

North Carolina Climate and Health Profile



Building Resilience Against Climate Effects

North Carolina Climate Ready Program



State of North Carolina
Department of Health and Human Services
Division of Public Health

www.ncdhhs.gov • www.publichealth.nc.gov

N.C. DHHS is an equal opportunity employer and provider 3/15.

Table of Contents

Executive Summary	1
I. Introduction	1
(i) Rationale	1
(ii) History of Engagement with Climate and Health	1
(iii) Describe Geographic Scope.....	2
II. Problem Assessment and Hazard Classification	2
(i) Baseline climate description	2
(ii) Source of Climate Projections	3
(iii) Summary of Climate Projections	3
III. Problem Assessment – Risk Characterization	4
<i>Water Quality and Quantity</i>	4
<i>Vector-borne Disease and Pest Management</i>	5
<i>Respiratory Health</i>	5
<i>Injuries</i>	6
<i>Infrastructure, Electricity, Critical Facilities, Adequate Shelter</i>	7
<i>Mental Health</i>	7
<i>Ultraviolet Radiation (UV)</i>	7
<i>Cardiovascular Disease and Stroke</i>	7
IV. Problem Assessment – Vulnerability and Health/Hazard Assessment	7
<i>North Carolina Climate-Health Scorecard</i>	9
V. Collaborations	11
<i>Photo Credits</i>	12
Bibliography	13

Executive Summary

I. Introduction

(i) Rationale

North Carolina is one of 16 states who have been funded by CDC's Building Resilience Against Climate Effects grant (Table 1) since 2010. As part of the Building Resilience Against Climate Effects framework, this first Climate and Health Profile Report, builds on the Strategic Plan for Addressing Health Impacts of Climate Change in North Carolina ([North Carolina Strategic Plan](#)), describes the leading climate-related risks and their associated public health impacts in the state. This report will seek to inform which health impacts are the focus of vulnerability assessments and health burden projections by highlighting the most pressing risks and impacts.

Table 1. North Carolina Building Resilience Against Climate Effects objectives:

- Conduct vulnerability assessments that identify community and geographic areas at greatest risk from risk factors and health outcomes
- Describe the disease burden of health impacts and risks factors associated with future climate change in North Carolina.
- Determine effective and suitable public health interventions for climate-related risks
- Develop and implement the North Carolina Climate and Health Adaptation plan
- Evaluate impact and quality of activities to improve grant performance

(ii) History of engagement with Climate and Health

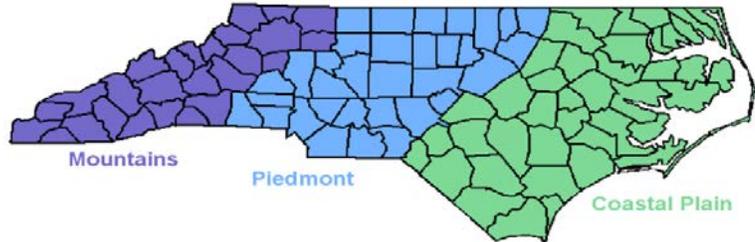
The North Carolina Department of Health and Human Services has been involved in multiple health assessments and interventions to address adverse weather and climate impacts on public health. For example, the Division of Aging and Adult Services has led efforts to deal with extreme heat through Operation Fan Heat Relief since 1986, distributing fans and air conditioning units to adults with disabilities and those over the age of 60 during the summer months¹. The Division of Mental Health has coordinated response to weather disasters that impact mental health². The Division of Public Health has conducted health assessments and interventions in respect to adverse climate impacts on public health. From 2006 to 2010, the Injury Prevention and Violence Control Branch conducted surveillance of heat-related injuries, focusing on major events and then later conducting syndromic surveillance of heat-related emergency department visits³. Since 2002, the Public Health Preparedness and Response Branch has established emergency plans in local districts, developed regional capacity for response to extreme-weather events, and coordinated the state's public health response to weather and climate-related disasters⁴.

Since 2010, the Occupational and Environmental Epidemiology Branch (OEEB) has managed the Building Resilience Against Climate Effects cooperative agreement. During this period, branch staff have conducted health assessments on how weather and climate in North Carolina impact cancer, developmental disease, waterborne disease, air quality and respiratory disease, vector-borne and zoonotic disease, heat-related illness, extreme weather-related injuries, mental health, cardiovascular disease and stroke⁵. Since 2011, branch staff have also conducted and reported weekly heat-related illness syndromic surveillance during the summer months³. In August 2011, the Occupational and Environmental Epidemiology Branch co-hosted a workshop with more than 70 health and climate professionals from across the state to discuss the state of the science related to climate and health in North Carolina⁶. Based on the outcomes of this workshop and work with seven other state agencies, staff developed a health chapter in the state's overall adaptation plan⁷. More recently, staff produced a strategic plan to address

climate and health in North Carolina using health assessments and a group of thirty experts on climate and health⁵. The Occupational and Environmental Epidemiology Branch staff also contributed to the 2011 Environmental Protection Agency Meeting on Climate and Older Adults, as well as the 2014 National Weather Service and the Centers for Disease Control and Prevention Heat-Health Summit.

(iii) Describe the geographic scope of the assessment

The geographic area for assessment is the state of North Carolina. At times, the geographic area may be subdivided into smaller areas, by region (mountains, piedmont, or coastal) or county. Subdivision into region has been done to distinguish the distinct weather experienced by these regions. Subdivision by county is to assist local health departments and other local officials in distinguishing results specific to their work.



*Image courtesy of Corey Davis, State Climate Office of North Carolina

II. Problem Assessment and Hazard Characterization Climate projections

(i) Baseline climate description (1981-2010)

The majority of North Carolina experiences a climate similar to the Southeastern United States, with mild winters, hot and humid summers, generally abundant precipitation, and the annual threat of hurricanes. The average winter brings a threat of snow or ice for most of the state, with a large amount of snow falling along the Appalachian Mountains in Western North Carolina. The highest point in the Eastern United States is within the North Carolina Appalachian Mountains, and the mountain region experiences colder winters and milder summers than the rest of the state^{8,9}.

The Bermuda High pressure system plays a significant role in dictating the day to day weather in our state. The daily weather is distinguished from the baseline climate in terms of time period. While weather is daily, weekly, or even a few years, the climate is a period of decades of weather data. From 1981-2010, the average annual temperature for North Carolina ranged from 51-55°F in the mountain region to 61-65°F along the southeastern part of the state.

The average daily January minimum temperature in North Carolina from 1981-2010 ranges from 18°F (Western North Carolina) to 36°F (Outer Banks on the Coast). The average daily July maximum temperature in North Carolina over the same time period has ranged from 74°F (Western North Carolina) to 90°F (Southeastern North Carolina). The mountains experienced an average of seven or fewer days annually above 95°F while the Southeastern region experienced an average of more than 20 days annually above 95°F^{8,9}.

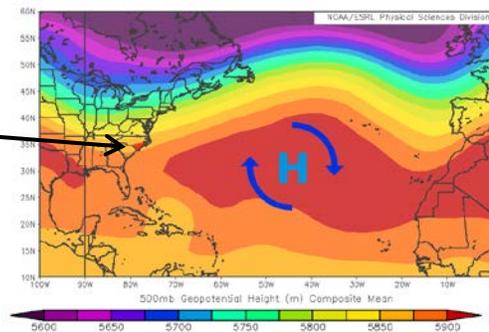


Image courtesy of Corey Davis, State Climate Office of North Carolina

State records of weather in North Carolina began in the late 1800s. Summer 2010 was the warmest on record across the state. The mean summer temperature for 2010 in North Carolina was more than 2°F higher than the previous record set in summer 2007. During the summer of 2010, Raleigh-Durham set a record for the most days of 90°F or above. In 2011, Raleigh-Durham set a record for the most consecutive days of 100°F or higher temperatures⁷.

During the 1961-2010 timeframe, annual precipitation has ranged from 100" in the southwestern part of the state in Transylvania County, a county known for the greatest concentration of waterfalls in the Eastern United States to 36" in Central North Carolina. Annual precipitation is generally distributed evenly over all regions of the state throughout the year. However, in recent years observations have shown an increase in precipitation variability. Droughts occur occasionally, lasting from one to several years. During the time period of 1998-2002, a 50-year drought brought record low water levels across the state. Sea levels have gradually increased over the North Carolina coast line. In addition, North Carolina has seen multiple billion dollar weather disasters, largely from hurricanes. Hurricanes have the highest return frequency on the Outer Banks of North Carolina, occurring every 2 years^{8,9}.

(ii) Source of climate projections used – description and rationale for use

Climate models are used to project future climate scenarios and inform public health planning. The Coupled Model Intercomparison Project phase 3 (CMIP3) model data set, the Downscaled CMIP3 (Daily_CMIP3), and the North American Regional Climate Change Assessment Program (NARCCAP) model data set were used to project future climate for North Carolina, as they were also used for the U.S. National Climate Assessment, a federally mandated climate assessment that is conducted every five years. The time periods used were 2021-2050 and 2041-2070⁹. As most public health planning occurs in the upcoming 3-5 years, using the closest time period (2021-2050) was practical.

(iii) Summary of climate projections – spatial and temporal

Model projections can be used to examine future conditions in North Carolina. The multi-model simulated mean projections project:

- An increase in average annual temperature of 1.5 to 3.5°F for the 2021-2050 time period as compared to the long-term average from 1971-2000.
- In comparison to the 1971-2000 reference, an annual increase of 15-20 days when maximum temperature exceeds 95°F in North Carolina during 2041-2070.
- An annual increase in the number of consecutive days with a maximum temperature above 95° in North Carolina during 2041-2070 to 4-12 days.
- A decrease in the number of days with low minimum temperatures annually during 2041-2070 as compared with 1971-2000.
- Models for 2021-2050 show an increase in annual precipitation for much of North Carolina and an increase in the annual number of days with precipitation greater than one inch. However, the models of future precipitation are very uncertain, and the models do not agree on the sign or magnitude of changes in precipitation. When the CMIP3 ensembles are averaged together, they estimate an increase in annual precipitation and an increase in the number of days with intense precipitation. But, the models individually are quite diverse⁹.

Changes in precipitation have numerous impacts on agriculture and ecology, extending also to public health and the economy. Droughts impact water levels (e.g. streams, lakes), crops and pastures (e.g., food, fiber crops, and livestock), reservoirs, and natural systems (e.g. aquatic and terrestrial ecosystems). For instance, drought can make a forest more prone to wildfire and pests. In addition, tidal wetlands (an important component in fishery health) in northern North Carolina are particularly dependent on inputs of fresh water from inland rivers and streams. Increased intense precipitation and flooding events also impact the state's ecology. Storm water runoff increases the nutrient load in streams, rivers, and reservoirs, negatively impacting aquatic creatures and potentially affecting drinking water. Rainfall intensity directly affects the physical, chemical, and biological features of streams. Intense precipitation also impacts agriculture. One of the largest drivers of agriculture in the state is pork production, which is largely dependent on lagoons for waste management. Rainfall can lead to inundation and flooding of these lagoons.

An increase in temperature and number of hot days also affects agriculture. Warmer nights give people and ecosystems less time to recover from hot days. Agriculture is dependent on outdoor workers and outdoor conditions for animals. Extreme heat can threaten the well-being of both workers and animals. Finally, temperature and precipitation affect the growing season and what plants are optimal for North Carolina's ecology. From 1990 to 2006, North Carolina's plant hardiness zone shifted from a majority zone 7 statewide to a majority zone 8 statewide. This drastic change impacts agriculture, plants, and pests^{7,10}.

III. Problem Assessment – Risk Characterization - Conceptual pathways linking exposures to health outcomes and health vulnerability

All climate patterns affect human health and well-being. This section focuses on the health effects of North Carolina residents due to the following climate scenarios: increased drought, increased and more intense precipitation, heat waves, hurricanes, and sea-level inundation. The public health impacts from these climate conditions are extremely complex. This section provides a few examples of some major adverse outcomes⁷.

Water Quality and Quantity

Each of the most likely climate impacts—increased drought, increased and more intense precipitation, heat waves, hurricanes, and sea level inundation—would affect the quality and quantity of clean water available to residents of North Carolina. The increased frequency and intensity of precipitation, compounded with more intense tropical cyclones and sea level inundation, could cause the flooding of storm-water and sewage systems, toxic waste facilities, and livestock waste lagoons. These aforementioned facilities, may be at risk to failure or overflow, may introduce release hazards such as sewage-related pathogens, nutrient pollution, animal wastes, and other toxic materials⁷.

When recreational and drinking water quality is compromised due to the increased demands on storm water systems that exceed the existing capacity, North Carolina's communities may issue boil water advisories or experience violations of drinking water standards. These insecurities are linked with waterborne disease outbreaks, beach and public use water closures, and skin infections. Increased demands on treatment systems for clean drinking water also require increase infrastructure investments. First responders would be particularly vulnerable to health risks. Additionally, during heavy precipitation events or hurricanes, contamination of irrigation water can contribute to food-borne diseases, as could contamination of shellfish harvesting waters. In addition to food consumers, the occupational health of shellfish harvesters and others who work closely with contaminated water may also be at risk⁷.

Drought also affects community and individual water supplies. During drought occurrences, contaminants are likely to build up on the ground and subsequent rainfall generates flash floods that may overwhelm storm water systems. As a result, communities may see a reduction in water quality and an increase in waterborne diseases during drought⁷.

Harmful algal blooms (HABs) in North Carolina are closely related to high temperatures and reduced precipitation or increased precipitation and carry toxins that may be harmful when ingested or inhaled. During droughts, more harmful algal blooms occur, increasing the potential for exposure to HAB toxins, via ingestion, especially by vulnerable groups such as children and family pets. Additionally, swimming areas would be closed to reduce exposure, decreasing recreational opportunities. HABs also reduce the amount of dissolved oxygen in the water, which can lead to fish kills, impacting subsistence fishing communities and recreation.

During summer, water and food-borne disease incidences increase due to a combination of bacterial activity and human behavior. With more high temperature days and nights or heat waves, water and food-borne illness events in North Carolina may increase^{7,11}.

Vector-borne Disease and Pest Management



Bacterial, viral and parasitic diseases that are transmitted by mosquitoes, ticks and fleas are collectively called "vector-borne diseases" (the insects and arthropods are the "vectors" that carry the diseases). Vector-borne diseases in North Carolina are transmitted primarily by ticks, mosquitoes, and fleas, and include diseases such as spotted fever Rickettsiosis, LaCrosse encephalitis, West Nile virus, eastern equine encephalitis, and Q fever. Most of these diseases can cause serious illness or even death. Vector-borne diseases may become newly established in a vector population or endemic diseases and may increase in incidence as a result of

changing climatic patterns. Chikungunya and Dengue are examples of emerging vector-borne diseases that may become established in the U.S. if conditions support local transmission. Imported cases of Chikungunya and Dengue have been identified in residents from North Carolina and other states, returning from endemic areas. In late 2013, the first local transmission of Chikungunya in the Americas was reported on islands in the Caribbean. Local transmission of Chikungunya has not been documented in the continental U.S., but is possible because a competent vector mosquito (*Aedes albopictus*), an aggressive day-time biter, is found throughout North Carolina.¹²

Drought and UV exposure may affect vector-borne diseases by influencing the reproductive cycle and behavior of ticks and mosquitoes. For example, ticks may burrow deeper into the ground cover when humidity is low. Furthermore, drought may weaken plants used in agriculture and making them more vulnerable to pests.

Mosquito populations can skyrocket after hurricanes or periods of intense precipitation. For example, following Hurricane Irene in 2011, mosquito landings on a person in one minute became 'too numerous to count' in some coastal counties. An increased number of mosquitoes and increased biting frequency may lead to more disease.

Vector-borne diseases increase during summer months due to a combination of vector activity and increased exposure to insects as people increase their outdoor activity. Therefore, high temperatures may also affect vector-borne diseases^{7,11,13}.

Respiratory Health

Reduced precipitation during prolonged drought periods contribute to increased fine and coarse particulate matter (PM_{2.5} and PM₁₀) in the air. Because precipitation is not regularly removing fine and coarse particulate matter, drier soil and roadways can generate more dust. Poor air quality during droughts may result in a greater number of poor air quality alert days, and have an increase impact on people with asthma, and a higher number of respiratory-related emergency department visits¹⁴. Furthermore, wildfires made worse by drought conditions may contribute smoke and particulate matter to the air. For example, the 2008 and 2011 wildfires in Dare County resulted in an increase in respiratory and cardiovascular-related emergency department visits in surrounding areas. The 2008 wildfire saw an increase in these types of visits by 42-66%^{7,11,15,16}.

Ground-level ozone contributes significantly to poor air quality days, and to associated impacts on respiratory health. Hot days influence the development of ground-level ozone, often the favoring the

creation of more ozone. While increasing ground-level ozone may be a problem in the future for population centers in the Northeast and a variety of other locations in the United States, future ozone projections in North Carolina do not show an increase in risk from ground-level ozone or its health impacts¹⁷.

Pollen is associated with several types of allergic disease and the release of pollen is tied to the amount of carbon dioxide in the atmosphere and ambient temperature. Thousands of North Carolinians are impacted by allergic disease and sensitive to changes in pollen production¹¹.

Extreme heat temperature changes in the environment can contribute to poor air quality, whereby increasing health risks among individuals with respiratory or cardiovascular disease. The impact of extreme heat events are expected to be higher in underserved communities whose residents have limited means to adapt to warming temperatures, and already experience disparate respiratory and cardiovascular disease burden^{7,11}.

Injuries

Climate conditions that may contribute to heat-related injury in North Carolina include hurricanes, drought, high temperature days and nights, and heat waves. Following a hurricane, power may be disrupted, so that people may be unable to use electricity to keep their homes cool. During drought, cloud cover decreases, allowing more of the sun's warmth to reach the earth's surface and precipitation is not available to cool the land or air. With high temperature days and nights, people face direct heat exposure, and hot spells. High temperatures early in the year have especially significant impacts, since people are not yet acclimated to the heat. A recent study found that workers are most likely to die from heat when they haven't had a full acclimatization period. Higher night-time temperatures do not allow complete recovery after hot days. In the future, periods of high temperature are expected to increase in frequency and magnitude.

Due to these climatic patterns, heat-related deaths, hospitalizations, and emergency department visits may increase, particularly among vulnerable groups. In North Carolina, young, relatively healthy males (19–44 years) are vulnerable to heat-related illness, especially related to work such as farm labor, construction, or landscaping. For example, a 2005 study found that among North Carolina occupational-related heat fatalities, nearly half occurred among farm workers. Further, a 1992-2006 study found that North Carolina had the highest rate of heat-related deaths among crop workers in the country. In addition, 15 to 18 year olds are often seen in the emergency department for sports-related heat exposures. Older North Carolinians (>65 years) may be more likely to be hospitalized for heat-related illness. Heat waves may affect those with co-existing conditions, such as cardiovascular disease or respiratory disease. Another vulnerable group is those taking medications that impair the body's ability to regulate temperature, such as people with mental health issues and patients suffering from heart disease^{7, 11, 18-23}.

In addition to heat injury, North Carolinians experience other types of injuries during extreme weather events. During heavy precipitation or hurricanes, wind and flooding increase risk of injury. Safe transportation may not be available; as a result, severe weather injuries, motor vehicle injuries, and drownings may occur. Fall injuries may also increase, as could injuries associated with storm clean-up. If conditions deteriorate sufficiently, domestic violence, homicides or suicides may increase. Increases in interpersonal violence, both assault and self-harm, are seen in populations surviving major weather events. Prior to a hurricane, North Carolinians incur injuries from evacuation activities. Following the hurricane, cleanup activities often lead to injury, with some people experiencing insect, snake, and other animal bites from displaced creatures, while others may be injured by chainsaws, broken glass, falling debris, or overexertion during cleanup^{7, 11, 24}.

Infrastructure, Electricity, Critical Facilities, Adequate Shelter

When North Carolina experiences emergencies, state and local health departments may be required to divert critical resources, despite needs for essential public health services. Tropical storms have a tremendous impact on health services infrastructure. Storm surge may impact transportation and other infrastructure upon which the chronically ill rely. Hurricanes may limit access to life-saving medicines, and may overwhelm or close hospitals, clinics, and doctors' offices. In addition, people, many of the most vulnerable North Carolinians may lose their homes. Sea level inundation may cause loss of income, particularly among tourism, agriculture and fishing industries. These losses may alter demands on the mental health system resulting from the mental stress of losing a home, income or livelihood.

Warm spells and heat waves that cause heat stress will have a compounding impact, leading to increases in energy and water demands, and decrease in air quality. Energy demands will be impacted by heat waves as heat stress on humans leads to an increase in air conditioning needs, which is a primary mechanism to mitigate heat stress^{7,11}.

Mental Health

Exceptional drought may lead to loss of income or livelihood for persons in the tourism or agriculture sectors, thereby contributing to mental stress, mental health disorders, and an increased demand for mental health services. A hurricane can increase mental stress by affecting access to adequate housing and other essential needs such as life-saving medicines and treatments. In the wake of a hurricane, a local health department or Local Management Entity-Managed Care Organization (LME-MCO) may respond to tremendous social disruption, mental stress, increased demand for mental health services, homelessness, increased substance abuse among abusers, and increased domestic violence. For example, following Hurricane Floyd, there was an increase in inflicted traumatic brain injury among children in the counties most affected^{7,11,25}.

Ultraviolet Radiation (UV)

In periods of drought, decreased cloud cover allows an increased exposure to UV radiation, which can increase risk for skin cancer. In addition, more organic chemicals, some of which may contribute to cancer, may be released into the air when heated and turned into vapors^{7,11,26}.

Cardiovascular Disease and Stroke

North Carolinians living with cardiovascular disease (CVD) or stroke are particularly vulnerable to poor air quality, which is impacted by drought and high temperatures. These individuals are also at risk for heat-related injury. Tropical storms have a tremendous impact on health services infrastructure. North Carolinians with pre-existing health conditions such as CVD are highly vulnerable if they lose access to essential medications and medical care^{7,11}.

IV. Problem Assessment – Vulnerability and Health/Hazard Assessment:

Vulnerability in North Carolina is multi-faceted with every community facing some vulnerability. Effort was made to identify vulnerability using New York City's criteria of an anticipated impact that is already an existing issue. Within those parameters, grant staff focused on existing resources to inform the collection of vulnerability data. The existing resources consisted of national guidelines and existing secondary data resources within North Carolina. Every effort to use the multitude of data available to identify and prioritize vulnerabilities has been made, and work will continue to better understand vulnerabilities²⁷.

In this profile, vulnerability is ‘the propensity or predisposition to be adversely affected’²⁸. The term ‘vulnerability data’ describes data collected that elucidate this likelihood of negative impacts. The vulnerability data summarized hereafter is specific to grant work done from 2011-2012, for the Centers for Disease Control and Prevention’s funding of the Climate-Ready Cities and States Initiative in North Carolina from 2010-2013 and the Council for State and Territorial Epidemiologists’ State Environmental Health Indicator Collaborative Pilot Project in North Carolina in 2011. The grant objectives for the current 2014-15 funding year (on page 1) build on the following summarization of vulnerability data. The scorecard below has allowed the grant staff to prioritize areas for subsequent, more in-depth (e.g. determining the impact of pollen on allergic disease) vulnerability assessments.

The Occupational and Environmental Epidemiology Branch staff has collected a variety of health and vulnerability data to assess vulnerability and prioritize health impacts for grant focus and interventions. The data was chosen and compiled using the following resources: the Council for State and Territorial Epidemiologists State Environmental Health Collaborative, the National Institute for Environmental Health Sciences’ A Human Health Perspective on Climate publication, and expert judgment through the grant’s advisory group. The data included mortality and morbidity data from national sources and from state sources such as the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (N.C. DETECT), our syndromic surveillance source for emergency department data and the North Carolina Electronic Disease Surveillance System (N.C. EDSS) for reportable conditions.

Data collected for vulnerability and health hazard assessment has been published on OEEB’s website, and will continue to be published through indicator reports. This vulnerability and health hazard assessment data is used to prioritize grant activities. For example, the highest scoring areas are prioritized for grant work, and in 2012, were used to prioritize the strategies and adaptations during the strategic planning process. In addition, the data are shared with stakeholders. For example, the mental health data was recently used to share with the Rutherford, Polk, and McDowell Counties Local Health Department. North Carolina considers a vulnerability and health hazard assessment a means to direct grant work in face of a broad area of issues and as a way to ensure that the most vulnerable communities receive the grant staff’s focus²⁹.

In order to summarize the vulnerability data, the Hanlon Method was used. Developed by JJ Hanlon, the Hanlon Method for Prioritizing Health Problems is a complex technique which objectively takes into consideration explicitly defined criteria and feasibility factors. Using the Hanlon Method is advantageous when the desired outcome is an objective list of health priorities based on baseline data and numerical values. This method and prioritization matrix includes scoring data using elements of burden, urgency, vulnerability, and strength of evidence. Burden is defined as the size of population exposed or affected. Urgency reflects the need to act soon and not later, with action needed within 5 years defined as high urgency, action needed within 10 years defined as medium urgency, and action needed within 25 years defined as low urgency. Vulnerability describes components of environmental, population, or geographical distribution. Strength of evidence is the level of precision in estimation of health risks associated with climate. Strength of evidence also describes the completeness of the data and may describe gaps in the literature. The score for each of these elements is added to create a final score using the equation:

$$A (\text{Burden}) + 2B (\text{Urgency}) + 2C (\text{Vulnerability}) + 0.5 D (\text{Strength of Evidence})$$

Urgency and vulnerability were doubled in the equation because it forms the basis and motivates the development of effective interventions. The strength of evidence was halved because staff felt a lack of evidence should not preclude taking action. Implementing public health practices in any of these impact areas would have co-benefits for health and reduce existing health impacts from weather and climate^{11,25}.

30-33

North Carolina Climate-Health Scorecard					
Health Impact	Burden (A)	Vulnerability (B)	Urgency (C)	Strength of Evidence (D)	Score (A+2B+2C+0.5D)
Air Quality and Respiratory Diseases	Very High (5)	Very High (5) <i>Children (N.C. asthma rates higher than national) Older adults</i>	Very High (5) <i>Potential to save lives and improve public health</i>	Very Strong (5)	27.5
Heat-related Deaths and Illnesses	High (4)	Very High (5) <i>Young Adults Athletes Farmworkers</i>	Very High (5) <i>Potential to save lives and improve public health</i>	Very Strong (5)	26.5
Mental Health	High (4) <i>20 counties</i>	High (4) <i>Third largest veteran population Substandard housing</i>	High (4)	Low (2)	21
Thunderstorm Deaths and Injuries	High (4)	Coastal (3) Piedmont (3) Mountains (4)	High (4)	Moderate (3)	Coastal (19.5) Piedmont (19.5) Mountains (21.5)
Hurricane Deaths and Injuries	High (4)	Coastal (4) Piedmont (4) Mountains (4)	Medium (3)	Moderate (3)	Coastal (19.5) Piedmont (19.5) Mountains (19.5)
Water and Food-borne Diseases	Medium (3.5 total) A. Salmonellosis, Campylobacteriosis High (4) B. Vibrio, Legionellosis, Cryptosporidiosis Medium (3)	High (4) <i>Children</i>	Medium (3.5)	Low (2)	19.5

Flood Deaths and Injuries	High (4)	Coastal (4) Piedmont (3) Mountains (3)	Medium (3)	Moderate (3)	Coastal (19.5) Piedmont (17.5) Mountains (17.5)
Vector-borne Diseases	A. Mosquito-borne Low (2.3 total) 1. <i>Lacrosse, EEE</i> <i>High (4)</i> 2. <i>Malaria</i> <i>Medium (2)</i> 3. <i>WNV, Dengue</i> <i>Low (1)</i> B. Tick-borne Low (2 total) 1. <i>RMSF</i> <i>High (4)</i> 2. <i>Lyme, Ehrlichiosis</i> <i>Medium (2)</i>	High (4) <i>Children</i> <i>Lack of surveillance presents risk</i>	Medium (3.5) <i>Lacrosse, EEE, & RMSF</i> <i>are threats; Interventions are proven to prevent disease</i>	Low (2)	18.2
Tornado Deaths and Injuries	Medium (3)	Coastal (3) Piedmont (3) Mountains (1)	Medium (3)	Moderate (3)	Coastal (16.5) Piedmont (16.5) Mountains (12.5)
Cancer	High (4)	Medium (3)	Low (2)	Research Needed (1)	14.5
Winter Weather Health Impacts	Minimal (1)	Coastal (1) Piedmont (4) Mountains (3)	Minimal (1)	Low (2)	Coastal (6) Piedmont (12) Mountains (10)

V. Collaborations

Staff has convened an advisory group of 40 experts on climate and health to provide guidance and recommendations on adapting to the impacts of changes in the climate and its effects on the population in the state. This working group is composed of members from state and federal agencies, non-profit and private non-governmental organizations, and academic institutions. Climate's effects on public health tend to be multi-faceted that it is challenging for a single program to adequately respond to its impact without collaborating with other partners. Some collaboration includes:

National Oceanic and Atmospheric Administration (NOAA)

Staff partner with NOAA's Eastern Coast Regional National Weather Service Office, the Raleigh National Weather Service Office, and the Newport/Morehead City National Weather Service Office. This collaboration includes sharing appropriate health outcome data, consulting meteorologists about climate and weather, and examining the impact of advisory, watch, and warning systems on health outcomes in North Carolina.

Council of State and Territorial Epidemiologists (CSTE)

Grant staff is active on CSTE's Environmental Health Steering Committee. The Principal Investigator of the grant chairs the Climate Subcommittee, is an active participant on the Disaster Epidemiology Subcommittee, and has piloted the State Environmental Health Indicator Collaborative in 2011. The grant has given four presentations at the CSTE's annual meetings on strategic planning for climate health, the use of climate and health indicator data, waterborne disease, and state efforts on climate and health.

Carolinas Integrated Sciences Assessment

Staff collaborates with the Carolinas Integrated Sciences Assessment by serving on its advisory panel and participating in evaluation of its services such as its health work on heat-related illness and its work on climate models. In addition, staff has supported proposals on climate and health that received funding from the Carolinas Integrated Sciences Assessment.

North Carolina State Hazard Mitigation

Staff has served on the North Carolina Hazard Mitigation's Advisory Board since 2012 and has advised the Board on heat-related illness and health impacts from infectious disease.

Photo Credits

Cover Page

- 1) North Carolina Welcome Sign – courtesy of www.morguefile.com
- 2) Hurricane Isabel over the North Carolina Coast image – courtesy of NASA
- 3) Mountain view image –courtesy of www.morguefile.com
- 4) Beach view image –courtesy of Sara Smith
- 5) Hot sun image – courtesy of www.morguefile.com

Page 2

- 1) North Carolina map with regions – courtesy of Corey Davis, State Climate Office of North Carolina
- 2) Bermuda High map - courtesy of Corey Davis, State Climate Office of North Carolina

Page 5

- 1) Mosquito image – courtesy of www.morgueprofile.com

North Carolina Climate and Health Profile Bibliography

1. North Carolina Division of Aging and Adult Services. Operation Fan/Heat Relief. 2014. Available at: <http://www.ncdhhs.gov/aging/heat/heat.htm>. Accessed February 9, 2015.
2. North Carolina Division of Mental Health, Developmental Disabilities, and Substance Abuse Services. Disaster Preparedness. 2015. Available at: <http://www.ncdhhs.gov/mhddsas/services/disasterpreparedness/index.htm>. Accessed February 9, 2015.
3. North Carolina Division of Public Health. 2014 Summer Heat Emergency Data and Prevention Tips. 2014. Available at: <http://publichealth.nc.gov/chronicdiseaseandinjury/heat.htm>. Accessed February 9, 2015.
4. North Carolina Division of Public Health. Public Health Preparedness and Response. 2012. Available at: <http://epi.publichealth.nc.gov/phpr/>. Accessed February 9, 2015.
5. North Carolina Division of Public Health. Climate and Health. 2014. Available at: <http://epi.publichealth.nc.gov/oeo/programs/climate.html>. Accessed February 9, 2015.
6. The Southeast Regional Climate Center. Climate and Health in the Southeast U.S. 2012. Available at: http://www.sercc.com/climate_health. Accessed February 9, 2015.
7. N.C. Interagency Leadership Team. Climate Ready North Carolina: Building a Resilient Future. 2012. Available at: <http://www.cisa.sc.edu/PDFs/Climate%20Ready%20North%20Carolina%20-%20Building%20a%20Resilient%20Future.pdf>. Accessed February 24, 2015.
8. Kunkel KE, Stevens LE, Stevens SE, Sun L, et al. 2013: Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 9. Climate of the Contiguous United States, NOAA Technical Report NESDIS. 2013. Available at: http://scenarios.globalchange.gov/sites/default/files/NOAA_NESDIS_Tech_Report_142-9-Climature_of_the_Contiguous_United_States_3.pdf. Accessed February 10, 2015.
9. Kunkel KE, Stevens LE, Stevens SE, Sun L, et al. 2013: Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 2. Climate of the Southeast U.S., NOAA Technical Report NESDIS. 2013. Available at: http://www.sercc.com/NOAA_NESDIS_Tech_Report_Climate_of_the_Southeast_U.S.pdf. Accessed February 10, 2015.
10. Slenning BD. One health and climate: linking environmental and animal health to human health. *North Carolina Medical Journal*. 2010;71(5):434-7.
11. Portier CJ, Thigpen Tart K, Carter SR, Dilworth CH, et al. A Human Health Perspective on Climate: a report outlining the research needs on the human health effects of climate. *Environmental Health Perspectives and National Institute of Environmental Health Sciences*. 2010. Available at: http://www.niehs.nih.gov/health/materials/a_human_health_perspective_on_climate_change_full_report_508.pdf. Accessed February 24, 2015.
12. Centers for Disease Control and Prevention. Chikungunya virus. 2015. Available at <http://www.cdc.gov/chikungunya/geo/united-states.html>. Accessed February 27, 2015.
13. North Carolina Division of Public Health. Vector-borne Diseases. 2014. Available at: <http://epi.publichealth.nc.gov/cd/diseases/vector.html>. Accessed February 27, 2015.
14. Centers for Disease Control and Prevention. Drought and Health. 2012. Available at: <http://www.cdc.gov/nceh/drought/default.htm>. Accessed February 27, 2015.
15. Rappold AG, Stone SL, Cascio WE, Neas LM, et al. Peat bog wildfire smoke exposure in rural North Carolina is associated with cardiopulmonary emergency department visits assessed through syndromic surveillance. *Environmental Health Perspectives*. 2011; 119:1415-20.
16. Tinling MA. Emergency Department Diagnoses in Eastern North Carolina Associated with Smoke Exposure from the 2011 Pains Bay Wildfire. 2012. Master's thesis.

17. Becker DA. The Human Health Impacts of Future Changes in Air Quality and Temperature in the United States. 2014. Master's thesis.
18. Mirabelli M, Richardson D. Heat-related fatalities in North Carolina. *American Journal of Public Health*. 2005; 95:635-7.
19. North Carolina Department of Health and Human Services. 2014 Summer Heat Emergency Data and Prevention Tips. 2014. Available at: <http://publichealth.nc.gov/chronicdiseaseandinjury/heat.htm>. Accessed February 11, 2015.
20. Rhea SR, Ising A, Fleischauer AT, Deyneka L, et al. Using near real-time morbidity data to identify heat-related illness prevention strategies in North Carolina. *Journal of Community Health*. 2012; 37:495-500.
21. Lippmann SJ, Fuhrmann CM, Waller AE, Richardson DB. Ambient temperature and emergency department visits for heat-related illness in North Carolina, 2007-2008. *Environmental Research*. 2013; 124:35-42.
22. Arbury S, Jacklitsch B, Farquah O, Hodgson M, et al. Heat illness and death among workers – United States, 2012-2013. *Morbidity and Mortality Weekly Report*. 2014; 63:661-5.
23. Luginbuhl RC, Jackson LL, Castillo DN, Loring KA. Heat-related deaths among crop workers, United States, 1992-2006. *Morbidity and Mortality Weekly Report*. 2008; 57:649-653.
24. North Carolina Department of Health and Human Services. Hurricanes. 2014. Available at: <http://www.ncdhhs.gov/hurricanes/>. Accessed February 11, 2015.
25. Keenan HT, Marshal SW, Nocera MA, Runyan DK. Increased incidence of inflicted traumatic brain injury in children after a natural disaster. *American Journal of Preventive Medicine*. 2004; 26(3): 189-93.
26. North Carolina Occupational and Environmental Epidemiology. North Carolina Climate-Related Health Indicators: Human Development. Available at: <http://epi.publichealth.nc.gov/oe/programs/climate.html>. Accessed February 11, 2015.
27. Graber N. New York City Climate and Health: Responding Today, Adapting for Tomorrow. 2013. Available at: https://www.niehs.nih.gov/about/visiting/events/pastmtg/2013/dert-climate/dert_climate_january_2013_panel_24_508.pdf. Accessed March 2, 2015.
28. Smith KR, Woodward A, Campbell-Lendrum D, Chadee DD, et al. 2014: Human Health: impacts, adaptation, and co-benefits. In: *Climate 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution to Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate*. Cambridge University Press, 709-54.
29. Manangan AP, Uejio CK, Saha S, Schramm PJ, et al. Assessing Health Vulnerabilities to Climate: a guide for health departments. 2014. Available at: <http://www.cdc.gov/climateandhealth/pubs/AssessingHealthVulnerabilitytoClimateChange.pdf>. Accessed February 27, 2015.
30. Council of State and Territorial Epidemiologists. Environmental Health Indicators: Climate. 2011. Available at: <http://www.cste.org/?page=EHIndicatorsClimate>. Accessed February 12, 2015.
31. North Carolina Division of Public Health and University of North Carolina at Chapel Hill School of Medicine. North Carolina Disease Event Tracking and Epidemiologic Collection Tool. 2004. Available at: <http://ncdetect.org/>. Accessed February 12, 2015.
32. North Carolina Department of Health and Human Services. North Carolina Electronic Disease Surveillance Systems. 2014. Available at: <https://ncedss.ncpublichealth.com>. Accessed February 12, 2015.
33. National Association of County and City Health Officials. First Things First: Prioritizing Health Problems. Available at: <http://www.naccho.org/topics/infrastructure/accreditation/upload/Prioritization-Summaries-and-Examples.pdf>. Accessed February 12, 2015.