projections for a higher emissions scenario.^{2,17}

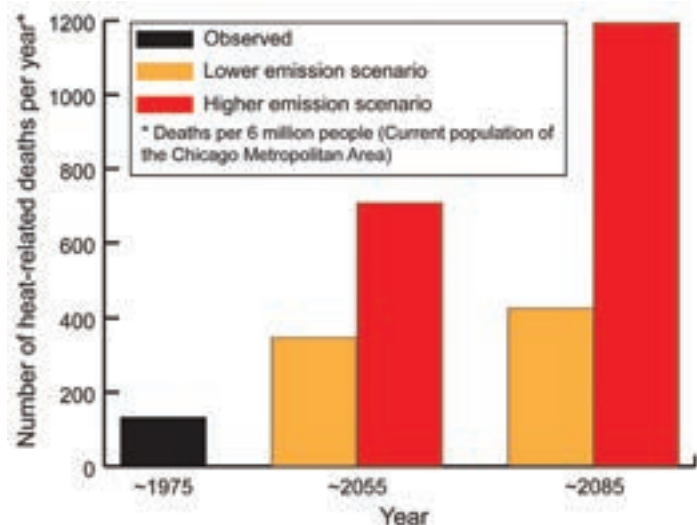
Projected Health Effects of Extreme Heat Events in the Future

As temperatures rise and extreme heat events become longer, more severe, and more frequent, experts expect to see more health problems and deaths caused by heat. Researchers have looked at a variety of scenarios and models, and consistently have reached the same conclusions:

- With climate change, the number of deaths due to extreme heat is expected to keep increasing over time.
- Higher emissions scenarios project a more dramatic rise in heat-related deaths over time.

These projections are not precise. For example, they assume that the death rate associated with a particular level of extreme heat (such as a 100°F day in Chicago) will be similar to the patterns observed in the past. But if the relationship between heat and death rates changes in the future, the expected number of deaths might increase or decrease. For example, people might get more used to extreme heat and communities might plan and prepare for heat more effectively. Changes in demographics could also affect the number of heat related deaths.

PROJECTED INCREASE IN HEAT-RELATED DEATHS IN CHICAGO



Heat-related deaths are projected to increase in Chicago during the 21st century. This graph shows the projected number of deaths per year, averaged over a three-decade period around 1975, 2055, and 2085, under two emissions scenarios. This analysis included some measures to adapt to the increased heat.^{2,17}

Responding to Extreme Heat Events

Extreme Heat Programs: Working to Protect Public Health

Many of the negative health effects attributable to extreme heat events are preventable.^{1,11} Many cities throughout the United States and abroad have successfully developed and deployed extreme heat programs over the past 30 years, protecting public health and saving lives.^{1,11} The most effective programs incorporate a variety of elements, which are found in federal recommendations and can be adapted according to local conditions and needs.^{4,10} Protecting the public from extreme heat events also can be part of a broader process of planning for natural hazards and disaster preparedness. These efforts require engaging many of the same stakeholders, affect many of the same vulnerable populations, and call for similar types of public outreach and education.

ELEMENTS OF AN EFFECTIVE EXTREME HEAT PROGRAM

- A written and publicly approved program plan that identifies program partners and vulnerable populations
- Clear criteria that define extreme heat events and help to evaluate weather forecasts and conditions
- Coordinated outreach to public and partners, with consistent messaging, information, and instructions via public broadcast, websites, email, and social media
- Strategic action plans that include formal check-in and buddy systems and in-person assessments for vulnerable persons
- Strategies and recommendations for staying cool at home and work
- Designated public cooling shelters
- Cancellation policies for outdoor activities and events
- Post-season reviews of program performance by partners
- Public input on ways to improve the program

How Do Extreme Heat Programs Perform?

Ideally, public health officials would evaluate the effectiveness of extreme heat programs and quantify the number of lives saved. In reality, though, it can be difficult to judge a program's performance, as its elements change over time and the number and nature of extreme heat events vary from year to year. As a result, few extreme heat programs in the United States have been studied in depth to determine if they are truly effective. However, the limited number of studies that have taken place have concluded that extreme heat programs save lives.^{3,18}

Developing and implementing extreme heat programs does not have to cost a lot of money.⁴ Given the potential to save many lives for a relatively small cost, communities may benefit from establishing extreme heat programs as an adaptive response to the very real threat that climate change poses.

KANSAS CITY, MISSOURI: 30 YEARS OF EXTREME HEAT PROGRAM EXPERIENCE

Kansas City developed its extreme heat program after a heat event in July, 1980, which caused a number of deaths in the metropolitan area.

Kansas City's program relies on numerous partnerships to help identify people at risk and coordinate services. The Kansas City Health Department is the lead agency for the city's extreme heat program. As such, the Health Department:

- Assists the National Weather Service in determining whether to issue heat-health notifications and notifies other program partners of extreme heat decisions.
- Coordinates extreme heat-related response activities.
- Develops and coordinates extreme heat-related public messaging, media, and communication strategies.
- Collects and summarizes information on the health impacts of extreme heat and interventions undertaken during specific events.
- Suggests improvements to health surveillance systems.

The Kansas City Health Department also coordinates pre-season and end-of-season meetings with partners to review community plans and evaluate performance. At these meetings, the Health Department and its partners can consider recruiting additional partners to help serve difficult-to-reach high-risk segments of the population, such as the elderly, "shut-ins," and the homeless.

Over time, the Health Department's role has shifted from providing assessment and intervention services to its current role of declaring events, coordinating partners, and managing public information and education efforts. This new role keeps the program effective by leveraging partnerships to extend the reach of information and services to the most vulnerable people during heat events.



Conclusion

More Extreme Heat Events Will Increase Need for Public Health Programs

Deaths and illnesses associated with extreme heat events will likely increase as more frequent, longer, and more severe future extreme heat events occur. There is a clear need for enhanced recognition of the public health challenges that future extreme heat events will pose.

Currently, effective programs offer hope that this health challenge can be met. Today, a wide range of creative and resourceful partnerships in locations across the country address the challenges of extreme heat events. As the earth continues to warm, public health officials will need to develop and implement extreme heat programs that are flexible enough to manage under extraordinary conditions that will become increasingly common.

Examples of materials that are available already for interested parties to incorporate in an extreme heat program are provided below.

**SPECIFIC GUIDANCE FOR RESPONDING TO EXTREME HEAT EVENTS
IS COMMON IN MANY EXTREME HEAT PROGRAMS**



**CODE RED
HEAT ALERT**

FACT SHEET FOR CARETAKERS

Extreme heat events are the most dangerous natural hazard in the United States, contributing to an average of 675 deaths per year.

Heat-related death and illness are preventable.

Be aware of the weather. If it seems unseasonably warm outside reduce your exposure to heat and sun, take precautions to stay cool, and help people under your care do the same.

Most at-risk during an extreme heat event include people who are:
living alone; mentally impaired; unable to travel; poor; homeless; elderly; infants; participating in outdoor exercise or work; under the influence of alcohol or drugs; or taking medications for high blood pressure, depression, or failure to sleep.

STAY COOL
Encourage your patients to follow the steps below to reduce the risk of heat-related illness.

- Spend time in air-conditioned buildings and avoid direct exposure to the sun.
- Drink more fluids; don't wait until you're thirsty to drink water.
- Avoid alcohol or liquids containing large amounts of sugar because these cause a loss in body fluid.
- Refrain from physical activity.
- Avoid direct exposure to sun by wearing brimmed hats and applying sunscreen.
- Dress in lightweight, loose-fitting clothing to keep cool.
- When the temperature is above 95°F, electric fans may not prevent heat-related illness.

HELP OTHERS

- During an extreme heat event, reach out and help at-risk people deal with the heat.
- Call 311 to notify 311 Baltimore of people at-risk who may need extra help.

Know the signs of heat-related illness and the right first aid response.

Many cities have developed specific tools to aid in the assessment of potential risk to populations during an extreme heat event or to help with the response to these conditions. Source: Baltimore City Health Department, 2009.

GENERAL GUIDANCE FOR CITIZENS TO REDUCE THEIR RISK FROM EHES

**HEAT
EXHAUSTION**

Heavy sweating
Weakness
Cold, pale, clammy skin
Fast, weak pulse
Nausea or vomiting
Fainting

WATCH FOR THE SIGNS

Seek medical care **immediately** if you have or someone you know has symptoms of heat sickness. Warning signs and symptoms vary but may include:

High body temperature
(104°F or higher rectally)
Hot, red, dry or moist skin
Rapid and strong pulse
Possible unconsciousness

**HEAT
STROKE****IT'S HOT OUTSIDE!**

Extremely hot weather can cause sickness or even death.

STAY COOL. Stay in air-conditioned buildings as much as possible and avoid direct sunlight.

STAY HYDRATED. Drink plenty of water and don't wait until you're thirsty to drink.

STAY INFORMED. Stay updated on local weather forecasts so you can plan activities safely when it's hot outside.

KNOW WHEN IT'S HOT!

Sign up to receive free weather alerts on your phone or e-mails from www.weather.com/mobile

www.cdc.gov/nceh/extremeheat

**IT'S HOT
OUTSIDE!**

STAY COOL.
STAY HYDRATED.
STAY INFORMED.



Centers for Disease
Control and Prevention
National Center for
Environmental Health

Check on the **elderly**, or people aged 65 years or older, to make sure they are safe by staying cool, hydrated, and informed.

People with a chronic medical condition are less likely to sense and respond to changes in temperature. Also, they may be taking medications that can intensify the effects of extreme heat.

During an extreme heat event, check on at-risk friends, family, and neighbors at least twice a day. Encourage them to:

- Check on a friend or neighbor, and have someone do the same for you.
- Avoid using the stove or oven to cook.
- Wear loose, lightweight, light-colored clothing.

FOR MORE INFORMATION

www.cdc.gov/nceh/extremeheat

WHO NEEDS SPECIAL CARE?

The elderly, people with a chronic medical condition, children, homeless or poor, outdoor workers, and athletes are most at-risk to heat sickness.

Most cities offer cooling centers or other air-conditioned shelter to the **homeless or poor** during times of extreme heat.

Never leave **infants** or **children** in a parked car.



Nor should **pets** be left in parked cars—they can suffer heat sickness too.

Athletes and people who exercise in extreme heat are more likely to become dehydrated and are more likely to get heat sickness.

- Limit outdoor activity, especially mid-day when it is the hottest part of the day.
- Schedule workouts and practices earlier or later in the day to avoid mid-day heat.
- Pace activity. Start activities slowly and pick up the pace gradually.
- Drink from two to four cups of water every hour while exercising. Muscle cramping may be an early sign of heat sickness.

STOP
all activity and get to a cool environment if you feel faint or weak.

People who work outdoors are more likely to become dehydrated and are more likely to get heat sickness.

- Drink from two to four cups of water every hour while working. Don't wait until you are thirsty to drink.
- Avoid alcohol or liquids containing large amounts of sugar.
- Wear and reapply sunscreen as indicated on the package.
- Ask if tasks can be scheduled for earlier or later in the day to avoid midday heat.

Public health agencies are increasingly providing information on appropriate extreme heat event responses. Source: CDC, 2011.

Examples of Resources for Further extreme heat events-related Information

Understanding the Health Risks of Extreme Heat Events	
Centers for Disease Control and Prevention: Heat Waves	www.cdc.gov/climateandhealth/effects/heat.htm
National Weather Service: Heat Wave: A Major Summer Killer	weather.gov/os/brochures/heat_wave.shtml
National Weather Service Heat Safety	weather.gov/om/heat/index.shtml
Excessive Heat – NOAA Watch	noaaWATCH.gov/themes/heat.php
The Impact of Climate Change on Extreme Heat Events	
Global Climate Change Impacts in the United States	globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report
U.S. Climate Change Science Program. Final Report, Synthesis and Assessment Product 4.6. Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems	globalchange.gov/publications/reports/scientific-assessments/saps/sap4-6
U.S. Climate Change Science Program. Final Report, Synthesis and Assessment Product 3.3. Weather and Climate Extremes in a Changing Climate	globalchange.gov/publications/reports/scientific-assessments/saps/sap3-3
Climate Change Indicators in the United States	epa.gov/climatechange/indicators.html
Guidance for Developing Extreme Heat Events Programs	
Centers for Disease Control and Prevention: Extreme Heat: A Prevention Guide to Promote Your Personal Health and Safety	emergency.cdc.gov/disasters/extremeheat/heat_guide.asp
Department of Health – United Kingdom: Heatwave Plan for England: Protecting Health and Reducing Harm from Extreme Heat and Heatwaves	dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_114430
Health Canada: Developing Heat Resilient Communities and Individuals in Canada	hc-sc.gc.ca/ewh-semt/climat/adapt/heat-chaieur-eng.php
U.S. Environmental Protection Agency: Extreme Heat Events Guidebook	epa.gov/heatIslD/about/heatguidebook.html
World Health Organization: Heat-Health Action Plans: Guidance	euro.who.int/__data/assets/pdf_file/0006/95919/E91347.pdf
Examples of Local Extreme Heat Program Resources	
Baltimore City Health Department: Code Red Heat Alert Information (homepage)	baltimorehealth.org/coderedinfo.html
City of Boston: Helping the Homeless During Extremely Hot Weather	cityofboston.gov
City of Chicago: Emergency Management and Communications: Weather Extremes – Extreme Temperatures	cityofchicago.org
City of Kansas City, Missouri: Heat Information	kcmo.org/CKCMO/Depts/Health/Heatinformation/
City of Phoenix Salvation Army: Heat Relief Response: The Salvation Army Emergency Disaster Heat Emergency Response	usw.salvationarmy.org
City of San Jose, California: Heat Wave Response	sanjoseca.gov
City of Toronto: Hot Weather Response Plan	toronto.ca/health/heataalerts/beatheat_program.htm
New York City Office of Emergency Management: NYC Hazards: Extreme Heat	nyc.gov/html/oem/html/hazards/heat.shtml
St. Louis, Missouri: Operation Weather Survival	crh.noaa.gov/lx/?n=ows
Washington, D.C: Heat program resources (homepage)	dcema.dc.gov
U.S. EPA: Heat Island Effect	epa.gov/heatislands

References

- 1 CDC. 2009a. Extreme Heat: A Prevention Guide to Promote Your Personal Health and Safety. Centers for Disease Control and Prevention. Available: http://www.emergency.cdc.gov/disasters/extremeheat/heat_guide.asp. Accessed February 3, 2011.
- 2 Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.). 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press, New York.
- 3 National Research Council. 2011. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia*. Washington, DC: National Academies Press.
- 4 U.S. EPA. 2006. *Excessive Heat Events Guidebook*. EPA 430-B-06-005. U.S. Environmental Protection Agency, Washington, DC.
- 5 Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. *PNAS* 101(34):12422–12427.
- 6 NOAA. 2010. Natural Hazard Statistics: Weather Fatalities. National Oceanic and Atmospheric Administration. Available: <http://www.weather.gov/om/hazstats.shtml>. Accessed January 10, 2011 – data adapted for presentation.
- 7 Bassil, K., D.C. Cole, K. Smoyer-Tomic, and M. Callaghan. 2007. What Is the Evidence on Applicability and Effectiveness of Public Health Interventions in Reducing Morbidity and Mortality During Heat Episodes? A Review for the National Collaborating Centre for Environmental Health. April 30. Vancouver, BC. – original figure adapted.
- 8 Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich, and A. Woodward. 2007. Human health. In *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- 9 Basu, R. and J.M. Samet. 2002. Relation between elevated ambient temperature and mortality: A review of the epidemiologic evidence. *Epidemiologic Reviews* 24(2):190–202.
- 10 Matthies, F., G. Bickler, N.C. Marin, and S. Hales (eds.). 2008. *Heat-Health Action Plans: Guidance*. World Health Organization, Copenhagen.
- 11 CDC. 2009b. Heat Waves. Centers for Disease Control and Prevention. Available: <http://www.cdc.gov/climatechange/effects/heat.htm>. Accessed November 11, 2010.
- 12 U.S. EPA. 2010. *Climate Change Indicators in the United States*. EPA 430-R-10-007. U.S. Environmental Protection Agency, Washington, DC.
- 13 IPCC. 2007. *Summary for Policymakers. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.). Cambridge University Press, Cambridge, UK.
- 14 NOAA. 2011. State of the Climate, Global Analysis: Annual 2010. National Oceanic and Atmospheric Administration. Available: <http://www.ncdc.noaa.gov/sotc/global/2010/13>. Accessed March 13, 2011.
- 15 IPCC. 2000. IPCC Special Report, Emissions Scenarios: Summary for Policy Makers. A Special Report of IPCC Working Group III.
- 16 IPCC. 2001. *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, R.T. Watson and the Core Writing Team (eds.). Cambridge University Press, Cambridge, UK.
- 17 The lower emissions scenario = B1; the higher emissions scenario = A2.
- 18 Ebi, K.L., T.J. Teisberg, L.S. Kalkstein, L. Robinson, and R.F. Weiher. 2004. Heat watch/warning systems save lives: Estimated costs and benefits for Philadelphia 1995–98. *Bulletin of the American Meteorological Society* 85(8):1067–1073.

