

BUILDING RESILIENCE AGAINST CLIMATE EFFECTS

ARIZONA
**EXTREME WEATHER,
CLIMATE AND HEALTH**
SYNTHESIS REPORT 2015



PREPARED BY:



INTRODUCTION

Humans have always been affected by Earth's environment. However, our risk of harm from environmental hazards may be increasing, as research shows extreme heat events are likely to intensify and occur more often across the globe. Extreme heat events are already of particular concern because of Arizona's dangerously hot summers. Observed warming trends and the projections summarized in this report suggest that some Arizona counties may see warming of up to 4.5 °F above current temperatures by 2060. These trends could affect air quality and human health. Some models suggest that future rises in temperature may also coincide with increases in droughts, flooding, wildfires, and other severe weather events. Some of the most intense events could disrupt public infrastructure and civil services, including transportation and communication networks, energy grids and water distribution.

This report looks at how future extreme heat events and changes in air pollution might affect the health of Arizona's vulnerable populations and suggests possible ways we can adapt to these changes.

HEALTH IMPACTS OF HIGH TEMPERATURES

As illustrated in the *Conceptual Pathways of Climate and Health* figure on the following page, increased temperatures can lead to a number of human health impacts. A particular challenge facing Arizona is that extreme heat is a health hazard in many parts of the state. Temperatures are high enough in some parts of Arizona to lead to dangerous increases in core body temperatures, even for individuals at rest.

A particular challenge facing Arizona is that extreme heat is a health hazard in many parts of Arizona.

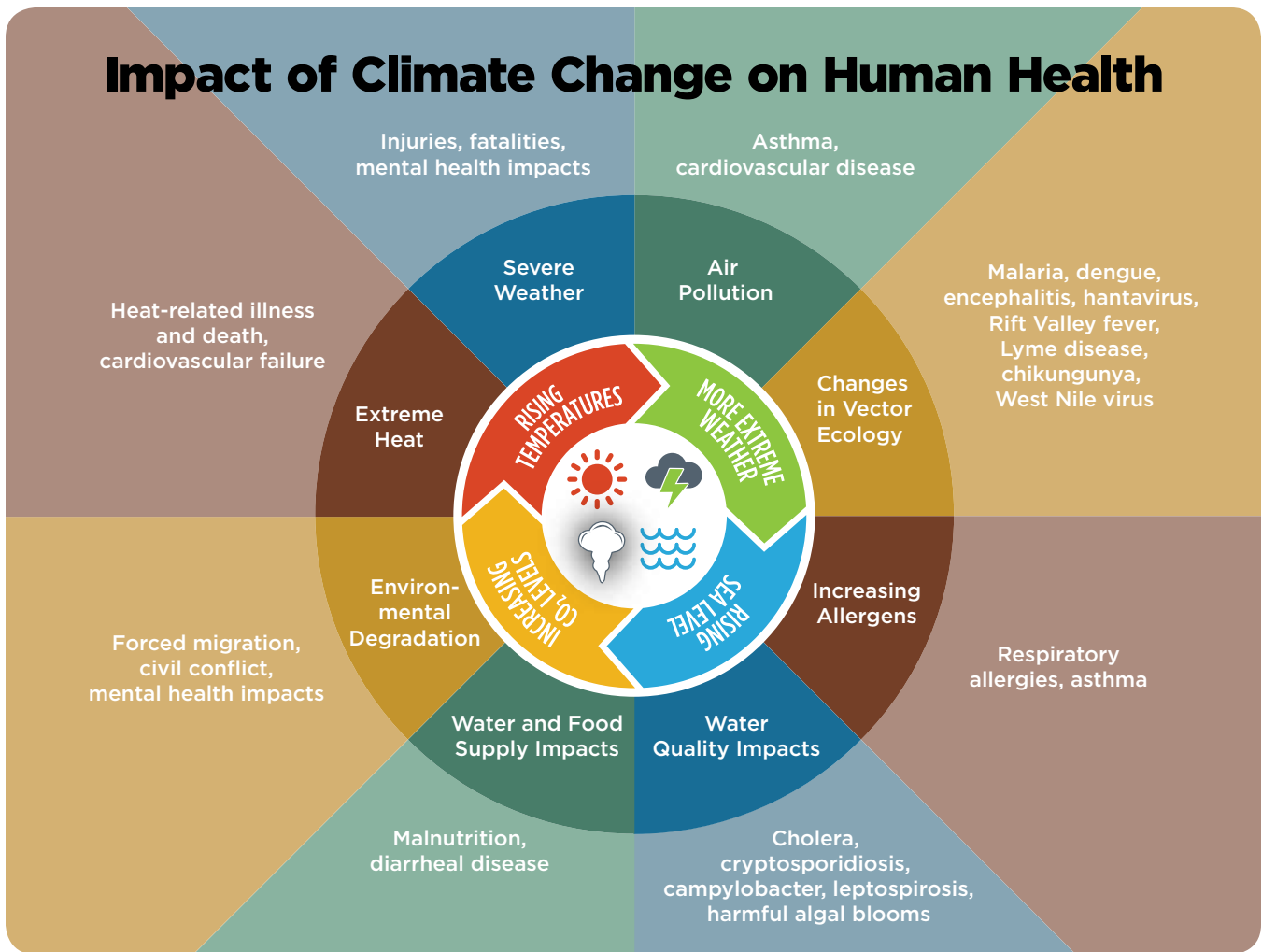
When extreme heat continues for several days and nights in a row, the risk of illness or even death greatly increases. Furthermore, the growth of the Phoenix metropolitan area since 1950 has led to a significant increase in nighttime temperatures due to the urban heat island (UHI) effect. High temperatures may also worsen existing health conditions like heart disease and respiratory illnesses, such as asthma.

Increases in the number of extremely hot days are likely to discourage people from exercising, taking part in outdoor activities, or walking and bicycling for transportation. In turn, this may increase the likelihood of chronic health conditions associated with sedentary lifestyles, like diabetes and cardiovascular disease. Extreme heat will also affect agriculture and water quality, potentially leading to long-term health issues related to food and water intake. Scientists predict that patterns of diseases carried by insects could change because of shifting environmental conditions.

The growth of the Phoenix metropolitan area since 1950 has led to a significant increase in nighttime temperatures due to the urban heat island effect.

Higher pollution concentrations would bring negative health effects as well. Air quality in Arizona has generally improved over the past several decades due to advances in emissions-control technology and implementation of pollution control measures. Despite this improvement, higher temperatures can make certain air pollutants, such as ozone, more difficult to control. Thus, meeting federal standards for air quality may become more difficult as Arizona warms, especially if pollution control measures weaken. More importantly, poor air quality increases the risk of heart disease and lung disorders as well as healthcare costs.

Impact of Climate Change on Human Health



Conceptual Pathways of Climate and Health. Source: CDC Climate Effects on Health - www.cdc.gov/climateandhealth/effects/

Some reports suggest that allergy season is likely to hit earlier and remain longer in the future. This means that susceptible populations in Arizona may experience worse allergy symptoms and diseases, including rhinitis, asthma and eczema, in the coming years.

Researchers across the state are examining what these changes could mean for the health of Arizonans. In spring of 2013, Arizona Department of Health Services (ADHS) held the first Statewide Heat Preparedness meeting, facilitating information exchange between local health departments; decision-makers from local, state and federal agencies; and representatives from nonprofit organizations and universities regarding the surveillance, prevention and treatment of heat-related illnesses.

Air quality in Arizona has generally improved over the past several decades due to advances in emissions-control technology and implementation of pollution control measures.

BUILDING RESILIENCE

To address potential impacts of changing environmental conditions, ADHS retained an interdisciplinary team at Arizona State University (ASU) in 2014 to look at this issue. The goal of the collaboration was to figure out what the worst impacts of rising temperatures, increasing

emissions and more extreme weather events might be, who would suffer the most, and what evidence-based strategies and interventions can be enacted to lessen those impacts.

In spring of 2013, Arizona Department of Health Services held the first Statewide Heat Preparedness meeting, facilitating information exchange between local health departments; decision-makers from local, state and federal agencies; and representatives from nonprofit organizations and universities regarding the surveillance, prevention and treatment of heat-related illnesses.

This ongoing work is funded by the U.S. Centers for Disease Control and Prevention’s (CDC’s) Climate-Ready States and Cities Initiative. The CDC has developed a framework—Building Resilience Against Climate Effects (BRACE)—which is intended to provide public health officials with an evidence-based method to address and reduce climate-related public health effects in their state’s most vulnerable communities. It is being used in 15 other states and two cities across the U.S.

The BRACE framework involves five steps:

Step 1 uses models to make local projections about climate and link them to health problems, with a focus on the climate-related health hazards of extreme heat and air pollution.

Step 2 calculates health impacts in terms of financial costs, number of deaths and illnesses.

Step 3 evaluates different public health interventions that may help avoid the most important threats. Understanding how rates of illness and disease will change is also included.

Factors that contribute to vulnerability

Exposure	Contact with hazards such as heat waves, extreme precipitation (rain, hail, snow), drought, or disease vectors (e.g. mosquitos)
Sensitivity	Population characteristics such as age (infants, elderly), race, ethnicity, poverty, access to health care, or access to transportation or air conditioning
Adaptive Capacity	Ability of members of the population to change their behavior to prepare for the impacts of future extreme events

Step 4 uses the information gathered in previous steps to develop and implement an adaptation plan to reduce the worst of the anticipated negative effects.

Step 5 assesses the performance of the plan. The process begins again with a return to Step 1 to address new projections and additional information.

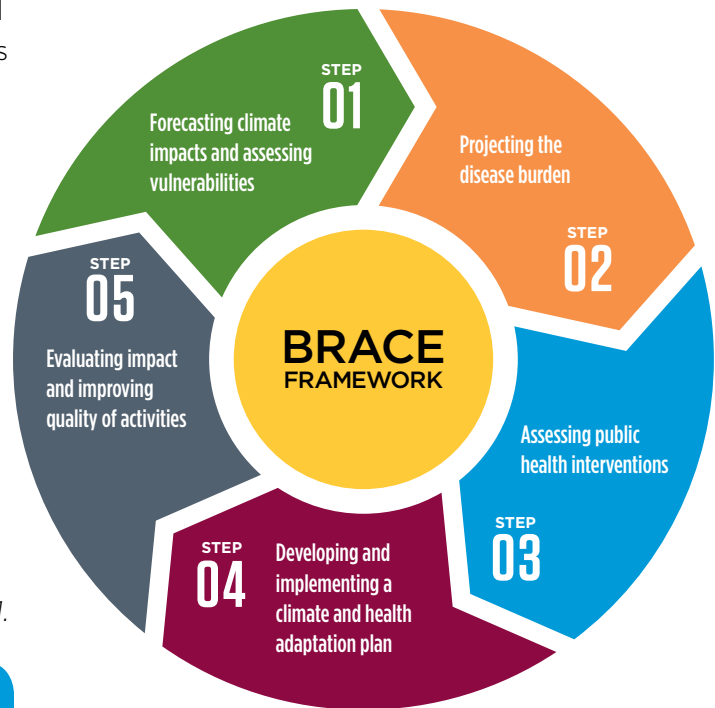
Arizona’s BRACE project is a work in progress. Steps 1 and 2 are due to be completed in summer 2015. Step 3 is expected to wrap up by fall 2015. Steps 4 and 5 are scheduled to conclude in fall 2016.

A key goal of the BRACE framework is to understand which populations are most vulnerable to the future impacts of climate hazards. The Third National Climate Assessment, released by the U.S. Global Change Research Program (USGCRP) in 2014, describes three factors that affect vulnerability: physical exposure to hazards, the sensitivity of the local population and its ability to adapt to the changes, as depicted in the Table above.

PROJECTIONS FOR ARIZONA: 2030, 2060 AND 2090

To understand physical exposure to climate hazards, the ASU-ADHS team implemented Step 1 of the CDC’s BRACE framework using a downscaled climate projection model to transform global climate simulations into projections that are more appropriate for planning and decision-making in Arizona.

Consistent with the most recent science, embodied in the Intergovernmental Panel on Climate Change’s (IPCC’s) Fifth Assessment Report, the team evaluated future Arizona climate scenarios based on four greenhouse gas (GHG) representative concentration pathways (RCPs): RCP 2.6, RCP 4.5, RCP 6 and RCP 8.5. The RCPs span high- to low-emissions scenarios. July average temperature by year and RCPs are shown in the the Table on the following page. July is usually the warmest month of the year, and thus is the month that usually has the highest risk for heat-related illness. Over time, the team will explore projections from more models to develop a more complete perspective of Arizona’s future climate. *For a detailed explanation of RCPs please see Appendix 1.*



The largest temperature changes are likely to occur in Arizona’s more rural areas.

The July average daily maximum temperatures projection table on the next page shows that the largest temperature changes are likely to occur in Arizona’s more rural areas. In the medium and high RCP scenarios, the greatest temperature increases are projected in northeastern and northern Arizona, including Mohave, Coconino, Navajo and Apache counties. The largest temperature increases in 2030 are projected to happen in Mohave County under RCP 2.6, with a 4.6 °F increase from 2010 temperatures. Navajo and Apache Counties could experience July 2060 temperature increases as high as 3.6 °F to 3.8 °F compared to 2010 temperatures. For the RCP 6.0 scenario, temperature increases by 2090 could be very high in rural areas with Navajo County in the northeast 9.5 °F warmer, and Greenlee and Graham counties in the southeast 9.5 °F and 9.0 °F warmer, respectively. *For maps illustrating July maximum temperature projections across Arizona in 2010, 2030 and 2060 under RCP 6.0 scenario, please see Appendix 2.*

The five-step BRACE framework.
Source: Adapted from Marinucci et al. (2014).

ASSESSING WHO MAY BE AT RISK

Understanding who the people are who have previously been at risk of adverse effects of extreme weather is useful for projecting potential future health burdens and effectively identifying where to target public health resources. Projected temperature increases and longer heat waves will affect public health, increasing the risk of heat-related illnesses and deaths. Populations at particular risk of heat-related illness and death include low-income people, minorities, those engaged in outdoor work or recreation, the elderly and those without access to air conditioning. Neighborhoods with higher heat exposure tend to have fewer ways of coping with heat (e.g., shade trees, air conditioning, networks of social support). Populations at risk of heat-related illness and death of air pollution-related illnesses include children, the elderly, those in poverty, those without a high school diploma, workers with occupational exposures, and those living near heavily-traveled roadways. *For figures illustrating statewide air quality status for Arizona, please see Appendix 3.*

Table shows projections of July average daily maximum temperatures from four climate scenarios for 2010, 2030, 2060 and 2090 (in °F).

	RCP 2.6				RCP 4.5				RCP 6.0				RCP 8.5			
	2010	2030	2060	2090	2010	2030	2060	2090	2010	2030	2060	2090	2010	2030	2060	2090
Apache	88.5	91.6	90.1	89.8	89.1	91.0	89.2	91.8	87.3	91.0	90.9	97.2	90.5	92.8	93.2	95.4
Cochise	93.2	96.4	94.5	94.5	93.2	95.2	93.9	96.8	93.0	94.8	94.8	101.8	95.0	96.8	97.2	99.7
Coconino	90.0	94.1	93.4	92.8	91.4	92.8	91.9	94.8	89.6	92.8	93.0	98.2	92.3	94.1	95.4	97.7
Gila	94.3	97.9	96.3	96.3	94.8	96.8	95.2	98.6	93.9	96.6	96.6	102.60	96.4	97.9	98.6	101.1
Graham	94.5	97.9	95.9	95.9	95.0	96.8	95.2	98.2	94.3	96.6	96.3	103.3	96.40	98.2	98.8	101.3
Greenlee	90.7	94.1	91.9	91.8	91.0	93.0	91.6	94.1	90.5	93.0	92.5	99.9	92.7	94.6	95.2	97.3
La Paz	105.3	109.2	108.7	109.4	106.3	108.3	108.0	110.7	107.2	108.7	108.9	113.5	107.8	108.5	110.3	113.9
Maricopa	104.4	108.5	107.4	108.0	105.4	107.2	106.5	109.8	105.8	107.6	107.4	112.6	106.9	107.4	109.0	112.6
Mohave	97.9	102.6	101.8	101.7	99.7	100.9	100.8	103.5	98.4	101.3	101.7	106.3	100.6	101.8	103.6	106.5
Navajo	90.7	94.3	93.0	92.5	91.6	93.4	91.6	94.6	89.6	93.2	93.4	99.1	92.8	94.8	95.5	97.7
Pima	99.5	103.5	101.8	102.6	100.2	102.2	100.9	104.7	100.4	102.0	101.8	107.8	101.7	102.4	103.8	107.4
Pinal	102.2	106.0	104.4	104.7	102.9	104.7	103.5	106.9	102.7	104.7	104.5	110.5	104.5	105.4	106.5	109.8
Santa Cruz	92.1	95.4	93.4	93.9	92.3	94.1	93.4	96.3	91.9	93.4	93.7	100.0	93.9	95.0	95.9	99.0
Yavapai	94.3	98.4	97.5	97.5	95.5	97.2	96.4	99.7	95.0	97.5	97.2	102.6	96.8	97.9	99.1	102.2
Yuma	104.7	108.7	108.0	108.9	105.4	108.0	107.4	110.1	106.9	108.3	108.3	112.5	106.7	107.4	109.4	113.4

INFORMING ARIZONANS ABOUT THE FUTURE

Better understanding of the expected health issues from projected extreme weather hazards and the populations most at risk from them is vitally important. It enables public health agencies, government officials, city planners and decision-makers to effectively target adaptation efforts where they are needed most and where they are likely to have the greatest effect. It is also important for the public to understand and anticipate changes. The goal of Arizona’s BRACE project is to build public health knowledge related to weather hazards and to inform interventions and policies aimed at reducing the risks of these hazards.

Populations at particular risk include low-income people, minorities, children, those engaged in outdoor work or recreation, the elderly, those without access to air conditioning and those living near heavily-traveled roadways.

For more information about this on-going work, click on the links below.

LINKS TO BRACE REPORT AND EXECUTIVE SUMMARY

[Arizona Extreme Weather Climate and Health Profile Report 2015 - Full Report](#)

[Arizona Extreme Weather Climate and Health Profile Report 2015 - Executive Summary](#)

APPENDIX 1: FINDINGS FROM ANALYSIS OF RCP SCENARIOS

The findings of the RCP scenarios can be summarized as follows:

RCP 2.6 scenario (assumes very low GHG concentration levels)*

Warming may be most severe in Mohave and west Pima County between 2010 and 2030. In 2060, large temperature increases are projected in Mohave and La Paz; however, the areas with average July maximum temperatures above 107.8 °F shrink in Maricopa, Pinal, Coconino and Navajo counties. Overall, the temperatures in July 2060 under RCP 2.6 are lower than the temperatures in 2030, a finding in need of further investigation.

.....

RCP 4.5 scenario (assumes low to medium GHG concentration levels)*

Between 2010 and 2030, modeled temperature increases range from 0.3 °F to 4.6 °F. The largest temperature increases were projected in Yuma, West Pima, La Paz, Maricopa, South Navajo, Apache, Greenlee and Cochise counties. For the temperature patterns in July 2060, the data show that the range of temperature increase and the average temperature are milder than in 2030 (similar to the RCP 2.6 patterns). The largest temperature increase range in July 2060 is 2.5 °F, with warming projected in Yuma, La Paz, Maricopa, Santa Cruz, South Mohave and West Pima counties.

.....

RCP 6.0 scenario (assumes medium to high GHG concentration levels)*

Between 2010 and 2030, the modeled temperature increases range from 0.7 °F to 4.8 °F. The temperature increase between 2010 and 2060 peaks at 4.9 °F, and the areas with the largest increase are Mohave, Coconino, Navajo and Apache. Although the greatest temperature increases were projected in northeastern Arizona counties, the hottest counties are Maricopa, Yuma, La Paz and Pinal. Their maximum July 2060 temperatures range from 105 °F to 109 °F.

.....

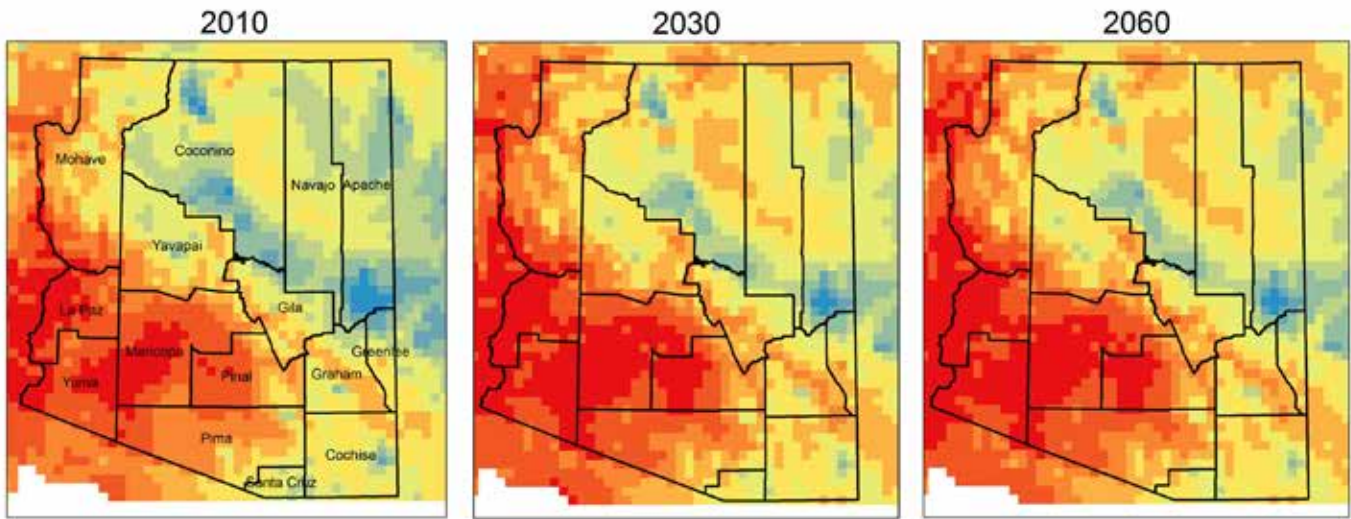
RCP 8.5 scenario (assumes high GHG concentration levels)*

Under this scenario, the maximum modeled temperature increases are 3.3 °F in 2030 and 4.4 °F, compared with the 2010 baseline temperature under the same scenario. The range of temperature increase under this scenario is less than the projected increase in RCP 4.5 and RCP 6.0 for 2030. However, the statewide July average maximum temperature could reach as high as 114.4 °F in 2060, with significant temperature increases in northern Arizona and Yuma County. Areas with the highest temperatures (above 107 °F) cluster in La Paz, Yuma, Maricopa and Pinal counties.

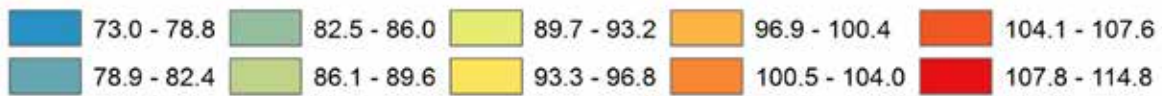
* RCP scenarios assume GHG levels given a combination of climate policies, economic development, and radiative forcing before and after 2100.

APPENDIX 2: JULY MAXIMUM TEMPERATURE PROJECTIONS

The maps below illustrate projected differences in maximum temperatures across Arizona in July 2010, 2030 and 2060 under RCP 6.0.

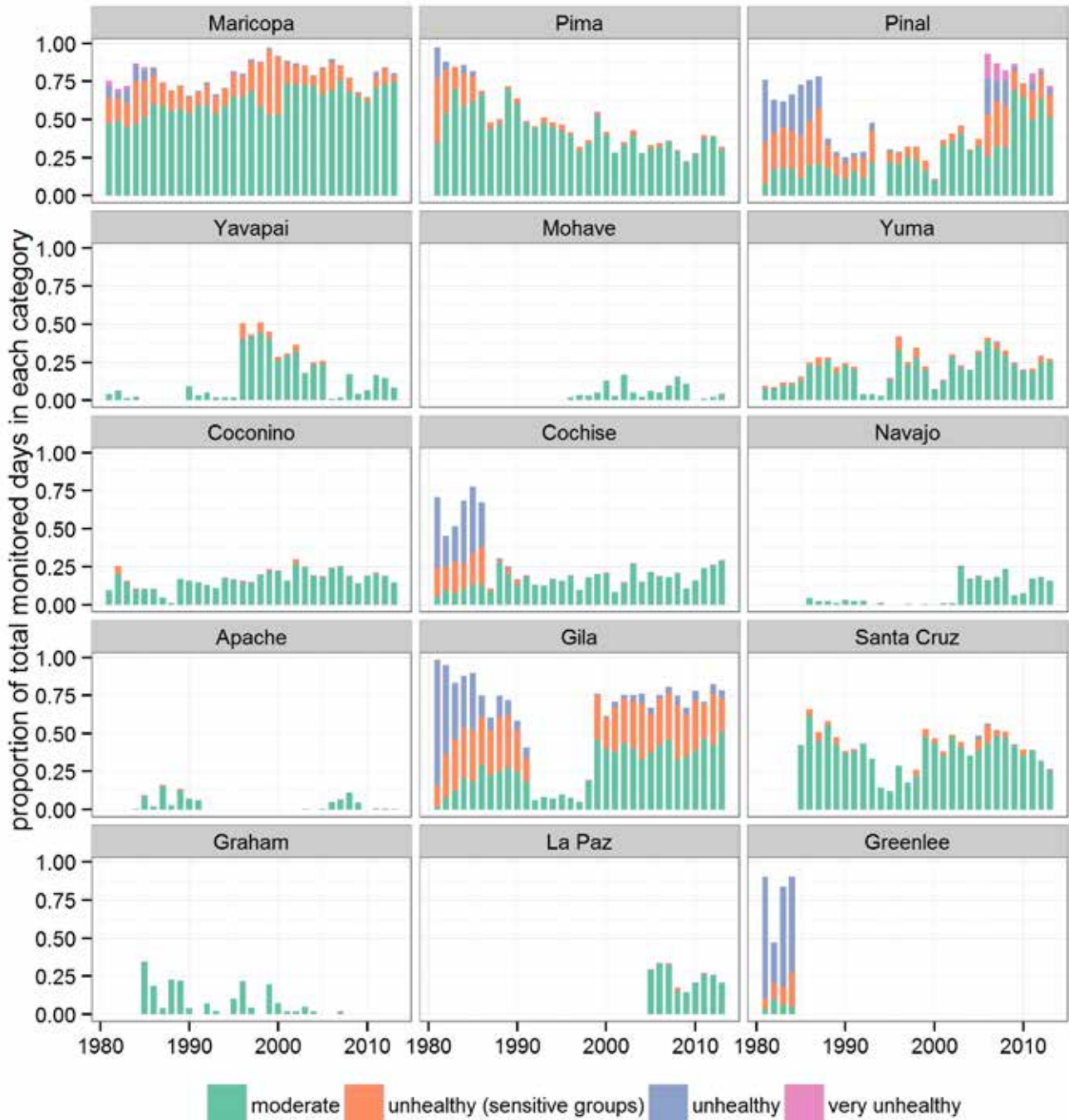


Projections of July Tmax under RCP 6.0 Scenario (°F)



APPENDIX 3: STATEWIDE AIR QUALITY

Some Arizona counties continue to have difficulties meeting federal air quality standards variously due to industrial activity, rising vehicle travel, and a challenging combination of weather patterns and physical geography. The figure below shows the number of days falling into each air quality index category, as defined by the U.S. Environmental Protection Agency. The unhealthy and very unhealthy categories generally represent days where federal standards were not met. Meeting standards for certain pollutants may become more difficult in the future because air pollution chemistry changes when temperatures increase.



AUTHORS

Arizona State University (ASU)

Nalini Chhetri, PhD - Consortium for Science Policy and Outcomes and the Julie Ann Wrigley Global Institute of Sustainability

Wen-Ching Chuang, PhD - School of Sustainability

David M. Hondula, PhD - Center for Policy Informatics and the School of Geographical Sciences and Urban Planning

Alex Karner, PhD - Julie Ann Wrigley Global Institute of Sustainability and the Walton Sustainability Solutions Initiatives

Ariane Middel, PhD - School of Geographical Sciences and Urban Planning and the Julie Ann Wrigley Global Institute of Sustainability

Nancy Selover, PhD - Arizona State Climatologist in the School of Geographical Sciences and Urban Planning

Arizona Department of Health Services (ADHS)

Brigitte Dufour, BScA, Principal Investigator, Extreme Weather and Public Health Program

Matthew Roach, MPH, Program Manager, Extreme Weather and Public Health Program

Suggested Citation: Chuang, W-C., A. Karner, N. Selover, D. Hondula, N. Chhetri, A. Middel, M. Roach and B. Dufour. 2015. *Arizona Extreme Weather, Climate and Health Synthesis Report*. A report prepared for Arizona Department of Health Services and the United States Centers for Disease Control and Prevention Climate-Ready States and Cities Initiative.

ACKNOWLEDGMENTS

The authors would like to recognize the ASU scholars and ADHS staff who reviewed this document and whose work informed the outcomes of this project.

Special thanks to:

James Anderson, PhD - School for Engineering of Matter, Transport & Energy

Anthony Brazel, PhD - School of Geographical Sciences and Urban Planning

Matei Georgescu, PhD - School of Geographical Sciences and Urban Planning

Sharon Harlan, PhD - School of Human Evolution & Social Change

Huei-Ping Huang, PhD - School for Engineering of Matter, Transport & Energy

Peter Hyde, School for Engineering of Matter, Transport & Energy

Lauren Vorisek, MPH, Office of Environmental Health

The project team would also like to thank Michele Roy for her editing contributions as well as the Julie Ann Wrigley Global Institute of Sustainability's Communications and Marketing team for their design contributions.

We wish to acknowledge the World Climate Research Programme's Working Group on Coupled Modeling, which is responsible for Coupled Model Intercomparison Project (CMIP), and thank the climate modeling groups for producing and making available their model output. For CMIP, the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals.

Additionally, the authors appreciate the generous support of the Julie Ann Wrigley Global Institute of Sustainability and the Rob and Melani Walton Sustainability Solutions Initiatives in providing the space and in-kind contributions needed to accomplish this project.

This publication was supported by Cooperative Agreement Number 5UE1EH001119-02, funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention of the U.S. Department of Health and Human Services.

Prepared for: Arizona Department of Health Services | Agreement Number: ADHS15-077418