

# Climate and Health Adaptation Plan

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GREATER MONADNOCK PUBLIC HEALTH NETWORK



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## ACKNOWLEDGEMENTS

The Greater Monadnock Climate and Health Adaptation Plan is a product of the Greater Monadnock Public Health Network with support from New Hampshire Department of Health and Human Services. This Plan incorporates the input of a number of public health and community partners. We are grateful to these individuals and organizations that took the time to be involved in the development of this document.

### **Council for a Healthier Community Executive Committee**

- Susan Ashworth, Home Healthcare, Hospice and Community Services
- Ellen Avery, Community Volunteer Transportation Company
- Lee Ann Clark, Monadnock Community Hospital
- Chris Coates, Cheshire County
- Hope Driscoll, Monadnock Voices for Prevention
- Erica Frank, Southwestern Community Services
- Eileen Fernandes, Cheshire Medical Center/Dartmouth-Hitchcock Keene
- Mary Lee Greaves, NH Department of Health and Human Services
- Dr. José Montero, Cheshire Medical Center/Dartmouth-Hitchcock Keene
- Tim Murphy, Southwest Region Planning Commission
- Natalie Neilson, Monadnock Voices for Prevention
- Nick Petersen, Greater Monadnock Public Health Network
- Linda Rubin, Cheshire Medical Center/Dartmouth-Hitchcock Keene
- Tricia Wadleigh, Cheshire Medical Center/Dartmouth-Hitchcock Keene

### **New Hampshire Department of Health and Human Services**

- Matthew Cahillane, Bureau of Disease Control
- Kathleen Bush, Bureau of Public Health Statistics and Informatics

### **Southwest Region Planning Commission**

- Henry Underwood
- Mari Brunner

### **Antioch University New England**

- Jessica Leonard
- Alex Rosen

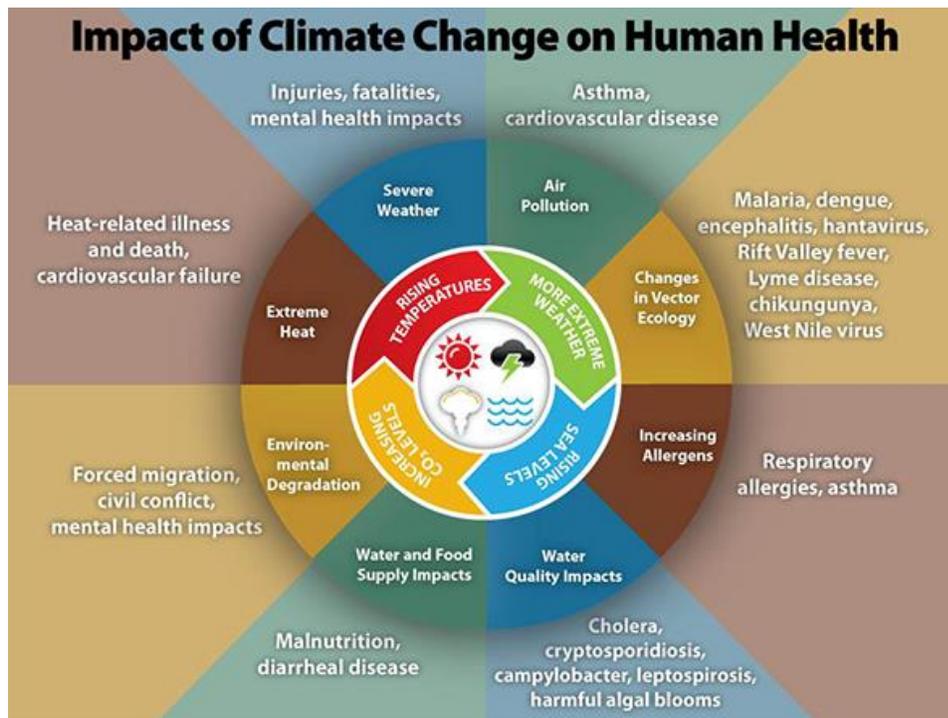
This publication was supported by Centers for Disease Control and Prevention (CDC) grant number #5UE1EH001046-03 via the National Center for Environmental Health in Atlanta, Georgia. The contents of the report are solely the responsibility of the authors and do not necessarily represent the official views of the CDC.

## INTRODUCTION

The Climate and Health Adaptation Plan for the Monadnock Region is a response to increased concerns about how our changing weather and climate may negatively impact our public health system and place additional burdens on populations already vulnerable to health problems. Natural hazards given the most attention have included hurricanes, floods, wildfires, and severe winter weather-for good reason. Extreme rainfall events in 2005 (Alstead) and 2006 (Keene and surrounding communities) brought severe flooding resulting in costly road washouts, property damage, and loss of life. Similarly, the Ice Storm of 2008 took down power lines, disrupted economic activity, and left many without heat, hot water, electricity, and the ability to communicate with others for days. Yet today, new hazards are understood to threaten human health into the future.

To better understand these concerns, the Public Health Network conducted an analysis of regional demographics and vulnerable population groups, identified and researched a variety of climate hazards and health topics, and identified short term interventions to address a priority health outcome. Those resulting from changes to climate are the subject of this plan (Figure 1). Although the impacts of severe weather cannot always be predicted and prevented, meaningful steps can be taken today to identify and protect those populations most at risk.

FIGURE 1 (CENTERS FOR DISEASE CONTROL AND PREVENTION, 2016)

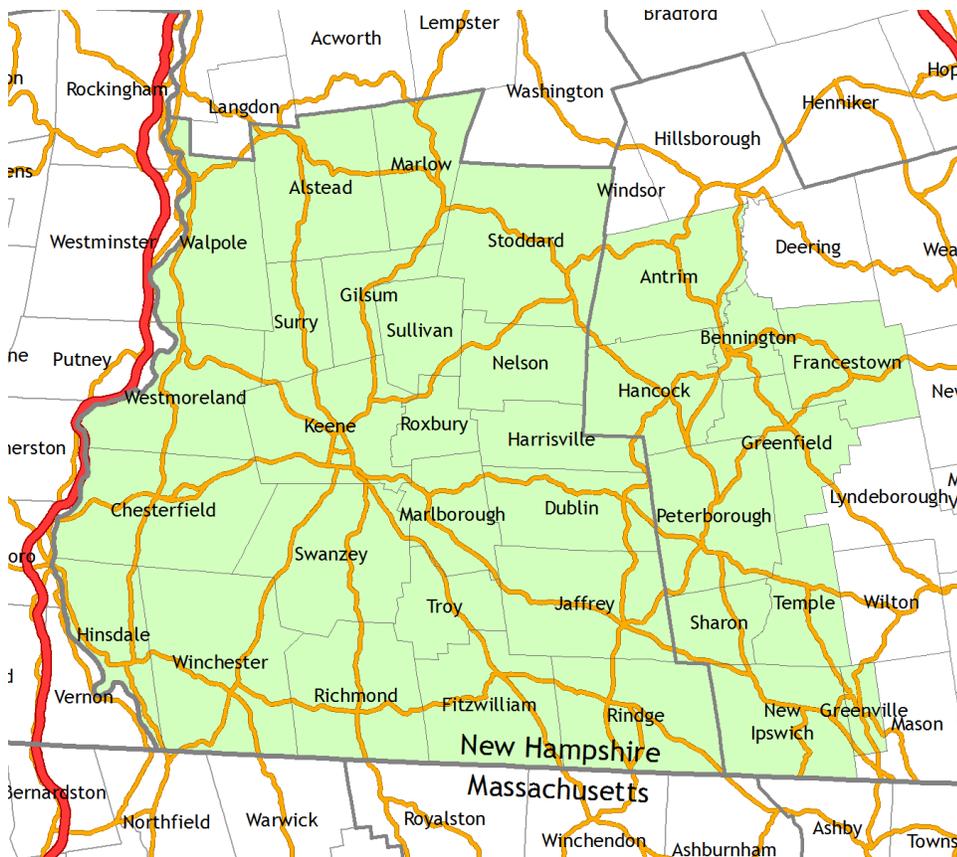


## REGIONAL CONTEXT

The Greater Monadnock Region, which is located in the southwestern corner of New Hampshire, includes all 23 municipalities in Cheshire County and the 10 western-most towns in Hillsborough County. With the exception of the City of Keene (population 23,409), the Region is a predominantly rural area with town populations ranging from 221 persons in Roxbury to 6,939 in Swanzey. As of 2010, the Region's population totaled 101,401. A central and defining feature of the Region is Mount Monadnock, which rises 3,165 feet above sea level. Forests cover more than 80% of this land with rural and suburban residential development emanating from village centers and small downtown areas. With the exception of Keene and a few small downtown areas, much of this development is dispersed with one house for every ten or more acres.

While a strong sense of local identity defined by municipal boundaries prevails, there is variety in where people work and shop, have social connections, spend leisure time, and access services, including health care. Mount Monadnock and its highlands bisect the landscape into two sub-regions. One is dominated by the City of Keene as an employment, commercial and population center and the other is a more linear configuration of the Contoocook River Valley's population centers of Peterborough, Jaffrey, and Rindge.

**FIGURE 2 - GREATER MONADNOCK PUBLIC HEALTH REGION**



## CHANGES IN CLIMATE

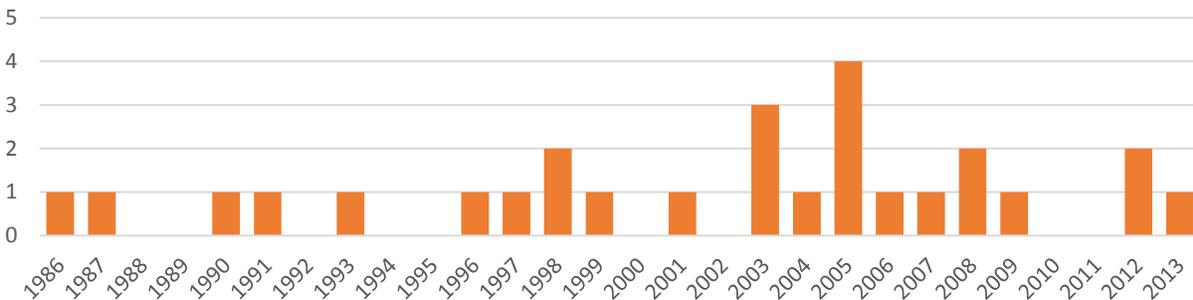
Since 1970, Southern New Hampshire has become both warmer and wetter.

Over the past four decades, Average annual maximum temperatures have warmed 1.1 to 2.6 degrees Fahrenheit, the numbers of days below freezing have decreased, and the coldest nights are not as cold as they once were. Further, the number of snow-covered days has decreased and the length of the growing season is 2 to 4 weeks longer.

Precipitation has also increased significantly since 1970, by 12 to 20 percent. And extreme precipitation events have resulted in several large floods across New Hampshire.

In the future, climate is expected to continue on the trajectory, with an increasing number and temperature of extreme heat days (greater than 90 degrees Fahrenheit). Additionally, average precipitation is projected to increase 17 to 20 percent by the end of the century, primarily in winter and spring, along with the incidence of extreme precipitation events. Between the period of 1986 to 2013, Presidentially Declared Disasters and Emergency Declarations impacted either Cheshire or Hillsborough County on average about one time per year (New Hampshire Department of Safety, 2013, pp. 22-24).

**FIGURE 3 - PRESIDENTIALLY DECLARED DISASTERS AND EMERGENCY DECLARATIONS (CHESHIRE AND HILLSBOROUGH COUNTY)**



Extreme storm events and flooding in the most recent decade have caused unprecedented damage to some areas of the Monadnock Region, and raised questions about our ability to overcome future events and unforeseen threats. Extreme rainfall events in 2005 and 2006 brought severe flooding resulting in costly road washouts, property damage, and loss of life. Similarly, the Ice Storm of 2008 disrupted electric supplies, economic activity, and left many without heat, hot water, and communication. These traumatic events are just some of the reasons why planning for the health impacts expected from changes in climate are needed.

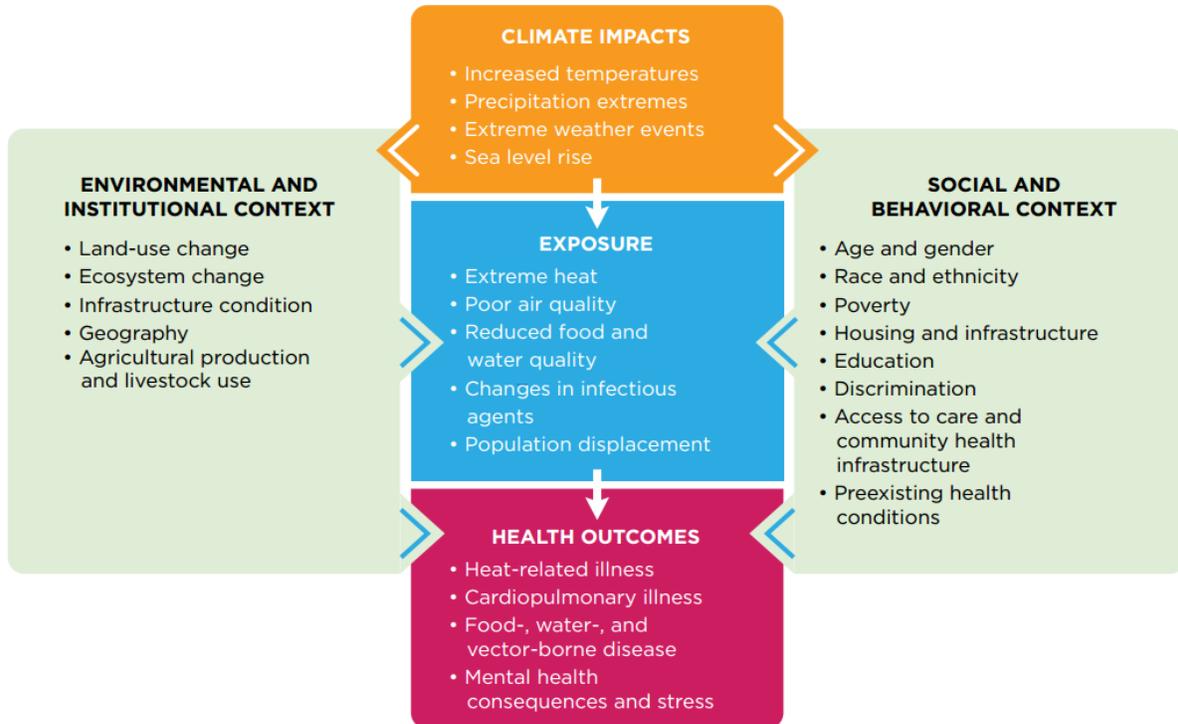
## CLIMATE CHANGE & HEALTH

Climate change, in combination with human-caused and natural stressors, presents a serious threat to human health and disease. Climate impacts expected to exacerbate existing health threats in the Monadnock region include:

- Increased frequency of extreme weather events that can result in injury, death, and disruptions to critical infrastructure that people rely on for access to health services and to meet basic needs
- Shifts in ecological conditions and increasing exposure to vectors such as ticks that spread infectious disease
- Rising temperatures and increased exposure to extreme heat conditions
- Degraded air quality and exposure to higher concentration of ground-level ozone and particulate matter
- Longer growing seasons and increased exposure to allergens
- Increased frequencies of flooding events, mild and moderate droughts, and degraded water quality
- Disruptions to the global food system leading to increased levels of food insecurity in the region

Climate change may also contribute to the emergence of new health threats not seen in the region before, such as new insect vectors and infectious diseases. The figure on the following page summarizes the exposure pathways by which climate change can lead to negative health outcomes, along with mitigating factors such as age, gender, socio-economic status, and geographic location, which can positively or negatively influence people's vulnerability to human health effects (Figure 4).

**FIGURE 4 - CLIMATE CHANGE CAN AFFECT PEOPLE BY CHANGING THEIR EXPOSURE TO HEALTH THREATS (MOVING FROM TOP TO BOTTOM) AND BY INFLUENCING THE ENVIRONMENTAL, INSTITUTIONAL, SOCIAL, AND BEHAVIORAL FACTORS THAT AFFECT A PERSON’S OR COMMUNITY’S HEALTH (MOVING THROUGH THE BOXES ON THE SIDES). KEY FACTORS THAT INFLUENCE VULNERABILITY FOR INDIVIDUALS ARE SHOWN IN THE RIGHT BOX, AND INCLUDE SOCIAL DETERMINANTS OF HEALTH AND BEHAVIORAL CHOICES. KEY FACTORS THAT INFLUENCE VULNERABILITY AT LARGER SCALES, SUCH AS NATURAL AND BUILT ENVIRONMENTS, GOVERNANCE AND MANAGEMENT, AND INSTITUTIONS, ARE SHOWN IN THE LEFT BOX. ALL OF THESE INFLUENCING FACTORS CAN AFFECT AN INDIVIDUAL’S OR A COMMUNITY’S VULNERABILITY THROUGH CHANGES IN EXPOSURE, SENSITIVITY, AND ADAPTIVE CAPACITY AND MAY ALSO BE AFFECTED BY CLIMATE CHANGE (US ENVIRONMENTAL PROTECTION AGENCY, 2016).**



## VULNERABLE POPULATIONS

Some groups of people are disproportionately affected by climate-related health threats and are therefore more vulnerable to climate stressors. In the context of this plan, a vulnerable population is defined as the tendency or predisposition of a group of people to be adversely affected by stressors, including climate-related health threats. A stressor can be an event, such as an extreme precipitation event or a hurricane, or it can be a gradual change or trend, such as a shift in ecological conditions over time or rising temperatures. Vulnerability can be thought of as a function of three factors: exposure, sensitivity, and adaptive capacity.

- **Exposure** involves contact between a person and one or more biological, chemical, or physical stressors, including stressors affected by climate change.
- **Sensitivity** refers to the degree to which people or communities are affected, either adversely or beneficially, by climate variability and change.
- **Adaptive Capacity** is the ability of communities, institutions, or people to adjust to potential hazards, to take advantage of opportunities, or to respond to consequences. Resilience, which is closely related to adaptive capacity, is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. People and communities with strong adaptive capacity have greater resilience.

FIGURE 5 - THREE COMPONENTS OF VULNERABILITY

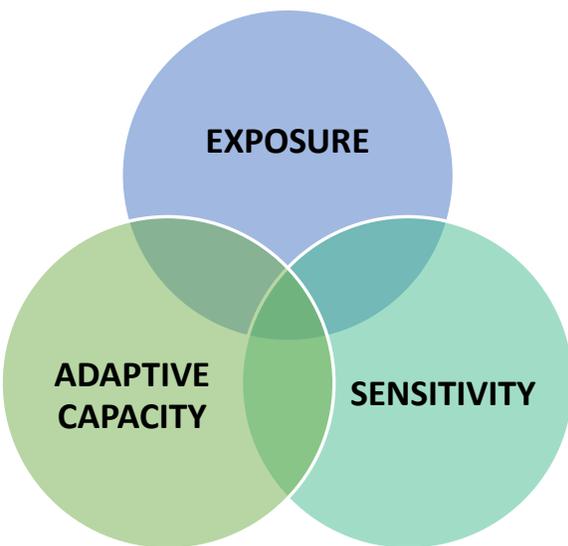
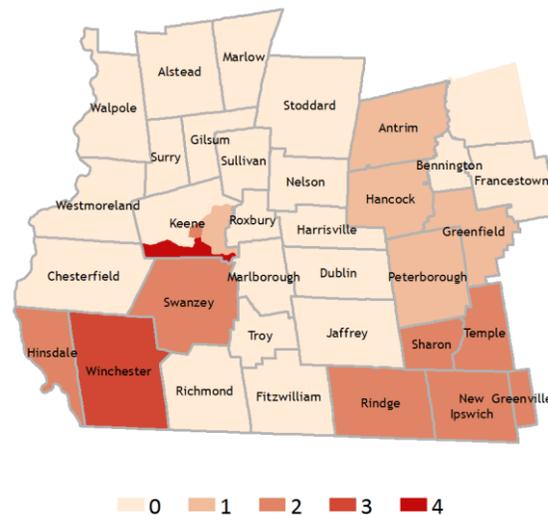


FIGURE 6 - SOCIAL VULNERABILITY INDEX

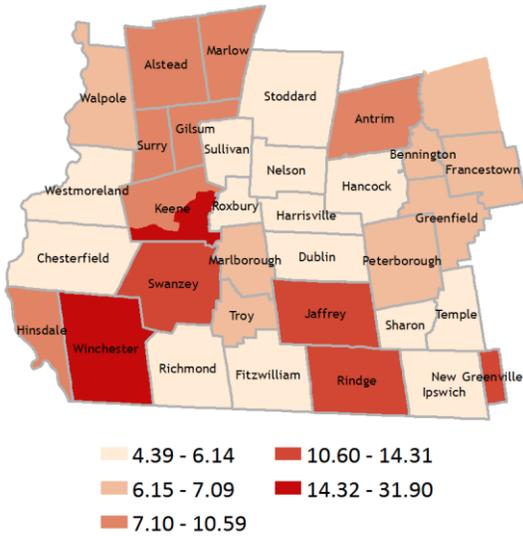


A population is considered vulnerable when the interaction between these three factors results in negative health outcomes. For example, low income individuals are more likely to be exposed to unsafe indoor temperatures during heat waves because they are less able to afford air conditioning. Young children and older adults are more sensitive to heat stress, and people with mobility restrictions are less able to adapt to heat stress. All of these populations - young children, older adults, people with mobility restrictions, and low-income individuals - are identified as vulnerable to heat emergencies in the New Hampshire Excessive Heat Plan.

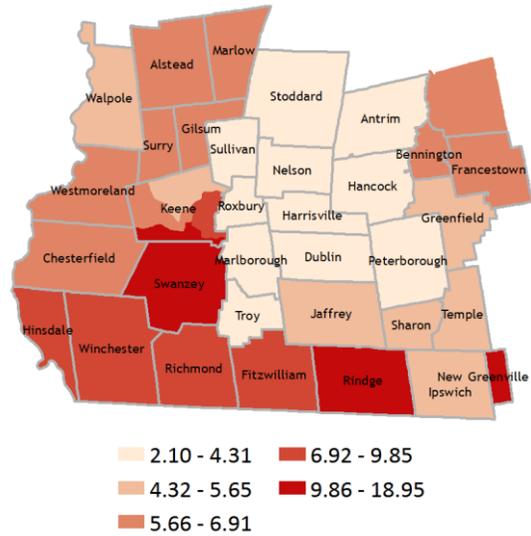
Many of these vulnerabilities are readily measured according to the NH Department of Health and Human Services Social Vulnerability Index (SVI), which leverages community survey data to assess the relative vulnerability of populations throughout the State. In the Monadnock Region, there are several communities with two or more factors that ranked among the most vulnerable in the State.

Individually, components of the social vulnerability index were utilized to identify the location and size of groups vulnerable to a particular health impact.

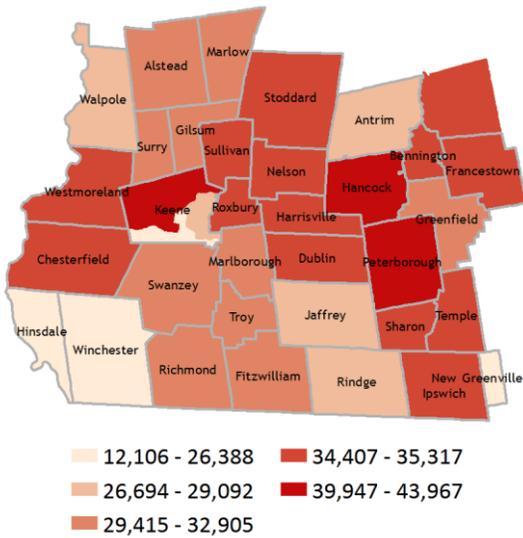
**FIGURE 7 - POVERTY—PERCENT OF POPULATION LIVING BELOW FEDERAL POVERTY LEVEL**



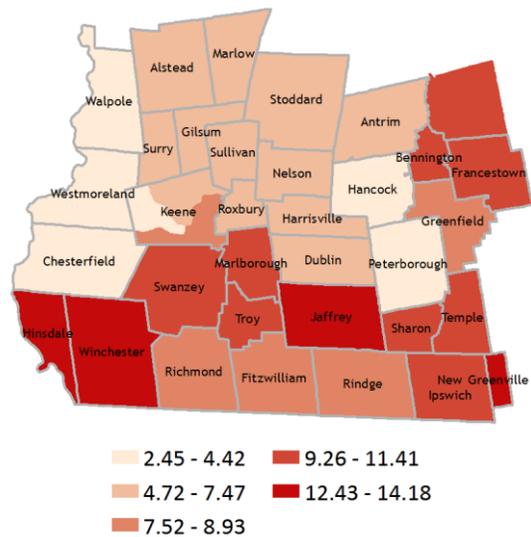
**FIGURE 8 - UNEMPLOYMENT—PERCENT OF POPULATION AGE 16+ AND SEEKING WORK**



**FIGURE 9 - PER CAPITA INCOME (\$)**



**FIGURE 10 - EDUCATION—PERCENT OF POPULATION AGE 25+ WITHOUT A HIGH SCHOOL DIPLOMA**



## CLIMATE IMPACTS AND HEALTH OUTCOMES

The Greater Monadnock Public Health Network identified a total of eight climate exposure pathways and resulting health outcomes that are of concern for the Monadnock Region. These climate exposure pathways are summarized in Table 1.

**TABLE 1 - CLIMATE EXPOSURE PATHWAYS**

<b>Climate Impact</b>	<b>Exposure</b>	<b>Health Outcomes</b>
Lengthening growing season	Increased exposure to allergens	Increased prevalence of allergies and asthma episodes
Degraded air quality	Increased exposure to ground level ozone and particulate matter	Increased prevalence of respiratory disease such as asthma
Rising temperatures	Increased exposure to extreme heat	Increased prevalence of heat-related illness and death
Increased frequency of extreme weather events	Increased exposure to traumatic experiences that can cause injury, death, and harm to family, friends, & livelihoods	Increased prevalence or severity of anxiety and mental illness
Increased frequency of extreme weather events	Increased exposure to damaged or non-functioning infrastructure systems, including transportation, water & sewer, electricity, heat, and telecommunications	Indirect outcomes include lack of access to health services due to damaged roads, lack of heat or air conditioning, lack of electricity resulting in food spoilage, and clean water
Shifts in ecological conditions	Increased exposure to vector-borne disease, in particular Lyme disease from black-legged ticks	Increased prevalence of Lyme disease
Increased frequency of flooding and drought conditions	Increased exposure to poor water quality	Increased prevalence of water-borne disease
Climate disruptions to the global food system	Inundation of transportation and distribution infrastructure, increased rates of soil erosion, and decreased agricultural yields and food quality	Increased prevalence of food-insecure homes

## EXTREME WEATHER, INFRASTRUCTURE DAMAGE, AND ACCESS TO HEALTH SERVICES

### *BACKGROUND*

Extreme weather encompasses flooding, tornadoes, high winds/downbursts, hurricanes/tropical storms, and severe winter weather. However, in the Monadnock Region, many of the human health impacts come from storms that have large precipitation events which in turn cause flooding, erosion, and damage to critical infrastructure.

According to the Federal Emergency Management Agency (FEMA), the state of New Hampshire has experienced 13 severe storm and flooding events presidentially declared as Major Disasters between 2003 and 2013. These events include severe storms and flooding that damaged road infrastructure in the Southwest Region in July-August 2003, October 2005, April 2007, September 2008 and May 2012. In the summer of 2014, Winchester suffered significant damage due to heavy rains and inadequate crossings. It appears that the frequency of these extreme weather events is increasing.

**FIGURE 11 - A SECTION OF NH 123 THAT WASHED OUT DURING THE OCTOBER 2005 FLOODING THAT CLAIMED FOUR LIVES IN ALSTEAD, NH. THREE DOZEN BUILDINGS WERE DESTROYED, 71 HOUSES DAMAGED, AND SEVERAL BRIDGES WERE WIPED OUT, CAUSING AN ESTIMATED \$25 MILLION IN DAMAGES.**



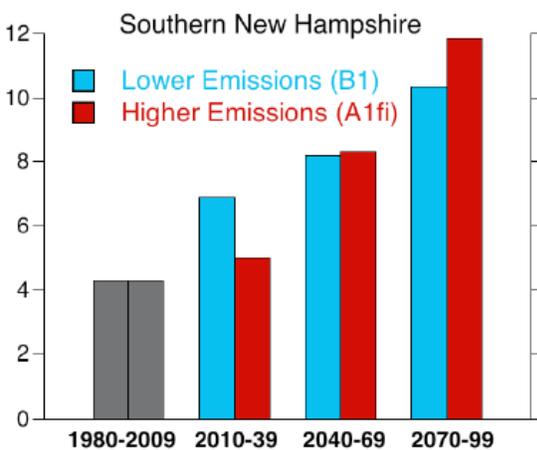
The greatest disaster damage in New Hampshire has traditionally involved flooding of vulnerable infrastructure (New Hampshire Department of Safety, 2013). Culvert and bridge crossings that are undersized in relation to the river or stream in which they are contained can lead to sedimentation and debris accumulation, potentially causing structural failures and major flooding downstream. The damage caused by these failures to road infrastructure and property can have tremendous economic impacts. The federal, private, and individual assistance for damage resulting from New Hampshire's three flood events

in October 2005, April 2006, and May 2007 totaled \$60 million (New Hampshire Department of Environmental Services, 2008).

Severe weather has been increasing in frequency and severity and is projected to continue this trend in the future. The United States in the last 30 years has seen the overall and insured losses from meteorological, hydrological, and climatological events quadruple (Wake, Bucci, & Aytur, 2014). The last three to five decades has also seen an increase in heavy downpours across the country, but particularly in the Northeast and the frequency and intensity of these extreme precipitation events is projected to increase with high confidence (Bell, 2016). Since 1973, approximately 55% of Major Disaster Declarations for severe storms and flooding in New Hampshire have occurred within the past decade.

According to Wake et al., the region will become increasingly wetter, seeing annual precipitation increasing by 15-20% by the end of the century. This increase will be complicated by the trend of the precipitation falling more often as extreme events. The number of events that dump 4" in 48 hours is predicted to double by mid-century.

**FIGURE 12 - HISTORICAL (GREY) AND PROJECTED LOWER EMISSIONS (BLUE) AND HIGHER EMISSIONS (RED) AVERAGE NUMBER OF PRECIPITATION EVENTS PER DECADE WITH MORE THAN 4 INCHES OF RAIN IN FORTY-EIGHT HOURS, SHOWN AS THIRTY-YEAR AVERAGES FOR SOUTHERN NEW HAMPSHIRE.**



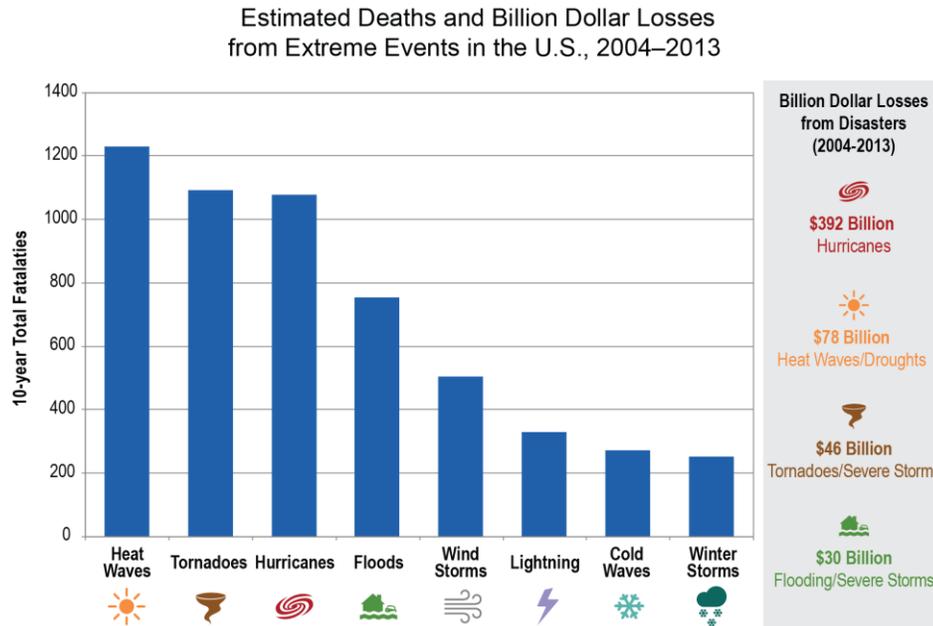
### *THE CLIMATE-HEALTH CONNECTION*

While there are some obvious direct impacts resulting from extreme weather events such as death and injury during the event, there are many other health outcomes that occur before and after an event in either preparing for the storm and clean up afterwards. In addition, some health outcomes can develop long after the event as a result of the loss of infrastructure and public services, loss of property, economic and social impacts, and environmental degradation (Bell, 2016). Because of the complex interactions that take place surrounding an extreme weather event, predictions of future health burdens due to extreme weather are not available in the literature (Bell, 2016).

However, it can be estimated that the direct and indirect effects of severe weather events and the associated flooding from extreme precipitation events are likely to increase. Direct impacts include physical injuries and in some cases death, including drowning in floods and structural collapse of buildings

and infrastructure. Indirect effects outnumber the direct and will usually be more costly to the community. Access to health services may be compromised due infrastructure damage; road washouts, power outages, and disruptions to delivery schedules can impact people who use medical devices that require electricity or depend on regular prescription refills. In addition, storms and flooding can pollute water supplies, lead to food spoilage during power outages, result in exposure to mold from flooded basements, and worsen immediate and chronic health effects (Wake, Bucci, & Aytur, 2014).

**FIGURE 13 - ESTIMATED DEATHS AND BILLION DOLLAR LOSSES FROM EXTREME EVENTS IN THE UNITED STATES 2004–2013 (U.S. GLOBAL CHANGE RESEARCH PROGRAM, 2015).**



Wake et al. provides a list of health effects associated with extreme weather:

- Increases in respiratory and diarrheal diseases because of crowding of survivors, often with limited shelter and access to potable water;
- Effects on mental health that may be long lasting in some cases (see Extreme Weather & Mental Health Impacts section)
- Reduced nutritional status, especially among children;
- Increased risk of water-related diseases from disruption of water supply or sewerage systems (see Water Quality & Related Disease section);
- Exposure to dangerous chemicals or pathogens released from storage sites and waste disposal sites into floodwaters
- Substantial indirect health impacts can also occur because of damage to the local infrastructure (such as damage to clinics and roads) and population displacement

Snow storms and ice storms can also impact human health through power outages, downed power lines, and damage to the electrical system that increase risk of electrocution and fire. The loss of electricity and reliable heat sources can lead to improper use of alternative heat sources and consequently carbon monoxide poisoning and death (Bell, 2016).

*VULNERABLE POPULATIONS*

Populations that are vulnerable to extreme weather events include the economically disadvantaged, homeless populations, people who live in flood-prone areas or on steep slopes, people who lack reliable access to transportation or are geographically isolated, people who are socially or linguistically isolated, and people with pre-existing conditions. People who use healthcare equipment that requires reliable power supply may be vulnerable to power outages, especially if they do not own a backup generator. During emergency response situations, first responders and emergency personnel are at high risk due to exposure to extreme weather conditions.

## EXTREME WEATHER & MENTAL HEALTH IMPACTS

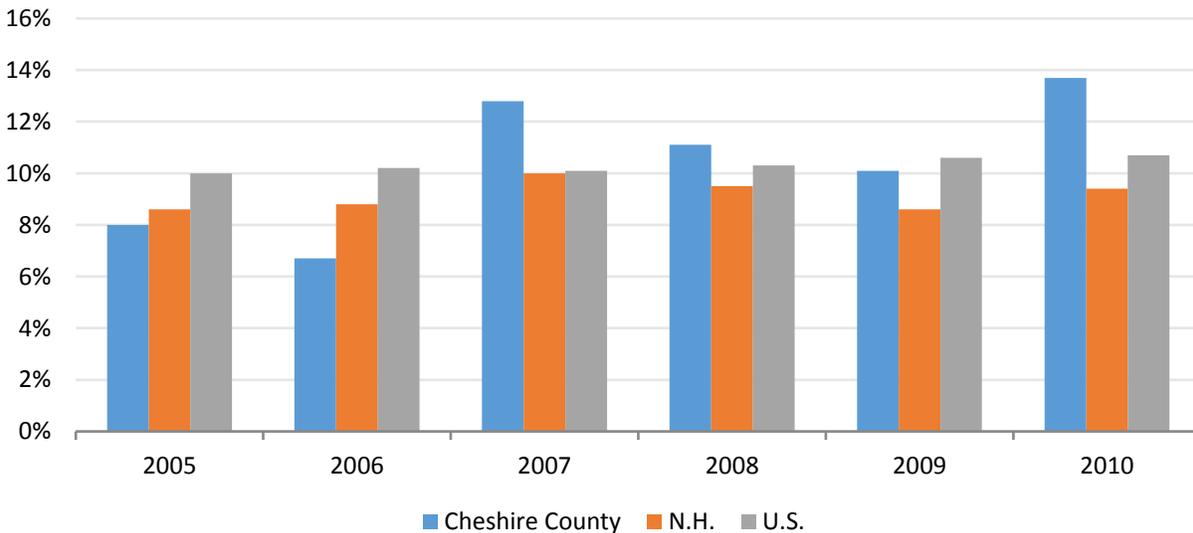
### BACKGROUND

Mental health is defined as a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively, and is able to make a contribution to his or her community. Wellness includes the mental, emotional, physical, occupational, intellectual, and spiritual aspects of a person’s life (Substance Abuse and Mental Health Services Administration, 2016).

It is estimated that 26.2% of Americans over the age of 18 suffer from a diagnosable mental health disorder in a given year; 9.5% suffer from mood disorders, and 6% suffer from serious mental illness (Wake, Bucci, & Aytur, 2014). If New Hampshire is consistent with the rest of the nation, this suggests that more than 250,000 adults have a diagnosable mental disorder in the state. Among children ages 5 to 19 in New Hampshire, it is estimated that as many as 55,756 have a diagnosable mental health disorder and almost 14,000 have a serious emotional disturbance (Greater Monadnock Public Health Network, 2015).

Currently, the demand for treatment exceeds the State’s capacity to respond. The public mental health system provides services to only 21% of adults who live with serious mental illnesses in the state, and NH ranks second to last in the nation for people in need of substance abuse treatment being able to access adequate care. Of the 130,000 New Hampshire residents estimated that need treatment for alcohol and other drug disorders, less than 5% per year are able to access treatment (Greater Monadnock Public Health Network, 2015).

**FIGURE 14 - PERCENTAGE OF ADULT POPULATION EXPERIENCING FREQUENT MENTAL HEALTH DISTRESS IN CHESHIRE COUNTY (TEAL), N.H. (ORANGE), AND THE U.S. (GRAY) FROM 2005-2010. SOURCE: NH BEHAVIORAL RISK FACTOR SURVEILLANCE SURVEY**



Cheshire County has a higher percentage of people experiencing mental health distress than the rest of the State, with 13.7% experiencing mental health distress in Cheshire County compared to 9.4% for the State in 2010 (Greater Monadnock Public Health Network, 2015). According to Monadnock Family

Services, between 2007 and 2014 the number of adult patients served increased from 457 to 1,046, an 87% increase (Greater Monadnock Public Health Network, 2015). In the Monadnock Region, the portion of the community experiencing more than 14 poor mental health days per month is trending upward from 8% to almost 14% between 2005 and 2010 (Greater Monadnock Public Health Network, 2015).

### *THE CLIMATE-HEALTH CONNECTION*

The mental health effects of severe weather events and natural disasters has been studied for the past 30 years, and the link between these weather disasters and extreme anxiety reactions has been well established (Berry, 2010). As the frequency and severity of these extreme weather events increase in the region, so do the exposures of the precursors to PTSD- injury, danger, death, and harm to family and friends.

Extreme heat events have been linked to higher rates of criminal and aggressive behavior and suicide, along with diminished mental task capacity and increased risk of accidents (Berry, 2010). One study demonstrated that existing mental health conditions tripled the risk of any-cause mortality during a heat wave (Berry, 2010). According to the World Health Organization, in any emergency, it is estimated that the number of people with mental health disorders increases by 6-11%. In addition to acute weather events like hurricanes and tornadoes, there are also chronic weather changes that impact mental health such as persistent extreme heat and drought. Climate change also causes precipitation to fall in extremes (too much or too little) and outside of the periods needed for particular agricultural purposes. These longer-term changes and stressors are associated with increased mental health problems (Berry, 2010).

While the degree to which mental health will be impacted by climate change is uncertain, it is reasonable to expect that as the climate changes and the frequency and intensity of severe weather events increase, mental health impacts will increase as well.

### *VULNERABLE POPULATIONS*

Young people are particularly vulnerable to PTSD and the social and emotional factors that predispose one to it (Berry, 2010). Children have been identified as at risk for distress, anxiety, and other adverse mental health effects after an extreme weather event (Dodgen, 2016). After a disaster, women are more likely to report having symptoms of stress and are more likely to have mental health disorders than men in general. The elderly population (65 or older) is also vulnerable due to physical health problems that are often associated with the development of mental health problems and higher rates of untreated depression. Other vulnerable groups include the economically disadvantaged, emergency workers and first responders, and the homeless (Dodgen, 2016).

## SHIFTS IN ECOLOGICAL CONDITIONS & VECTOR-BORNE DISEASE

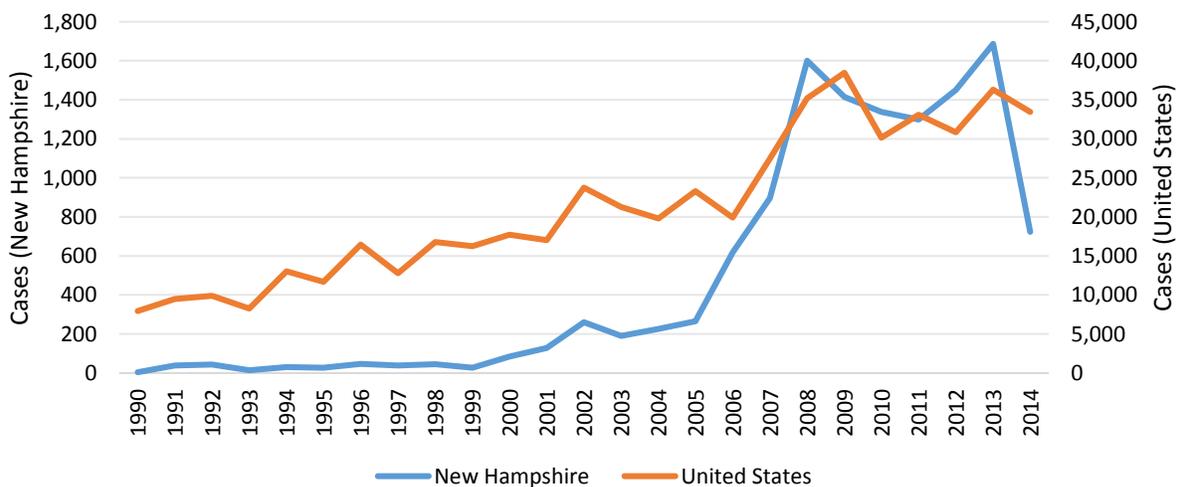
### BACKGROUND

Vector-borne diseases are infections (bacterial and viral) transmitted to humans from mosquitoes, ticks, and fleas. Examples in the Monadnock Region include tick-borne diseases such as Lyme disease (LD) and mosquito-borne diseases such as West Nile Virus (WNV), Eastern Equine Encephalitis (EEE), and potentially Zika Virus.

The most common tick-borne diseases in the State include Lyme disease, anaplasmosis, and babesiosis (New Hampshire Department of Health and Human Services, 2016). LD is the most common vector-borne disease in the United States, and the early symptoms include a “bull’s eye” rash, headache, fever, fatigue, stiff neck and muscle or joint pain. If not treated, the complications may include nervous system disorders, heart abnormalities, and intermittent episodes of joint swelling and pain. LD and other tick-borne diseases are transmitted through the bite of the blacklegged tick, commonly known as the deer tick, most often in its nymph stage. Nymphs are active in the late spring and summer, usually May through August, which correspond to the months with the highest number of reported Lyme disease cases in the state.

Between 1990 and 2014, 12,500 confirmed or probable New Hampshire cases were reported to the CDC (Lyme Disease Association). Nationally, and according to 2001-2010 data, reported cases of Lyme diseases are most common among boys, aged 5-9 and the most frequent months of disease onset were June, July, and August. In New Hampshire, the highest Lyme disease rates are in Rockingham, Strafford, and Hillsborough counties. According to 2014 figures, New Hampshire is second only to Vermont in the number of cases per 100,000 population.

Figure 15 - Total Lyme Cases Reported by CDC 1990–2014<sup>1</sup>



<sup>1</sup> Following its implementation in 1991, the national surveillance case definition for Lyme disease was modified in 1996 and again in 2008. Changes were generally minor but may have had some impact on surveillance and must be considered when attempting to interpret trends. The revision in 2008 resulted in the inclusion of probable cases.

Mosquito-borne diseases include WNV, EEE, and potentially Zika virus. EEE and WNV are arboviral illnesses that are spread through infected mosquitoes. Most years, WNV is the most common mosquito borne disease in the United States. The virus is transmitted to people by mosquitoes that have contracted it from infected birds, the main host of the virus.

In New Hampshire, the arboviral surveillance season runs from July 1 through September 30 and the results are published weekly, which corresponds to the peak transmission of WNV to humans during the summer months when the temperature is highest and mosquitoes are the most active. WNV causes no symptoms in the majority (70-80%) of those infected, however those that do experience symptoms develop headache, muscle or joint pain, rash, or gastrointestinal problems. Less than 1% develop neuro-invasive disease that affects the brain. These cases account for nearly half of the cases reported to the CDC from 1999 to 2014. There is significant under-reporting of cases, with 30,700 cases reported in the US from 1999 to 2010 out of an estimated 3 million infections and 780,000 estimated to have symptoms of the illness. WNV and other arboviruses are rare in NH, with only 2 cases of WNV reported since 2011.

#### *THE CLIMATE-HEALTH CONNECTION*

Climate change is expected to be one of the most important drivers of infectious disease in the future by shifting the seasonality, distribution and pervasiveness of vector-borne diseases (Wake, Bucci, & Aytur, 2014) (Charles Beard, 2016). Warming temperatures, changing precipitation patterns, and more severe weather events will affect the aquatic habitats that mosquitoes breed in and the rate that both the mosquitoes and virus reproduce. Higher temperatures accelerate the mosquito life cycle, the biting rates, and the viral replication rates in the host. This changes the distribution and prevalence of the mosquitoes in any given year. In addition, shorter, warmer winters change the migration and breeding patterns of the birds that are the natural hosts of WNV, although it is still unknown how this will affect WNV transmission.

Ticks thrive and are the most pervasive when there is high humidity (>85%), temperatures are above 45°F, and there is access to a large population of hosts. Climate change in the Monadnock Region is affecting all three of these factors. The warming temperatures and increase in precipitation, primarily in the form of rain, lead to a projected increase in suitable tick habitat. The warmer temperatures in spring, summer and fall also accelerate the life cycle of the tick, increase egg production, and increase population density. In addition, because ticks are active above 45°F, shorter winters could extend the time each year that humans are exposed to Lyme disease. It is projected that the warming winters and springs in the Northeast will lead to earlier annual onset of LD.

Climate change can also affect the host population for black-legged ticks. Deer are not the only hosts for blacklegged ticks, and it is actually the white-footed mouse and other hosts that carry the bacteria that causes Lyme disease. Specific types of land cover are associated with the habitat of certain vector and reservoir hosts. As these habitats change and shift with climate change, we are expected to see changes in where we see these species, and the diseases they carry.

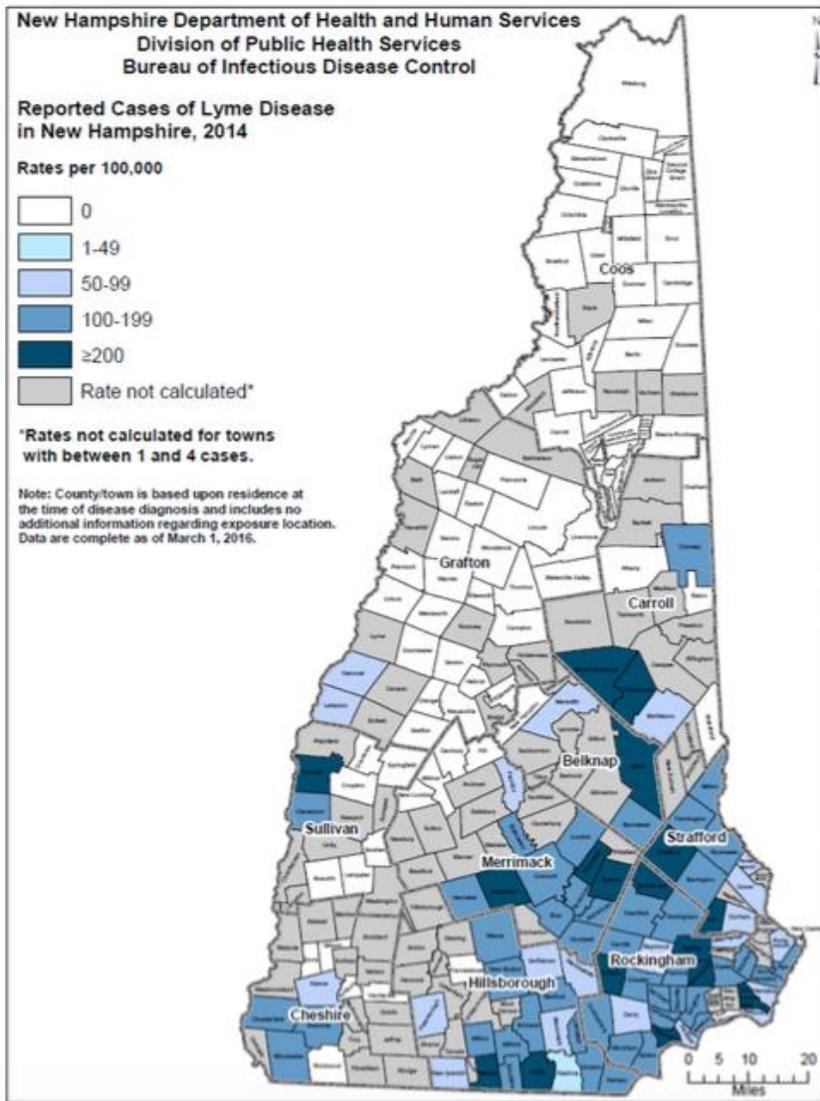
The Monadnock Region has already been experiencing the changes predicted above. The home range of the black legged tick has been expanding, as documented by the tick studies done by the University of New Hampshire extension. This increase possibly reflects the expansion of the range of the vector species,

changes in the habitat of the primary host species, changes in development and recreational patterns, but also the changes in the diagnosing and reporting of Lyme disease.

*VULNERABLE POPULATIONS*

Age and gender are clear risk factors for Lyme disease, WNV and other vector borne diseases. Lyme disease and WNV disproportionately affect children, who are more likely to play outside, and adult males, due to outdoor work and recreational habits. Maps are available from the state for the past 9 years showing incidents reported by town. Although the towns in the Monadnock Region with the highest rates shift from year to year, they tend to be in the southwest portion of the county, with Keene routinely showing up.

FIGURE 16 - REPORTED CASES OF LD IN NEW HAMPSHIRE BY TOWN, 2014. SOURCE: NH DHHS



## EXTREME HEAT & HEAT STRESS

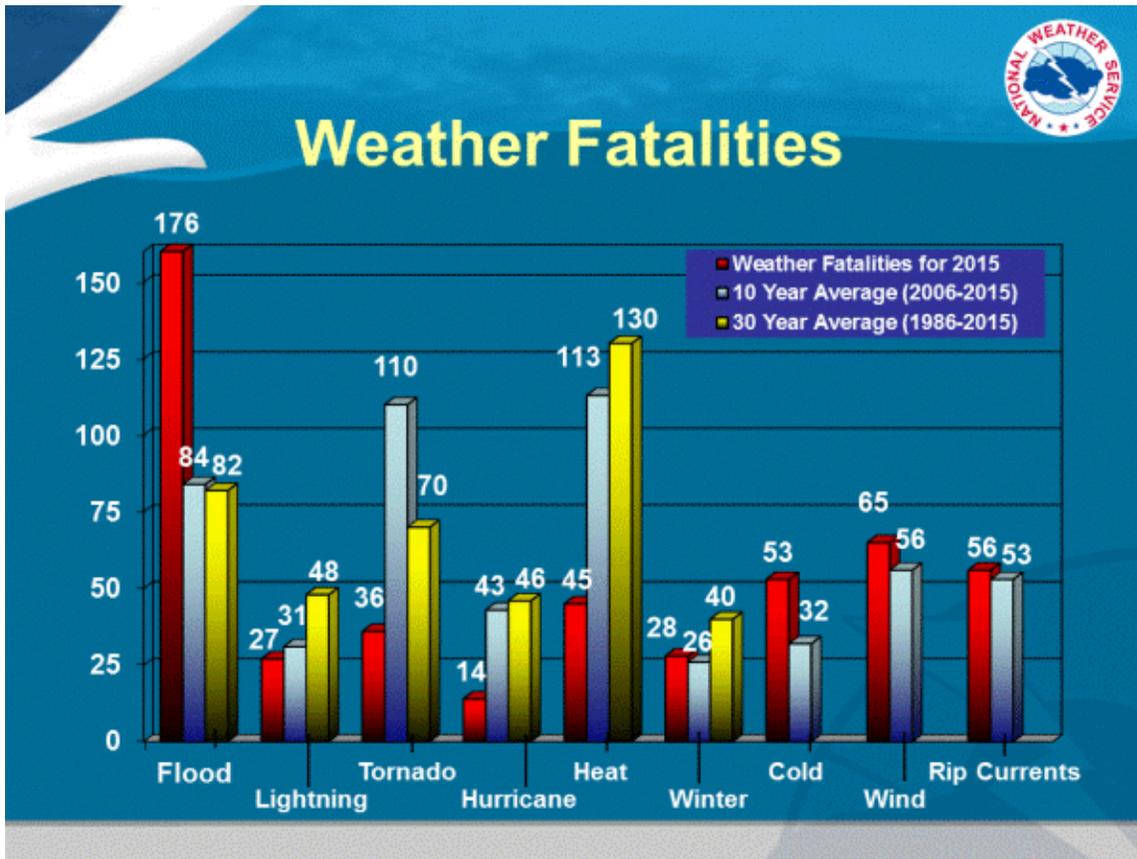
### *BACKGROUND*

Extreme heat events are defined by the EPA as “periods of summertime weather that are substantially hotter and/or more humid than typical for a given location at that time of year” (Center for Disease Control and Prevention). In the NH Climate Change and Health Impact Assessment, extreme heat is calculated using days over 90°F, days over 95°F, and the average temperature on the hottest day of the year (Wake, Bucci, & Aytur, 2014).

Extreme heat events can result in hospitalizations for cardiovascular, kidney, and respiratory disorders, along with heat exhaustion, hyperthermia, heat cramps, sunburns, and heat rashes (U.S. Global Change Research Program, 2016). If the body is unable to return to a normal temperature, organs can shut down and result in heat stroke and death (Wake, Bucci, & Aytur, 2014). From 1999 through 2009, extreme heat exposure caused or contributed to more than 7,800 deaths in the United States, making it the leading cause of weather-related deaths from 2000 to 2009 (Center for Disease Control and Prevention).

It can be difficult to link temperature and death due to a lack of consistent reporting of diagnosis on death certificates and because health complications from heat vary from location to location and over time. It also can be difficult to identify heat as a factor that exacerbated an existing medical condition and medical records do not include the weather at the time of the medical event (U.S. Global Change Research Program, 2016). It is therefore generally accepted that direct attribution studies underestimate the number of people who die from extreme temperatures. However, predictions can be made using statistical studies that combine the climate modeling of future temperatures with estimates about how health and temperature are related (U.S. Global Change Research Program, 2016).

FIGURE 17 - WEATHER FATALITIES IN THE UNITED STATES FOR 2015 (RED), 2006-2015 (BLUE), AND 1986-2015 (YELLOW). SOURCE: NATIONAL WEATHER SERVICE



In New Hampshire, heat-related mortality is relatively unusual, resulting in between 0 and 3 deaths per year from 2000 to 2014 (NH Department of Health and Human Services, 2016). Typically, in-patient hospitalizations for heat are linked to older adults. However, heat-related emergency department visits are just as likely to be tied to a younger population cohort. The rate of heat-related hospital visits in Southwest NH is 1.49 per 10,000 (2005-2009), which is not statistically different from the rate for the State, which is 1.47 per 10,000 (2005-2009). There were a total of 153 heat-related hospital visits in the Monadnock Region from 2005 to 2009 (NH Department of Health and Human Services, 2016).

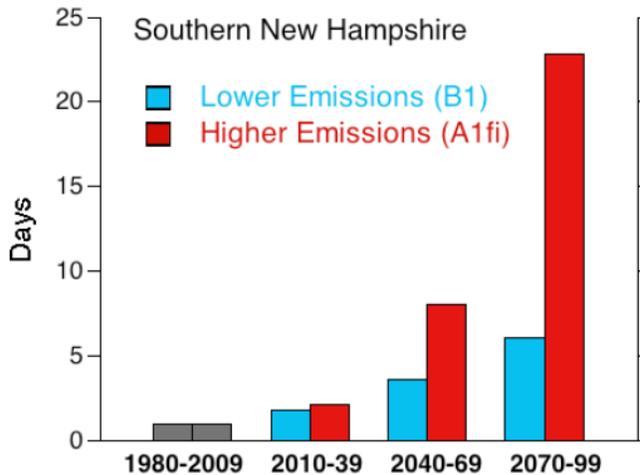
According to historical data originating from Keene, there has not been a statistically significant increase in the number of high-heat days over the past three decades. Rather, most of the warming has occurred during winter months. On average, the number of days over 90°F in Keene from 1981-2013 was 7.3 days/year, and days with a maximum temperature of 95°F followed a similar pattern, averaging 1.2 days/year from 1981-2010.

*THE CLIMATE-HEALTH CONNECTION*

Despite historical trends, the Monadnock Region is projected to see an increase in extreme heat days over the next 20 years (Wake, Bucci, & Aytur, 2014). Historical data shows that Southern New Hampshire has experienced about 6.7 days per year over 90°F and about 1 day per year over 95°F (1980-2009). In the

short term, the number of days over 90°F are expected to increase by 4.2 days/year and 5.2 days/year under low and high carbon emissions scenarios, respectively (2010-2039). Days over 95°F are expected to increase by 0.8 days/year and 1.2 days/year under low and high carbon emissions scenarios, over the same time period (Wake, Bucci, & Aytur, 2014).

**FIGURE 18 - AVERAGE NUMBER OF DAYS ABOVE 95°F PER YEAR, HISTORICAL (GREY) AND PROJECTED LOWER EMISSIONS (BLUE) AND HIGHER EMISSIONS (RED), SHOWN AS 30-YEAR AVERAGES FOR SOUTHERN NH. PROJECTED VALUES REPRESENT THE AVERAGE OF FOUR AOGCM SIMULATIONS. SOURCE: WAKE, BUCCI & AYTUR, 2014.**



The average temperatures on the hottest days are also increasing. For Southern New Hampshire, the temperature on the hottest day of the year is projected to increase, on average, 3 to 5°F by the middle of the century (Wake, Bucci, & Aytur, 2014).

As the number of high heat days and temperature on the hottest day of the year increase, it is likely that there will be an associated increase in heat-related illness and death. Under a high emissions scenario and assuming a direct relationship between heat-related mortality rates, heat-related hospital discharges, and the projected increase in high heat days above 95°F, the mortality rate and hospital discharge rate could increase by an order of magnitude by the end of the century due to warming (Wake, Bucci, & Aytur, 2014).

### *VULNERABLE POPULATIONS*

The elderly and those with pre-existing health conditions are most susceptible to heat. According to populations estimates created by the New Hampshire Office of Energy and Planning (2013), it is estimated that the proportion of the Monadnock Region's population 65 years and older will increase from 15% to 26% of the total population between 2010 and 2040, a more rapid shift than any other age group. Although the majority of households in the northeast are equipped with air conditioning (86%), according to the U.S. Energy Information Administration (2009), nearly 1 in 3 housing units in Southwest New Hampshire are over 75 years old, making them less likely to be air conditioned. And, air conditioning access is known to be reduced for low-income households, especially those below the poverty line (nationally, 18%) (U.S. Energy Information Administration, 2009). In addition to age and lack of air

conditioning, other risk factors to heat include lower socioeconomic status and socially isolated individuals (Wake, Bucci, & Aytur, 2014).

According to the State of New Hampshire Excessive Heat Plan, the following groups are identified as vulnerable to heat emergencies:

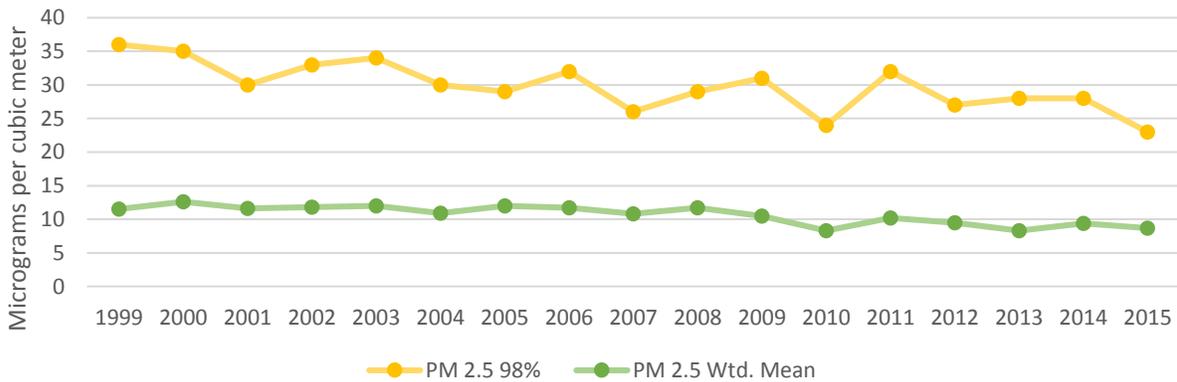
- Older persons (65 years old and older);
- Infants and young children;
- Women who are pregnant;
- People with a mental illness or who are under the influence of drugs or alcohol;
- Those with chronic diseases such as heart conditions, diabetes, obesity, and high blood pressure;
- People with mobility restrictions;
- People engaged in rigorous outdoor work or exercise;
- Those living in poverty;
- The homeless;
- People who are socially isolated;
- Non-English speaking people who may not have access to current information; and
- People living in older buildings or lacking air conditioning. (Department of Health and Human Services, 2014)

## AIR QUALITY & RESPIRATORY DISEASE

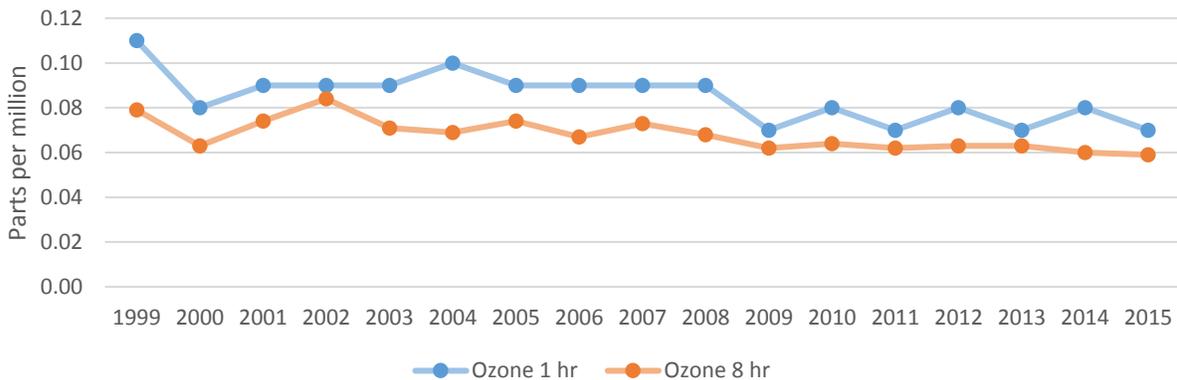
### BACKGROUND

Air quality is affected by various factors, including the atmospheric concentrations of ozone (O<sub>3</sub>), particulate matter, sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and carbon monoxide (CO). Of these, ground level ozone and particulate matter pose the greatest public health threat. Fine particulate matter can get deep within the lungs and cause premature death, aggravated asthma, decreased lung function, coughing, or difficulty breathing. Ozone is a lung irritant and is linked to increased hospital visits for respiratory illness, diminished lung function, exacerbation of asthma symptoms and chronic obstructive pulmonary disease (COPD), and increased risk of premature mortality (Wake, Bucci & Aytur, 2014). It has also been related to adverse birth outcomes and lung cancer (WISDOM). Fine particulate matter in New Hampshire is on a downward trend across the state, according to NH DES data.

**FIGURE 19 - KEENE, NH TRENDS IN PM 2.5 98TH PERCENTILE OR (DESIGN VALUE) AND WEIGHTED MEAN (ANNUAL AVERAGE)**



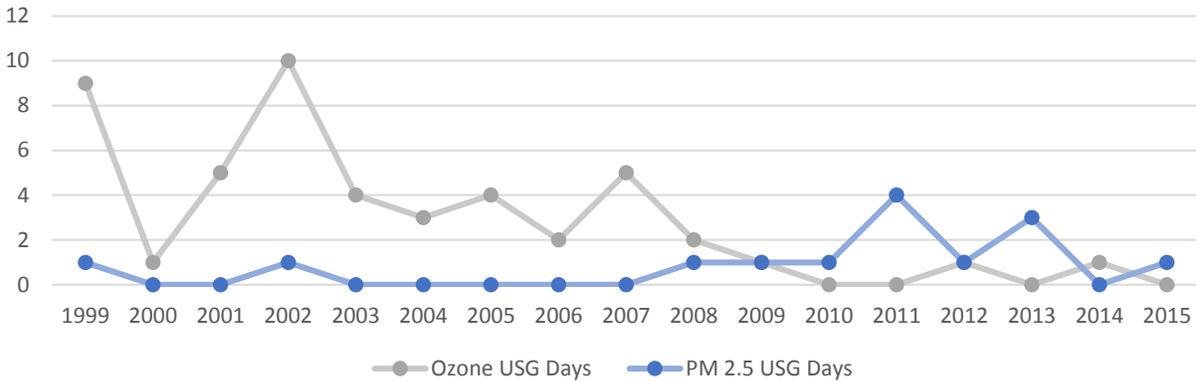
**FIGURE 20 - KEENE, NH TRENDS IN OZONE 4<sup>TH</sup> HIGHEST DAILY MAXIMUM (8-HOUR) AND 2<sup>ND</sup> HIGHEST DAILY MAXIMUM (1 HOUR)**



Data for ozone in Cheshire County shows a downward trend in the number of ozone exceedance days (NH Department of Health and Human Services, 2016). The data has only been monitored since 2004 and modeled back to 2001. In 2001 and 2002, it was modeled that Cheshire County was seeing 9-10 days over

the regulatory standards (75 ppm or parts per million for this time frame, currently 70 ppm as of 2015). From 2003-2008 the county averaged 2 days a year in exceedance. The period 2009-2011 has no days over the standard for ozone (NH Department of Health and Human Services, 2016).

**FIGURE 21 - DAYS AIR POLLUTION WAS "UNHEALTHY FOR SENSITIVE GROUPS" AS MEASURED IN KEENE, NH**



Similarly, small particle air pollution annual levels have been trending downward in Cheshire County. Since 2001, they have not been above regulatory standards ( $12\mu\text{g}/\text{m}^3$ ). In 2001 they were modeled at  $11.2\mu\text{g}/\text{m}^3$  and as of 2011 were monitored at  $8.5\mu\text{g}/\text{m}^3$ . However, short term air pollution measured in 24-hour periods is much more variable and is susceptible to local wood-burning practices and wintertime temperature inversions (NH Department of Health and Human Services, 2016).

#### *THE CLIMATE-HEALTH CONNECTION*

Warmer temperatures will increase ozone production, especially in more densely populated areas during the summer. The warmer temperatures increase the reaction rates that produce ozone and also increase emissions of natural ozone precursors (i.e. volatile organic compounds) from plants. With a longer growing season also comes a lengthening of the “summer” ozone season. However, with warmer winter temperatures, there is a possibility that less particulate matter will be released from home heating in the winter months, although the impact of climate change on particulate matter has been inconclusive (Wake, Bucci & Aytur, 2014).

The lengthening of the ozone season into late spring and early fall, along with the projected increase in summertime ozone is likely to lead to more air pollution-related illness and death in southern NH. Research has shown that with these changes to ground level ozone, future pediatric asthma emergency department visits will increase (Wake, Bucci & Aytur, 2014). Research has linked extreme temperature and ozone pollution to increased mortality. However, because ozone is high when temperatures are high, it is difficult to attribute the number of deaths to ozone alone.

#### *VULNERABLE POPULATIONS*

People who have pre-existing asthma or other respiratory illnesses, and those who work or play outside, young people, and the elderly can be more vulnerable to air pollution.

## LONGER GROWING SEASON & ALLERGENS

### BACKGROUND

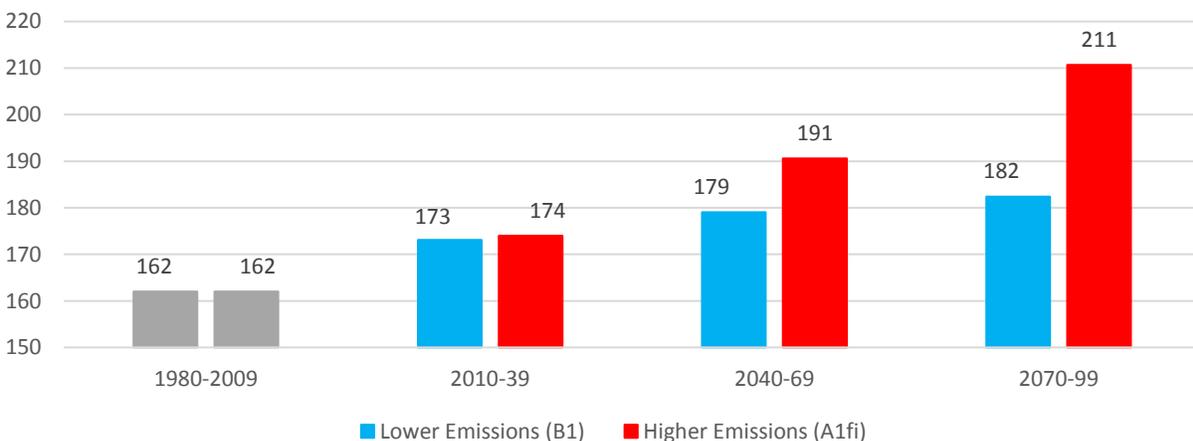
An allergic condition is a hypersensitivity disorder in which the immune system reacts to substances in the environment that are normally considered harmless, such as pollen and mold. Allergic diseases, including asthma, allergic rhinitis (hay fever), and atopic dermatitis (eczema), are among the major causes of illness and disability in the United States, affecting approximately 50 million Americans nationwide (Portier CJ, 2010, April 22).

According to data collected by the Center for Disease Control and Prevention, the prevalence of allergic diseases such as asthma has been increasing. Between 2000 and 2009, the rate of inpatient hospitalizations for females due to asthma in New Hampshire rose from 9.5 to 11.26 per 10,000 population. Asthma currently affects approximately 6.9% of children in the Greater Monadnock health region and about 9.6% of adults, and the lifetime prevalence for adults in the region is 11.7% (WISDOM, 2014).

### THE CLIMATE-HEALTH CONNECTION

Climate change, which is expected to result in higher temperatures, a longer growing season, and increased levels of atmospheric carbon, can affect the timing and length of the pollen season and elevate production of plant-based allergens. (Wake, Bucci & Aytur, 2014). Over the next 25 years, the growing season in New Hampshire will likely extend by nine to twelve days across the state. By the end of the century, the growing season is projected to be three to seven weeks longer, depending on the emissions scenario (Wake, Bucci & Aytur, 2014).

**FIGURE 22 - HISTORICAL (GREY) AND PROJECTED LOWER EMISSIONS (BLUE) AND HIGHER EMISSIONS (RED) AVERAGE LENGTH OF THE GROWING SEASON (USING A THRESHOLD OF 28°F), SHOWN AS 30-YEAR AVERAGES FOR SOUTHERN NEW HAMPSHIRE (AVERAGE OF 25 STATIONS). SOURCE: WAKE, BUCCI & AYTUR, 2014.**



Higher pollen concentrations and longer pollen seasons can increase allergic sensitizations and asthma episodes, and diminish productive work and school days. However, additional information is needed to address the impact of climate change on allergens. According to the report *Climate Change and Health in New Hampshire*, New Hampshire lacks specific data on how the length and intensity of the pollen season

has changed over time or how allergic reactions, asthma episodes, or lost work or schools days has been impacted by climate change. The report continues to say, “While projections of pollen load are available, there is little to no quality data for New Hampshire that has been used to develop these projections. To address this gap, the development of environmental health indicators for pollen load and presence of ragweed have been recommended” (Wake, Bucci & Aytur, 2014).

#### *VULNERABLE POPULATIONS*

In general, the prevalence of asthma is higher among groups with a higher body mass index and among women (CHIP, 2014?). Allergic conditions are the most common health issue affecting children in the U.S., affecting approximately 10 percent of children under 18 years (National Institute of Allergy and Infectious Diseases, 2016). Persons with pre-existing allergies are also sensitive to increased pollen loads and longer pollen seasons.

People who recreate or work outdoors have a high risk of exposure. In the case of asthma, poor control can be attributed to inadequate health insurance, including coverage for drugs, and reduced access to primary care.

## FLOODING, DROUGHTS, & WATER QUALITY

### *BACKGROUND*

Waterborne diseases are caused by a wide variety of pathogenic microorganisms, biotoxins, and toxic contaminants found in the water we drink, clean with, play in, and are exposed to through other less direct pathways such as cooling systems. Waterborne microorganisms include protozoa that cause cryptosporidiosis, parasites that cause schistosomiasis, bacteria that cause cholera and legionellosis, viruses that cause viral gastroenteritis, amoebas that cause amoebic meningoencephalitis, and algae that cause neurotoxicity (Batterman, 2009). Health impacts of waterborne diseases include gastrointestinal illness (i.e. Giardiasis) and secondarily dehydration.

According to a National Institutes of Health report, surveillance of waterborne pathogens in the United States is inconsistent, as are there related diseases. Further, experts estimate the mortality burden to be negligible. However, a relatively high incidence of mild symptoms is expected (Craun, 2006).

Waterborne disease outbreaks are typically associated with contamination of drinking water supplies. One potential cause of water contamination is flooding, which can contaminate water supplies with oil, gasoline, chemicals, and fecal matter from sewage systems and septic tanks (N.H. Department of Environmental Services, 2008). Bacteria also becomes mobilized during heavy precipitation events, affecting water quality. A 2001 article in the Journal of Public Health reported evidence that 68% of the waterborne disease outbreaks in the U.S. from 1948-1994 were preceded by the largest precipitation events (N.H. Department of Environmental Services, 2008). Private drinking water wells have the highest risk of contamination during flood events, especially wells that are in poor condition (New Hampshire Department of Environmental Services, 2008).

Another potential cause of water contamination is low rainfall conditions when bacteria concentrates (Wake, Bucci, & Aytur, 2014). Mild droughts conditions are relatively common in N.H.; data collected and averaged from weather observations throughout the state over the past 100+ years shows that the State has been in a mild drought condition that has extended for a period of at least three months approximately 25 percent of the time, as shown in Figure 14 (New Hampshire Department of Environmental Services, 2008).

People can also be exposed to water contamination through recreational activities such as swimming. Beaches in NH are routinely tested from Memorial Day to Labor Day for fecal bacteria by the N.H. Department of Environmental Services (NHDES). Otter Brook Lake Beach in Keene is currently rated as “Fair” for 88% of samples coming back clean since 2003 (NH Department of Environmental Services, 2015). It has had 5 fecal advisories since 2003 and a cyanobacteria advisory both last year and currently this year. During the last 5 years, about one-fifth of NH beaches have had at least one advisory in the summer months (NH Department of Environmental Services, 2015).

### *THE CLIMATE-HEALTH CONNECTION*

Waterborne microbial organisms will have a greater impact on human health as the temperature and precipitation increases in our region. Increases in the frequency and intensity of heavy rain events and droughts have been linked to outbreaks of waterborne diseases, algal blooms, and increases in agricultural waste and heavy metals in drinking water sources (Wake, Bucci, & Aytur, 2014).

As discussed previously in the Severe Weather section, the number of precipitation events that dump 4” in 48 hours is expected to double by mid-century (Wake, Bucci, & Aytur, 2014). Hydrologic simulations from the Variable Infiltration Capacity (VIC) model indicate that over the long-term (2070–2099) under the higher emissions scenario, New Hampshire can expect to experience a two- to three-fold increase in the frequency of short-term drought and more significant increases in medium-term drought. Under the low emissions scenario, the frequency of short- and medium-term drought increases only slightly by the end of the century (Wake, Bucci, & Aytur, 2014).

#### *VULNERABLE POPULATIONS*

People with private water wells are at a high risk of exposure to water contamination, especially those with wells that are in poor condition (New Hampshire Department of Environmental Services, 2008). As of 2014, Cheshire County served 15,542 people on groundwater systems, 25,480 people on surface water systems, and 1,250 on purchased surface water. There are 30 groundwater, 2 surface water, and 1 purchased surface water community water systems (NH Department of Health and Human Services, 2016).

In addition, people who are vulnerable due to age, socioeconomic status, pre-existing health conditions, social/linguistic isolation, geographic isolation, and homelessness are at a higher risk of water contamination due to a reduced ability to adapt.

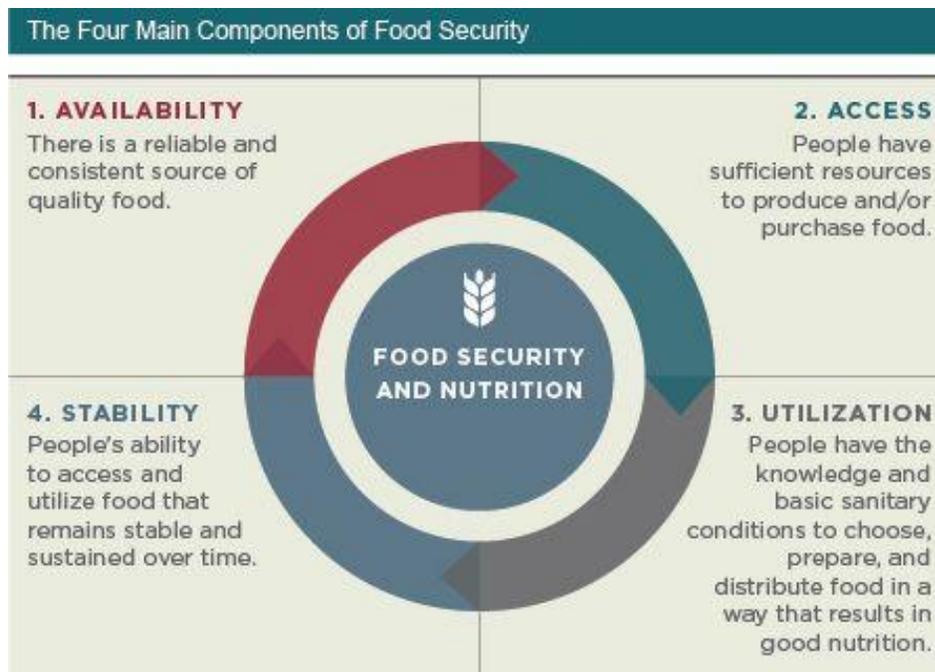
## CLIMATE DISRUPTIONS & FOOD SECURITY

### BACKGROUND

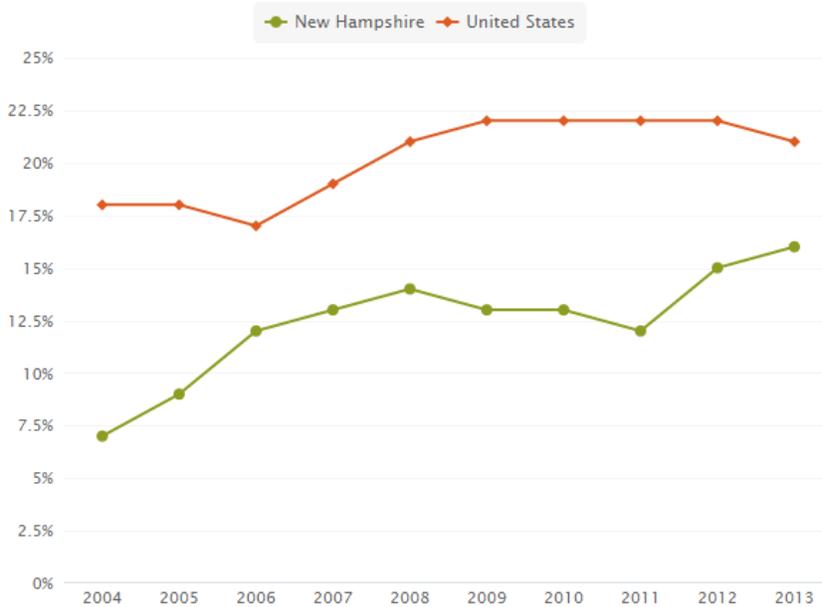
Food security is defined as the state or condition “when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (Brown, 2015). Food security is closely related to water security, which is defined by the United Nations as “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability” (UN-Water, 2014).

The Food and Agriculture Organization of the United Nations (FAO) recognizes four components of food security, including availability (the existence of food in a particular place and time), access (the ability of a person or group to obtain food), utilization (The ability to use and obtain nourishment from food), and stability (The absence of significant fluctuation in availability, access, and utilization).

FIGURE 23 - THE FOUR COMPONENTS OF FOOD SECURITY. SOURCE: UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)



Globally, about 805 million people are food insecure and at least 2 billion live with insufficient nutrients (Brown, 2015). In the U.S., 14.3% of the population is food insecure, even though the country produces over 3,600 kcal per-capita per day (Brown, 2015). According to Census Bureau data obtained by Kids Count, an estimated 43,000 children in New Hampshire were food insecure at some point during 2013, an increase from 13% in 2009. This, however, is relatively low compared to the national figure of 21% (National Kids Count, 2016).



**FIGURE 24. PERCENT CHILDREN LIVING IN HOUSEHOLDS THAT WERE FOOD INSECURE AT SOME POINT DURING THE YEAR IN NEW HAMPSHIRE AND THE U.S. FROM 2004-2013. SOURCE: NATIONAL KIDS COUNT**

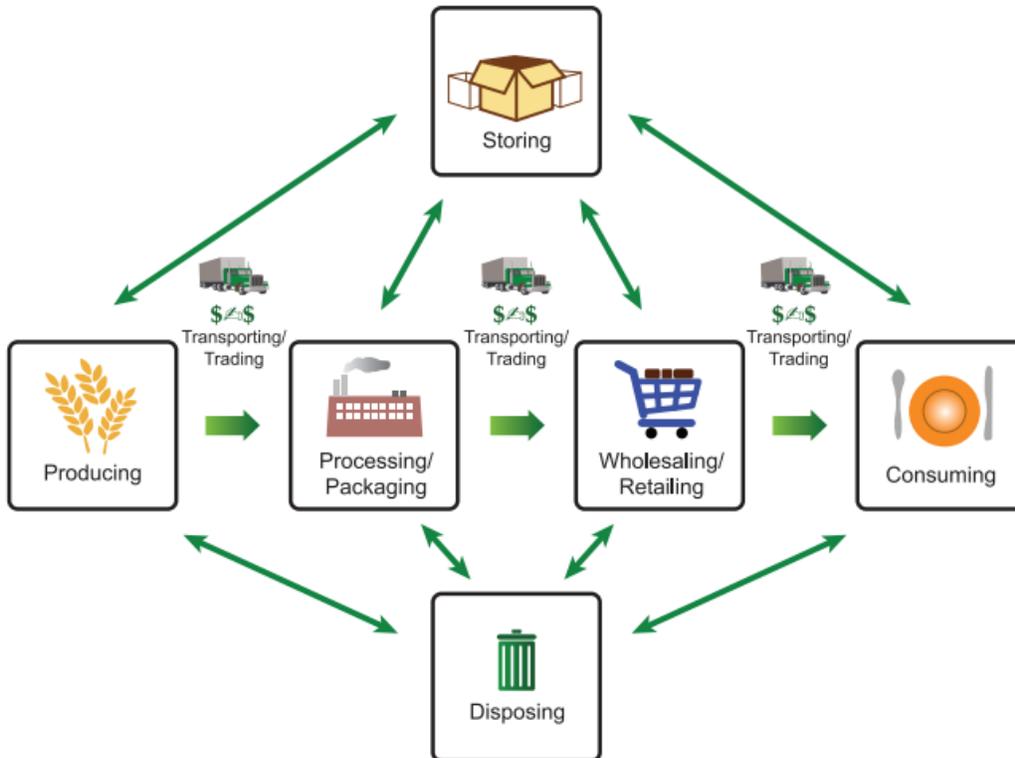
Chronic food insecurity may result in impaired physical and mental health and development and increase risk of chronic disease (Brown, 2015). Undernourishment, which results from an inadequate intake of either calories, nutrients, or both, is an outcome of food insecurity that leads to stunting, wasting, and micronutrient malnutrition (Brown, 2015).

Food security is an outcome of a well-functioning food system as well as external factors, such as trade, food prices, and income (Brown, 2015). Factors affecting food security include:

- Agricultural yields
- Trade (exporting/importing food)
- Food processing
- Packaging and storing food products
- Transportation of food products
- Wholesaling and retailing food products
- Ability of consumers to purchase food
- Disposal of food waste

**FIGURE 25 - FOOD-SYSTEM ACTIVITIES AND FEEDBACKS. FOOD-SYSTEM ACTIVITIES INCLUDE THE PRODUCTION OF RAW FOOD MATERIALS, TRANSFORMING THE RAW MATERIAL INTO RETAIL PRODUCTS, MARKETING THOSE PRODUCTS TO BUYERS**

AND PRODUCT CONSUMPTION. FOOD TRANSPORTATION, STORAGE AND WASTE DISPOSAL PLAY A ROLE IN EACH OF THESE ACTIVITIES. SOURCE: USDA



Impacts to any food system activity has the potential to affect food security outcomes. For example, flooding can result in major damage to transportation routes, which can lead to local supply shortages. Even impacts that occur far away can affect food security; a chronic or severe drought may affect agricultural yields, driving food prices up and restricting the overall food supply (Brown, 2015).

#### *THE CLIMATE-HEALTH CONNECTION*

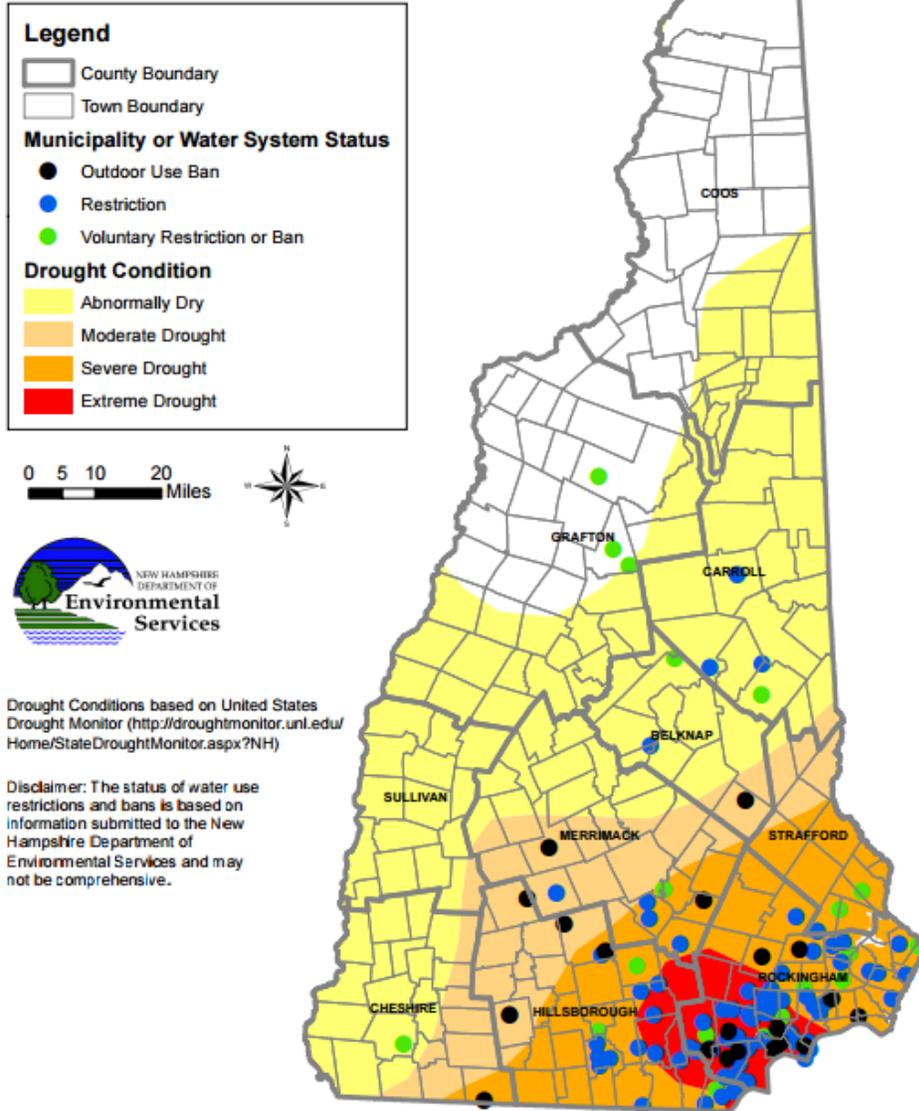
Climate change is expected to affect all four components of food security: availability, access, utilization, and stability (World Food Programme, 2016). Globally, climate change is projected to result in more-frequent disruption of food production in many regions and increased overall food prices. As temperatures rise, exceeding optimum temperatures for crops will steadily reduce productivity up to a threshold, after which productivity decreases sharply. High heat also increases animal stress, especially when coupled with high humidity (Brown, 2015).

Heavy precipitation events coupled with increased drying out of soils will accelerate erosion and degrade soil quality, and local drought conditions combined with a lack of adequate water storage has the potential to affect local yields.

FIGURE 26 - KNOWN WATER USE RESTRICTIONS AND BANS IN NEW HAMPSHIRE AS OF AUGUST 25, 2016. RESTRICTIONS IN THE MONADNOCK REGION INCLUDE A VOLUNTARY RESTRICTION IN SWANZEY AND OUTDOOR USE BANS IN PETERBOROUGH AND RINDGE. SOURCE: N.H. DEPARTMENT OF ENVIRONMENTAL SERVICES

## Known Water Use Restrictions and Bans

Last Update: August 25, 2016



Rising sea levels are projected to cause damage and inundation of critical transportation and distribution infrastructure. For example, given a globally averaged 0.61 m rise in sea level, researchers predict that 64% of the U.S. Gulf Coast region’s ports may be inundated, while an additional 20% of highway arterial miles and 19% of total interstate miles would be at risk by 2100 (Brown, 2015). Locally, increases in the frequency and/or severity of extreme precipitation events has the potential to affect transportation and distribution infrastructure critical to the region.

In response to disruptions to the food system, food supply and prices are expected to become less stable. Another potential impact is an increase in human conflict due to resource scarcity, which can impact global food price volatility. Even if the effects of conflict are not felt directly in NH, the indirect effects, such as increasing food prices, will affect NH families.

#### *VULNERABLE POPULATIONS*

Infants and young children are especially vulnerable to food insecurity as malnutrition results in damaging lifelong health and economic outcomes for these age cohorts (Brown, 2015). Other vulnerable groups include low income individuals, people who isolated geographically or linguistically, the homeless, and people who depend on agriculture for income.

## HAZARD MITIGATION PLANNING IN SOUTHWEST NEW HAMPSHIRE

Hazard Mitigation Planning is about creating long term strategies to eliminate or reduce the risk of natural and man-made hazards, including wildfires, flooding, and hazardous spills. For many years, states and communities have been required to maintain these plans to be eligible for Federal hazard mitigation project funding, such as culvert and bridge improvements. In New Hampshire, hazard mitigation plans, both state and local versions, are coordinated by New Hampshire Homeland Security and Emergency Management. According to the State of New Hampshire Multi-Hazard Mitigation Plan Cheshire County Risk Analysis, major past and potential concerns included flooding, drought, wildfire, radon, tornadic activity, and hurricanes, severe winter weather, and ice storms (New Hampshire Department of Safety, 2013, pp. 132-133). Many of these hazards are related to changes in weather and climate. Others, like radon, have specific and direct impacts on human health. However, hazard mitigation planning at the local and state level considers not only human health but also the destruction of property and infrastructure as areas of concern.

### LOCAL AND REGIONAL VULNERABILITY ASSESSMENTS AND HAZARD MITIGATION PLANS

A variety of local and regional plans also help to explain existing priorities in more detail.

#### **Cheshire Medical Center/Dartmouth-Hitchcock Keene Community Health Needs Assessment**

Last updated in 2013, the routine [assessment](#) and [implementation strategy](#) documents mentioned a variety of the indirect needs of climate-related health hazards, including access to transportation and a variety of services aimed at improving mental health and well-being.

#### **Greater Monadnock Public Health Region Community Health Improvement Plan**

The first-ever plan lists emergency preparedness as priority area 5, and acknowledges that natural public health threats, are all around us (including those linked to extreme weather and climate effects). Goals in support of emergency preparedness included increased partnerships, volunteerism, social connectedness, education, and awareness. Other climate-related health topics mentioned by the plan include food-borne illnesses, asthma, and support for mental health and well-being (Greater Monadnock Public Health Network, 2015).

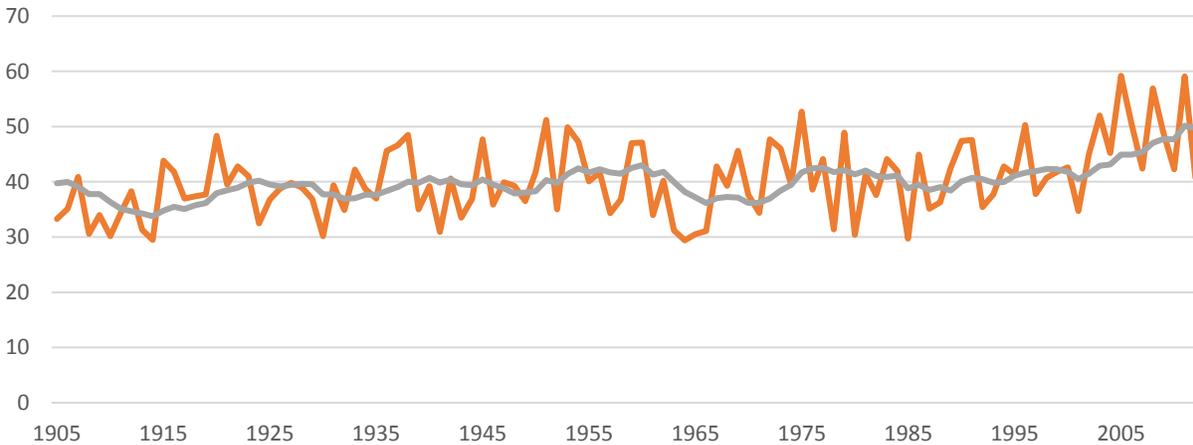
#### **Monadnock Region Future: A Plan for Southwest New Hampshire**

Preparedness is one of four overarching themes of Monadnock Region Future, Southwest New Hampshire's regional plan. The plan includes a total of 48 strategies that directly relate to public health. Unprecedented damage to some areas of the state due to extreme storms, disruptions to energy and food supplies, and emerging infectious diseases all illustrate and reinforce the need for additional steps towards resilience to mitigate these concerns. Key strategies in the public health topic area identified by the plan include expanding awareness of air quality issues such as small particle air pollution, raising awareness about climate change, an incorporating climate adaptation and mitigation strategies as part of natural resources planning (Southwest Region Planning Commission, 2015).

### Climate Change in Southern New Hampshire: Past, Present, Future

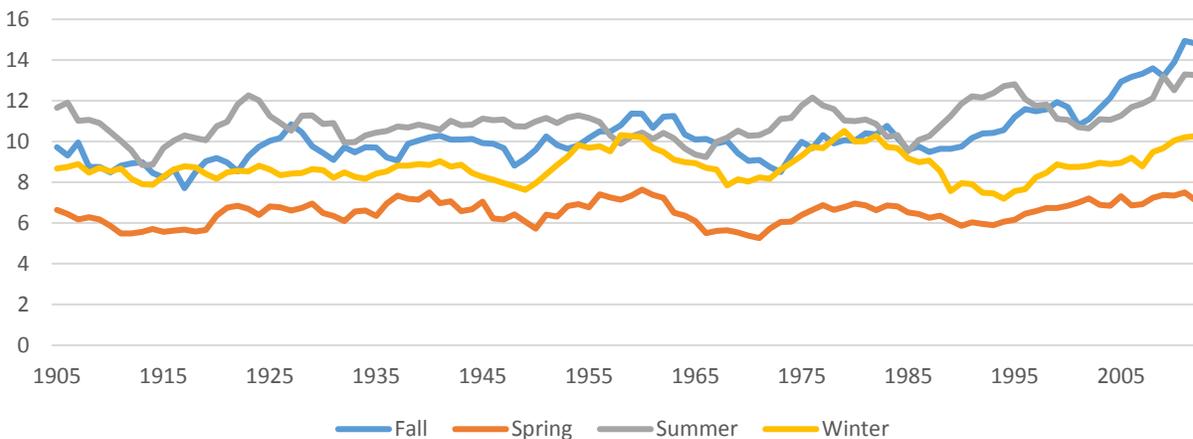
The report brings attention to expected climate effects in the southern portion of the State, the area of highest population concentration. Specifically, the authors predict increasing temperatures, more days above freezing and fewer snow-covered days, longer growing season, and increases in both annual precipitation and the number of extreme precipitation events.

**FIGURE 27 - KEENE ANNUAL PRECIPITATION TOTAL FOR 1895-2012 AND 10-YEAR MOVING AVERAGE (INCHES)**



In particular, historical data indicate more substantial increases in annual fall and summer precipitation amounts.

**FIGURE 28 - KEENE ANNUAL PRECIPITATION TOTAL FOR 1905-2012 (10-YEAR MOVING AVERAGE) BY SEASON (INCHES)**



### Local Hazard Mitigation Plans

In New Hampshire, municipalities also undertake hazard mitigation planning, and are responsible for updating plans every five years. Typically, the plans do not directly consider climate-related health impacts. A total of 30 plans were reviewed with respect to prioritized threats (See appendix x). Topics such as allergens and air pollution were not mentioned in any reviewed plan. Extreme heat appeared in

25 reviewed plans, and was ranked at the lowest and highest ratings of plan risk assessments, depending on the community. A combination of human, property, and business impacts, as well as the likelihood a hazard will occur over a 25 year period result in the overall risk level. Vector-borne disease, water and food supplies, water-borne disease, and mental health and well-being were not listed as part of the risk assessment of any plan. The plans provide the most emphasis and specificity about the impacts of severe weather, which include flooding, tornadoes, high winds, hurricanes and tropical storms, and severe winter weather. These forms of climate-related health hazards were found in almost every local hazard mitigation plan.

### **Other Local Plans**

The City of Keene Cities for Climate Protection Committee addresses the impacts of climate change with a Climate Adaptation Plan (City of Keene, 2007). The Plan addresses specific climate-related health hazards directly, as well as systemically. The public health sector is acknowledged as a vulnerable subsector of the social environment, which also includes the economy and emergency services. The Plan cited specific human health concerns based on research by the Union of Concerned Scientists, which projected increases in poor air quality days as a result of increased ground-level ozone, resulting in early death and increased medical expenses for New Hampshire residents. The same study cautioned that increases in the number of high heat index days and extreme cold index days posed a danger for vulnerable populations, such as children, seniors, and those with existing respiratory-related illnesses. The increase in high heat days in New Hampshire was also expected to increase the incidence of vector-borne illnesses such as West Nile Virus. The Plan proposes specific goals and strategies related to public health as follows:

#### **Goal A: Increase public awareness about the public health implications of climate change, including risks and the need for emergency preparedness.**

- Target A: Provide public education on mosquito and tick protection and disease prevention.
- Target B: Provide public education on emergency preparedness (e.g., creating an emergency food supply, community evacuation procedures, etc.). In developing a public education program, consider the methods available to effectively communicate the issue to a general audience.
- Target C: Provide public education on how to handle flood emergency situations (e.g., toxic substances in basement, electrical lines, etc.).
- Target D: Develop a program that identifies various vector control methods and policies to apply those methods.
- Target E: Anticipate the arrival of new vectors and associated diseases and identify alternative methods to control or eradicate those vectors (develop early detection and warning systems, review the use of spraying and consider the health implications of those actions, etc.).

#### **Goal B: Train and Educate Emergency/Human Services/Public Health officials and workers.**

- Target A: Establish training programs for public health workers to deal with the emotional aspects associated with loss of life and property caused by extreme weather events.

## HEALTH VULNERABILITY ASSESSMENT

The following tables provide a detailed evaluation of eight climate-related health hazards along with a relative ranking of regional priority.

**TABLE 2 - HEALTH VULNERABILITY ASSESSMENT**

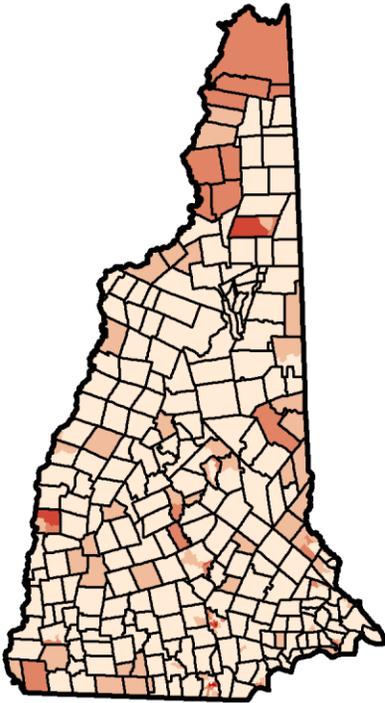
<b>Climate Exposure or Vulnerability</b>	<b>Direct &amp; Indirect Pathways</b>	<b>Health Effects &amp; Impacts</b>	<b>Evidence for Relevance to Southwest New Hampshire</b>	<b>Data Source</b>	<b>Southwest Priority Level</b>
Increased frequency of extreme weather events	Increase in number of days with heavy rain or snowfall, resulting in flooding, power failures, and damage to property	Injury, drowning, death, carbon monoxide poisoning, increased exposure to mold, and contaminated water and food supplies	Based on data from Keene, the region expects an increase number of heavy precipitation events	Plymouth State University	Higher Priority
Shifts in ecological conditions	Extended season for disease vectors like ticks or mosquitoes	Increased cases of disease such as Lyme, EEE, and West Nile. Also introduction of new diseases to the region	Confirmed cases of Lyme Disease	New Hampshire Department of Health and Human Services	Higher Priority
Increased frequency of extreme weather events	Direct and traumatic impacts of weather-related disaster, chronic stress related to post-disaster recovery, depression	Individuals with existing mental health needs and vulnerable populations impacted by stressors such as financial burdens	No effective regional data was available	Climate Change in Southern New Hampshire (2014)	Higher Priority
Rising temperatures	Increased indoor and outdoor heat	Heat stroke, cramps, exhaustion, death, dehydration, and exacerbation of chronic illnesses like respiratory or cardiovascular disease	Based on data from Keene, in the short term, the number of high heat days is not expected to increase	Plymouth State University	Moderate Priority

<b>Climate Exposure or Vulnerability</b>	<b>Direct &amp; Indirect Pathways</b>	<b>Health Effects &amp; Impacts</b>	<b>Evidence for Relevance to Southwest New Hampshire</b>	<b>Data Source</b>	<b>Southwest Priority Level</b>
Degraded air quality	Increase in formation and Inhalation of ozone, Inhalation of fine particulates related to wintertime air pollution	Aggravates asthma and other respiratory diseases, related hospital visits, early death, loss of workdays, school attendance, and reduced physical activity	Continuous air quality monitoring data from Keene already indicate instances of increased wintertime fine particulates	New Hampshire Department of Environmental Services	Lower Priority
Lengthening growing season	Increased exposure to pollen and other allergens	Reduced physical activity, lost workdays, school attendance, and potential for severe complications incl. asthma, cardiac distress, chronic obstructive pulmonary disease, and anaphylaxis.	No effective regional data was available	Climate Change in Southern New Hampshire (2014)	Lower Priority
Increased frequency of flooding and drought conditions	Increased prevalence of water supply contamination	Outbreaks of bacteria such as Giardia, Cryptosporidium, and other microorganisms resulting in gastrointestinal disease	No effective regional data was available	Climate Change in Southern New Hampshire (2014)	Lower Priority
Climate disruptions to the global food system	Food and Water Security	Increased cases of malnutrition and dehydration	No effective regional data was available	Climate Change in Southern New Hampshire (2014)	Lower Priority

## VULNERABLE POPULATIONS

Primary care centers with the most capability are centralized, along with many other services, in the City of Keene and the Town of Peterborough. This can create challenges for residents looking for care. In addition, work led by the Department of Health and Human Services to develop a “Social Vulnerability Index” indicates that many of these communities have risk factors tied to health concerns (i.e. poverty, unemployment, and insurance coverage). According to the index, Winchester, Hinsdale, Swanzey, Rindge and portions of Keene were communities in Cheshire County with multiple risk factors. Communities in Hillsborough County with multiple risk factors were Temple, Sharon, New Ipswich, and Greenville.

FIGURE 29 - NEW HAMPSHIRE SOCIAL VULNERABILITY INDEX



### RATINGS OF PROBABILITY, SEVERITY, AND VULNERABLE POPULATION

The severity of the climate-related health hazard was considered with respect to their probability to increase in the short term (5 years), and the level of confidence around past increases in a given exposure. The following table provides a summary of each climate-driven health hazard, and sources of information used to identify Monadnock Region residents with known risk factors (Table 3).

TABLE 3 - AFFECTED POPULATIONS

<b>Climate Exposure or Vulnerability</b>	<b>Direct &amp; Indirect Pathways</b>	<b>Health Effects &amp; Impacts</b>	<b>Vulnerable Populations and Places</b>	<b>Data Source of Risk to Populations</b>	<b>Locations of Populations At-Risk</b>
<b>Increased temperature and excess heat leading to threats to Air Quality</b>	Increase in formation and Inhalation of ozone, Inhalation of fine particulates related to wintertime air pollution	Aggravates asthma and other respiratory diseases, related hospital visits, early death, loss of workdays, school attendance, and reduced physical activity	Children, especially children with asthma, older adults, and those with pre-existing respiratory diseases, Higher rates of asthma are known to occur in women, less educated and poor	Behavioral Risk Factor Surveillance Survey (BRFSS)/New Hampshire Asthma Control Program (2014), NH DES, Plymouth State University	According to the SVI, Winchester, portions of Keene, and other communities have higher proportions of vulnerable populations with known risk factors
<b>Longer Growing Seasons</b>	Increased exposure to pollen and other allergens	Reduced physical activity, lost workdays, school attendance, and potential for severe complications incl. asthma, cardiac distress, chronic obstructive pulmonary disease, and anaphylaxis.	Persons who: have pre-existing allergies, asthma, or other respiratory illnesses; work or play outside; are homeless, young, or elderly. Nationally, older children are more likely to have a respiratory allergy.	Wake, Bucci & Aytur, 2014, CDC	Precise geographic locations related to this health hazard have not determined.

<b>Climate Exposure or Vulnerability</b>	<b>Direct &amp; Indirect Pathways</b>	<b>Health Effects &amp; Impacts</b>	<b>Vulnerable Populations and Places</b>	<b>Data Source of Risk to Populations</b>	<b>Locations of Populations At-Risk</b>
<b>Longer Growing Season</b>	Extended season for disease vectors like ticks or mosquitoes	Increased cases of disease such as Lyme, EEE, and West Nile. Also introduction of new diseases to the region	Over the last 5 years, 0.067% of the population of Cheshire County has had a reported a case of LD; outdoor workers and children who recreate in wooded and grassy areas	NH DHHS; CDC and The National Institute for Occupational Safety and Health	Male children ages 5 through 15
<b>Increasing occurrence of extreme heat events (days over 90F)</b>	Increased indoor and outdoor heat	Heat stroke, cramps, exhaustion, death, dehydration, and exacerbation of chronic illnesses like respiratory or cardiovascular disease	Persons who have pre-existing issues with food or water access, are vulnerable due to socioeconomic status, social/physical isolation, age of housing unit	Wake, Bucci & Aytur, 2014, Plymouth State University; Social Vulnerability Index, especially: Population over 65 years, Population living below poverty level, and, Housing units more than 30 years old, population under 4 years of age	Residents of older homes, common in Southwest New Hampshire, are less likely to have access to air conditioning
<b>Warming temperatures and changes in precipitation negatively impacting food and water supplies</b>	Food and Water Security	Increased cases of malnutrition and dehydration	Families living below the federal poverty and people who live in areas of low population density, 10 communities in Southwest NH described as moderate or higher food insecurity.	National and International studies; UNH Carsey Institute	Communities with pre-existing issues related to food and water access including “food deserts”.

<b>Climate Exposure or Vulnerability</b>	<b>Direct &amp; Indirect Pathways</b>	<b>Health Effects &amp; Impacts</b>	<b>Vulnerable Populations and Places</b>	<b>Data Source of Risk to Populations</b>	<b>Locations of Populations At-Risk</b>
<b>Threats to Mental Health and Well Being</b>	Direct and traumatic impacts of weather-related disaster, chronic stress related to post-disaster recovery, depression	Individuals with existing mental health needs and vulnerable populations impacted by stressors such as financial burdens	People living in areas prone to disasters such as riverine flooding, first responders	National and International studies	Communities with multiple stressors related to social vulnerability may be more at risk. Rural areas may be more at risk.
<b>Warming temperatures and changes in precipitation leading to increased number of water-borne illnesses</b>	Increased prevalence of water supply contamination	Outbreaks of bacteria such as Giardia, Cryptosporidium, and other microorganisms resulting in gastrointestinal disease	People with direct exposure to contaminated surface water or drinking water	NH DES Populations reliant on private water supplies and surface waterbodies with a history of contamination	The majority of communities in Southwest NH do not have access to public water and sewer systems;
<b>Increased extreme precipitation and occurrence of extreme weather events</b>	Increase in number of days with heavy rain or snowfall, resulting in flooding, power failures, and damage to property	Injury, drowning, death, carbon monoxide poisoning, increased exposure to mold, and contaminated water and food supplies	People living in riverine areas prone to flooding, those living in manufactured housing, vulnerable populations with lower economic means, certain health condition, and mobility	Social Vulnerability Index, especially poverty status, elderly and disabled populations, households without a vehicle	Keene, Hinsdale, Marlborough, Troy, and Peterborough are communities with less access to a vehicle

## ACTION PLAN

### TEAM APPROACH

The first step is forming teams to ensure the right compliment of subject matter experts and stakeholders are present on the project to make it successful. The assessment team has included public health network staff, SWRPC staff, and others with the skills to... The intervention team will need to include SMEs familiar with the specific evidence-based public health actions, depending on whether the focus is marketing, direct education, or environmental change.

### RESOURCES

The plan of action will also need to have enough funds to carry the project through. We estimate the next phase will need the cooperation of a variety of regional stakeholders to implement one or more of the following strategies.

### MEASURABLE GOALS AND OBJECTIVES

#### **Goal 1**

Avoid or mitigate the impacts of extreme precipitation on the health outcomes of residents of the Monadnock region.

#### **Objective 1**

Increase the level of individual resilience to the stressors of extreme precipitation

##### Strategy 1

Connect vulnerable populations with information about preparations that may mitigate health impacts of extreme precipitation and flooding in their own home.

##### Strategy 2

Document and promote community assets offering relevant support services.

##### Strategy 3

Promote the use of design elements that better handle stormwater and floods.

#### **Objective 2**

Improve the capacity, collaboration, and decision-making ability of agencies and other supports tasked with protecting public health against threats from extreme precipitation.

##### Strategy 1

Promote the use of the Social Vulnerability Index by emergency response personnel as a means of identifying areas more vulnerable to isolation (e.g. % of households with a resident living alone, resident over 65 living alone, and % of population reporting a disability)

**Strategy 2**

Promote the use of tools or policies that identify those in most need of assistance to the groups most able to provide help.

**Strategy 3**

Publicize findings and resources of the Climate and Health Adaptation Plan to communities undertaking municipal Hazard Mitigation Plan updates.

**Strategy 4**

Share best practices that harden public infrastructure to the effects of extreme precipitation (e.g. Public Works Mutual Aid) as part of a new or already existing regional training opportunity.

**Strategy 5**

Recruit additional members to the Medical Reserve Corps.

**Strategy 6**

Incorporate the review of climate and health hazards into health needs assessments.

**Objective 3**

Increase awareness about the increasing frequency of extreme precipitation events and their health impacts, as well as measures of community resilience.

**Strategy 1**

Determine the extent effectiveness of current outreach initiatives and raise their profile (or, consider a more unified campaign).

**Strategy 2**

Present information on anticipated changes in extreme precipitation events to local emergency preparedness and response personnel.

**Strategy 3**

Determine suitable measures of community resilience with respect to extreme precipitation and incorporate them into the monitoring of regional health outcomes and targets.

**Strategy 4**

Promote monitoring of health hazards tied to extreme precipitation by regional health providers (i.e. hospitalizations following extreme precipitation events).

## INTERVENTIONS AND OUTCOMES

In looking for solutions to complex problems that involve weather, climate change, and human health, the GMPHN staff and supports have some general guidelines for how to choose interventions that take in the big picture. In the best of all worlds, the solutions would include:

- Actions that fit community wants, needs, and available resources.
- Actions that address both adaptation to short-term weather events, and longer-term climate change via mitigation of greenhouse gas emissions.
- Actions that increase overall community-level resilience to all-hazards, rather than just address one hazard at a time.
- Actions that increase wellness and independence (plus improve air quality), via activities such as physical fitness and human-powered transportation (i.e. walking, biking, etc.)

## MEASURES OF COMMUNITY RESILIENCE

A set of measures of community health resilience and adaptation that include better preparedness-response-recovery cycles, increased collaboration, innovative communications, and improved decision-making. Because population-level health outcomes can be difficult to measure, and often take many years to change, we encourage organizations to develop intermediate measures of resilience and vulnerability.

### Hazard Indicators

- Flood zone (% of land in 100 year floodplain)
- Heat Vulnerability (impervious surface, tree coverage, traffic, air quality, age, and density, % of land in high heat vulnerability zones)

### Environmental Indicators

- Impervious surface (% impervious surface)
- Tree cover/canopy (maybe less indicative for rural areas than city, % tree cover)
- Air Quality (total PM 2.5 concentration, % of land with low or very low air quality)

### Transportation Indicators

- Active transportation (walking + biking, average minutes of active transport per day)
- Public Transportation (for Monadnock this might just be access to transportation in general)

### Community Indicators

- Violent crime
- Voting rates
- New to region (% of population that moved to region within the last year)
- Citizenship
- Non-English speaking

### Public Realm Indicators

- Healthy food score (proximity to healthy food)
- Education (% of population over 25 with a high school degree)
- Proximity and Access to Pharmacy (% residents within .25 miles of a pharmacy)

### Housing Indicators

- Living alone (% of households with a resident living alone, resident over 65 living alone)
- Overcrowding (1 or more person per room)
- Residential health and safety violations (violations per 1,000 people)
- Air conditioning (% of buildings with air conditioning)
- Excessive rent burden (% of renter households whose gross rent is 50% or more of household income)

### **Economy Indicators**

- Employment status (% of population over 16 that is employed)

### **Health Indicators**

- Proximity and access to shelters and cooling centers (# within .25 miles per 1000 people)
- Proximity and access to hospitals and clinics
- Mobility disability (% of population reporting a disability)
- Over 11% of non-institutionalized persons have some form of disability, and almost 1 in 3 residents age 65 or older have a disability that impacts their daily life (CHIP)
- Preventable hospitalization (diabetes, chronic obstructive pulmonary disease, hypertension, heart failure, dehydration, bacterial pneumonia, urinary tract infection, angina without procedure, and asthma)

### **Demographic Indicators**

- Age (over 85, over 65, under 18, under 5)
- Ethnicity
- Low Income Families (families at or below 200% of the poverty rate)
- Residential population density

## REFERENCES

- Batterman, S. E. (2009). Sustainable control of water-related infectious diseases: a review and proposal for interdisciplinary health-based systems research. *Environmental Health Perspectives*, 117(7), 1023-32.
- Bell, J. S.-P. (2016). Impacts of Extreme Events on Human Health. In *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (pp. 99–128). Washington, D.C.: U.S. Global Change Research Program. Retrieved from <http://dx.doi.org/10.7930/J0BZ63ZV>
- Berry, H. B. (2010). Climate change and mental health: a causal pathways framework. *International Journal of Public Health*, 55(2), 123-132.
- Brown, M. J. (2015). *Climate Change, Global Food Security, and the U.S. Food System*. Retrieved from [http://www.usda.gov/oce/climate\\_change/FoodSecurity2015Assessment/FullAssessment.pdf](http://www.usda.gov/oce/climate_change/FoodSecurity2015Assessment/FullAssessment.pdf)
- Center for Disease Control and Prevention. (n.d.). *Climate Change and Extreme Heat Events*. Retrieved from <http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf>
- Centers for Disease Control and Prevention. (2016, 7 26). *Climate Effects on Health*. (N. C. Health, Producer) Retrieved 10 20, 2016, from Climate and Health: <http://www.cdc.gov/climateandhealth/effects/>
- Charles Beard, e. a. (2016). Vectorborne Diseases. In *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. Washington, DC: U.S. Global Change Research Program. Retrieved from <http://dx.doi.org/10.7930/J0765C7V>
- City of Keene. (2007). *Adapting to Climate Change: Planning a Climate Resilient Community*. Keene: City of Keene.
- Craun, M. F. (2006). Waterborne outbreaks reported in the United States. *Journal of Water and Health*, 4(S2), 19-30.
- Department of Health and Human Services. (2014, June). State of New Hampshire Excessive Heat Emergency Response Plan. Retrieved from <http://www.dhhs.nh.gov/dphs/climate/documents/nh-excessive-heat-plan.pdf>
- Dodgen, D. D. (2016). Mental Health and Well-Being. In *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (pp. 217–246). U.S. Global Change Research Program. Retrieved from <http://dx.doi.org/10.7930/J0TX3C9H>
- Greater Monadnock Public Health Network. (2015). *Greater Monadnock Community Health Improvement Plan*.
- Greater Monadnock Public Health Network. (2015). *Greater Monadnock Public Health Region Community Health Improvement Plan*. Keene: Greater Monadnock Public Health Network.

- Lyme Disease Association. (n.d.). *Total Lyme Cases Reported by CDC 1990–2014*. Retrieved June 28, 2016, from Lyme Disease Association:  
[http://lymediseaseassociation.org/LDA\\_Apps/content/Maps/pdf/data\\_1990to2014summary.pdf](http://lymediseaseassociation.org/LDA_Apps/content/Maps/pdf/data_1990to2014summary.pdf)
- N.H. Department of Environmental Services. (2008). Drinking Water. In N. D. Services, *N.H. Water Resource Primer*. Concord, N.H.: N.H. Department of Environmental Services.
- N.H. Department of Environmental Services. (2008). Floods and Droughts. In N. D. Services, & S. C. Pillsbury (Ed.), *Water Resources Primer*. Concord, N.H.: N.H. Department of Environmental Services.
- National Institute of Allergy and Infectious Diseases. (2016, August 10). *Allergic Diseases*. Retrieved from <http://www.niaid.nih.gov/topics/allergicdiseases/Pages/default.aspx>
- National Kids Count. (2016). *Children Living in Households that were food insecure at some point during the year*. (The Annie E. Casey Foundation) Retrieved August 30, 2016, from Kids Count Data Center: <http://datacenter.kidscount.org/data/line/5201-children-living-in-households-that-were-food-insecure-at-some-point-during-the-year?loc=31&loct=2#2/31/true/36,868,867,133,38,35,18,17,16,15/asc/any/11675>
- New Hampshire Department of Environmental Services. (2008, December). *New Hampshire Water Resources Primer*. (S. Pillsbury, P. Currier, & P. Susca, Eds.) Retrieved June 28, 2016, from [http://des.nh.gov/organization/divisions/water/dwgb/wrpp/documents/water\\_resources\\_primer.pdf](http://des.nh.gov/organization/divisions/water/dwgb/wrpp/documents/water_resources_primer.pdf)
- New Hampshire Department of Health and Human Services. (2016, March 31). *Lyme and Other Tickborne Diseases*. Retrieved June 28, 2016, from New Hampshire Department of Environmental Services:  
<http://www.dhhs.nh.gov/dphs/cdcs/lyme/documents/tbdpreventionplan.pdf>
- New Hampshire Department of Safety. (2013). *State of New Hampshire Multi-Hazard Mitigation Plan*. Concord: New Hampshire Department of Safety. Retrieved June 28, 2016, from <https://www.nh.gov/safety/divisions/hsem/HazardMitigation/documents/hazard-mitigation-plan.pdf>
- NH Department of Environmental Services. (2015). *NH Swimming Beaches at a Glance: Otter Brook Lake Beach*. Retrieved from <http://www2.des.state.nh.us/OneStopPub/Beach/NH8835052015annualreport.pdf>
- NH Department of Health and Human Services. (2016, June). *NH Health WISDOM*. Retrieved from NH Health WISDOM: <https://wisdom.dhhs.nh.gov/wisdom/>
- Portier CJ, T. T.-Y. (2010, April 22). *A Human Health Perspective on Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change*. Research Triangle Park, NC: Environmental Health Perspectives, National Institute of Environmental Health Sciences.  
 doi:10.1289/ehp.1002272

- Southwest Region Planning Commission. (2015). *Monadnock Region Future*. Keene: Southwest Region Planning Commission.
- Substance Abuse and Mental Health Services Administration. (2016, July). *SAMHSA's Wellness Initiative*. Retrieved from Substance Abuse and Mental Health Services Administration: <http://www.samhsa.gov/wellness-initiative>
- U.S. Global Change Research Program. (2015, February 23). *Extreme Events*. Retrieved from Climate and Health Assessment: <https://health2016.globalchange.gov/extreme-events>
- U.S. Global Change Research Program. (2016). Temperature-Related Death and Illness. In U. G. Program, & A. J. Crimmins (Ed.), *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. (p. 312). Washington, DC: U.S. Global Change Research Program,. Retrieved from <https://health2016.globalchange.gov/>
- UN-Water. (2014). *Water Security*. Retrieved August 30, 2016, from <http://www.unwater.org/topics/water-security/en/>
- US Environmental Protection Agency. (2016, August 17). *Understanding the Connections Between Climate Change and Human Health*. Retrieved from Climate Change Indicators: <https://www.epa.gov/climate-indicators/understanding-connections-between-climate-change-and-human-health>
- Wake, C., Bucci, J., & Aytur, S. (2014). *Climate Change and Human Health*. University of New Hampshire. Durham: Climate Solutions New England. Retrieved June 28, 2016, from <https://www.climatesolutionsne.org/sites/climatesolutionsne.org/files/candhreport4.30.pdf>
- World Food Programme. (2016). *Climate Impacts on Food Security*. Retrieved August 30, 2016, from <https://www.wfp.org/climate-change/climate-impacts>

## APPENDIX

## LIST OF CONSULTED PLANS

TABLE 4 - CONSULTED PLANS (GLOBAL)

Title	Organization	Year
Climate Change and Human Health-Risks and Responses	WHO	2003

TABLE 5 - CONSULTED PLANS (NATIONAL)

Title	Organization	Year
The President's Climate Action Plan	White House	2013
The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment	US Global Change Research Program	2016
Assessing Health Vulnerability to Climate Change: A Guide for Health Departments	CDC	2015
Climate Models and the Use of Climate Projections: A Brief Overview for Health Departments	CDC	2015

TABLE 6 - CONSULTED PLANS (STATE)

Title	Organization	Year
Climate Change and Human Health in New Hampshire: An Impact Assessment	Sustainability Institute at the University of New Hampshire	2014
Preparing for Climate Change: A Strategic Plan to Address the Health Impacts of Climate Change in New Hampshire	DHHS; DPHS; DES	2010
State Health Improvement Plan (SHIP): Charting a Course to Improve the Health of New Hampshire	DHHS	2013
State of NH Multi-Hazard Mitigation Plan	NH Dept of Safety	2013

TABLE 7 - CONSULTED PLANS (REGIONAL)

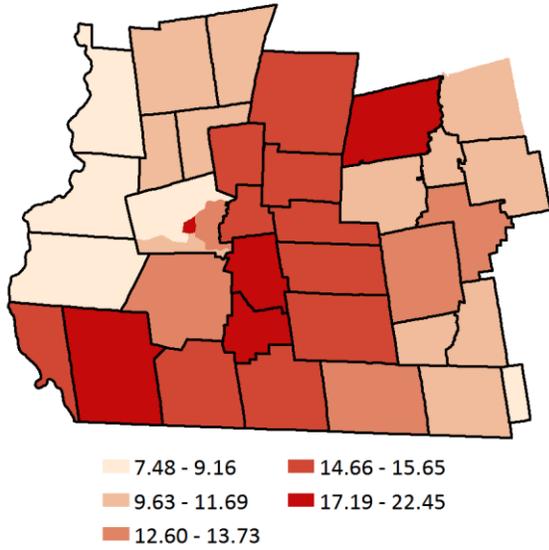
Title	Organization	Year
Community Health Needs Assessment	Cheshire Medical Center	2013
Greater Monadnock Public Health Region Community Health Improvement Plan	Greater Monadnock Public Health Network	2015
Monadnock Region Future: A Plan for Southwest New Hampshire	SWRPC	2015
Climate Change in Southern New Hampshire: Past, Present and Future	Sustainability Institute at the University of New Hampshire	2014

TABLE 8 - CONSULTED PLANS (LOCAL)

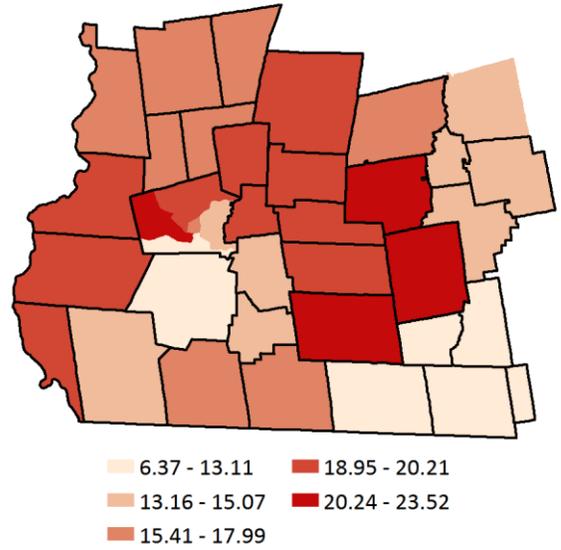
Title	Organization	Year
Alstead Hazard Mitigation Plan Update	Town of Alstead	2012
Antrim Hazard Mitigation Plan Update	Town of Antrim	2016
Bennington Hazard Mitigation Plan Update	Town of Bennington	2015
Chesterfield Hazard Mitigation Plan Update	Town of Chesterfield	2016
Fitzwilliam Hazard Mitigation Plan Update	Town of Fitzwilliam	2012
Gilsum Hazard Mitigation Plan	Town of Gilsum	2011
Greenfield Hazard Mitigation Plan Update	Town of Greenfield	2014
Greenville Hazard Mitigation Plan Update	Town of Greenville	2015
Hancock Hazard Mitigation Plan Update	Town of Hancock	2012
Harrisville Hazard Mitigation Plan	Town of Harrisville	2005
Hinsdale Hazard Mitigation Plan Update	Town of Hinsdale	2015
Keene Climate Action Plan Update	City of Keene	
Keene Comprehensive Master Plan	City of Keene	2010
Keene Hazard Mitigation Plan	City of Keene	2012
Langdon Hazard Mitigation Plan Update	Town of Langdon	2012
Marlborough Hazard Mitigation Plan Update	Town of Marlborough	2015
Marlow Hazard Mitigation Plan	Town of Marlow	2015
Nelson Hazard Mitigation Plan	Town of Nelson	2013
New Ipswich Hazard Mitigation Plan Update	Town of New Ipswich	2013
Peterborough Hazard Mitigation Plan	Town of Peterborough	2010
Richmond Hazard Mitigation Plan Update	Town of Richmond	2016
Rindge Hazard Mitigation Plan	Town of Rindge	2013
Roxbury Hazard Mitigation Plan	Town of Roxbury	2012
Stoddard Hazard Mitigation Plan	Town of Stoddard	2013
Sullivan Hazard Mitigation Plan Update	Town of Sullivan	2016
Surry Hazard Mitigation Plan Update	Town of Surry	2016
Swanzy Hazard Mitigation Plan Update	Town of Swanzy	2016
Temple Hazard Mitigation Plan Update	Town of Temple	2015
Walpole Hazard Mitigation Plan Update	Town of Walpole	2012
Westmoreland Hazard Mitigation Plan Update	Town of Westmoreland	2016
Winchester Hazard Mitigation Plan Update	Town of Winchester	2012
Windsor Hazard Mitigation Plan Update	Town of Windsor	2016

ADDITIONAL SOCIAL VULNERABILITY INDEX MAPS

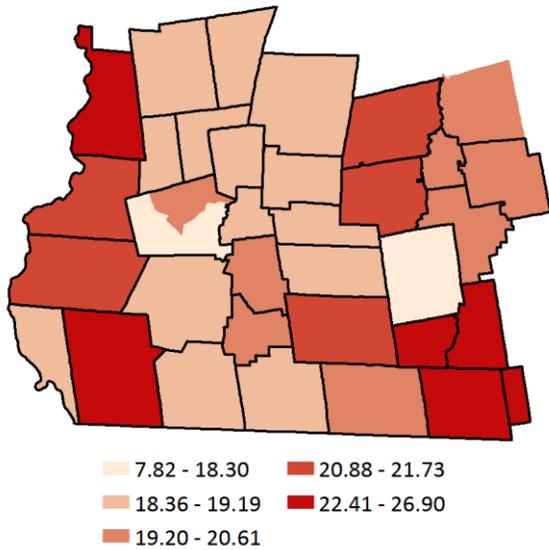
**FIGURE 30 - HEALTH INSURANCE—PERCENT OF POPULATION AGE LESS THAN 65 WITHOUT INSURANCE**



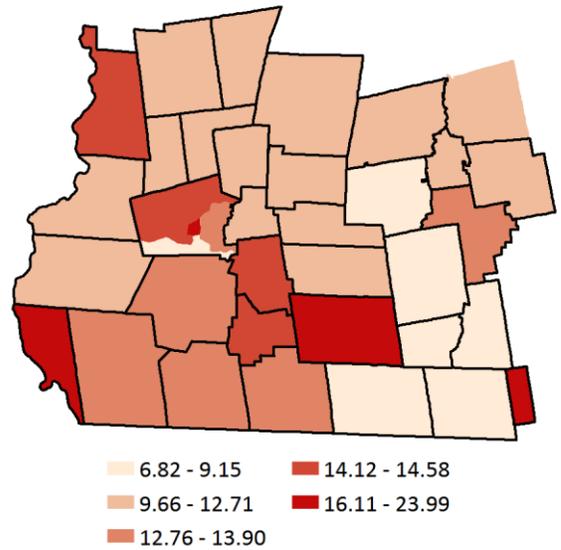
**FIGURE 32 - ELDERLY—PERCENT OF POPULATION AGE 65 AND OVER**



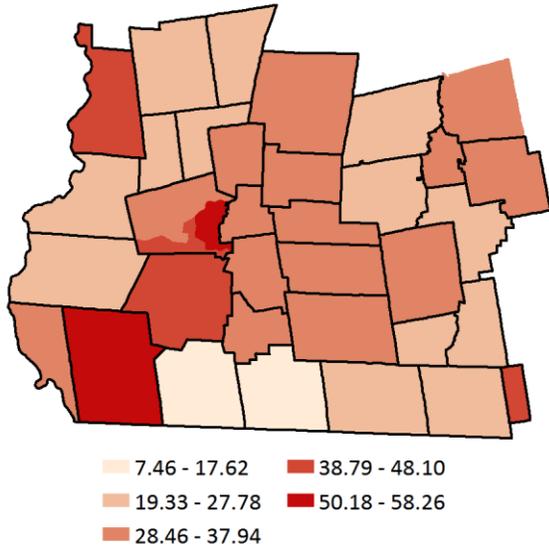
**FIGURE 31 - CHILDREN—PERCENT OF POPULATION AGE LESS THAN 18**



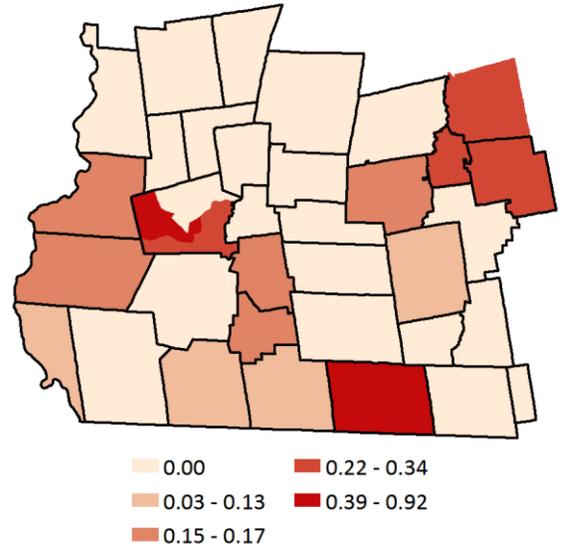
**FIGURE 33 - DISABILITY—PERCENT OF POPULATION AGE 5+ WITH A DISABILITY**



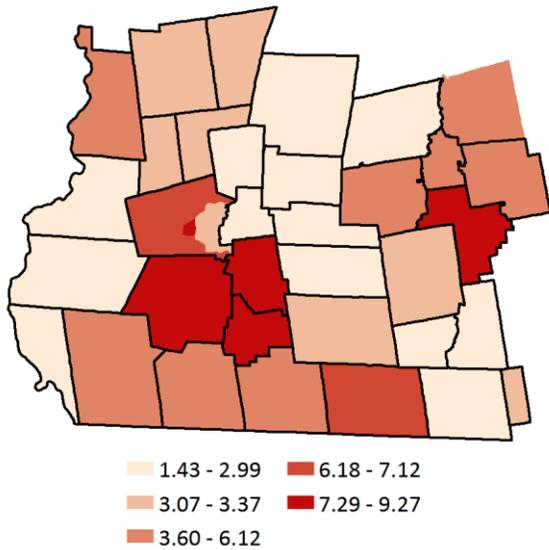
**FIGURE 34 - SINGLE PARENT—PERCENT OF HOUSEHOLDS WITH CHILDREN**



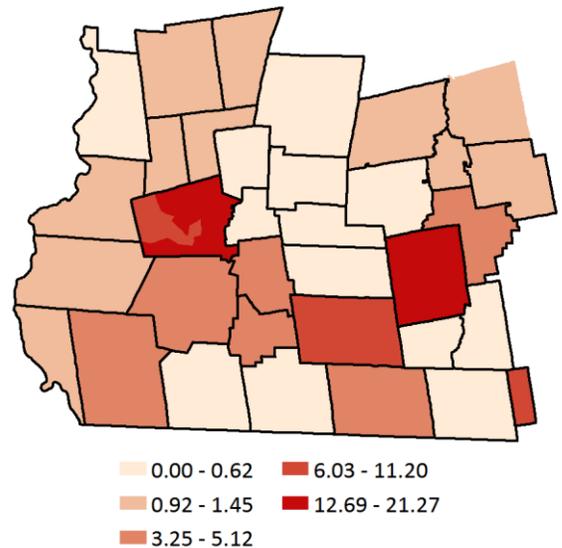
**FIGURE 36 - LIMITED ENGLISH—PERCENT OF POPULATION AGE 5+ WHO SPEAK ENGLISH LESS THAN "WELL"**



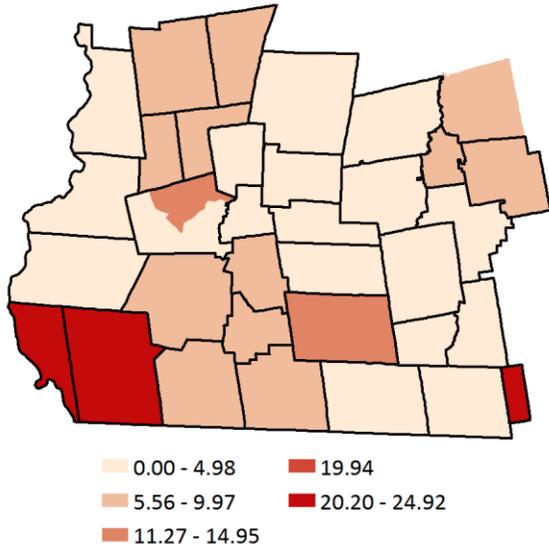
**FIGURE 35 - MINORITY—PERCENT OF POPULATION HISPANIC OR NON-WHITE RACE**



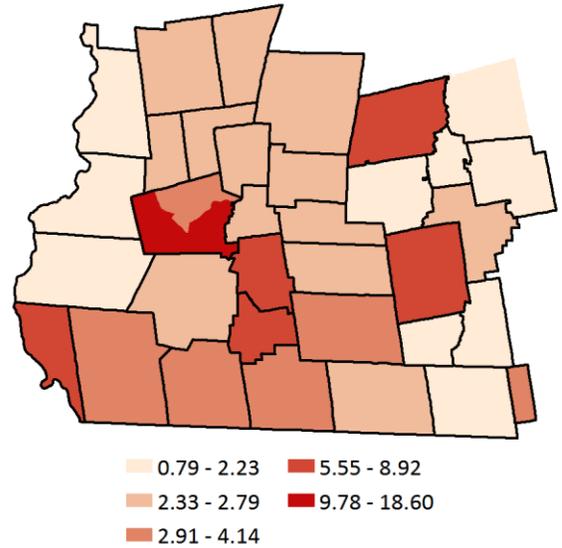
**FIGURE 37 - LARGE APARTMENT BUILDINGS—PERCENT OF HOUSING UNITS WITH 10 OR MORE HOUSING UNITS PER BUILDING**



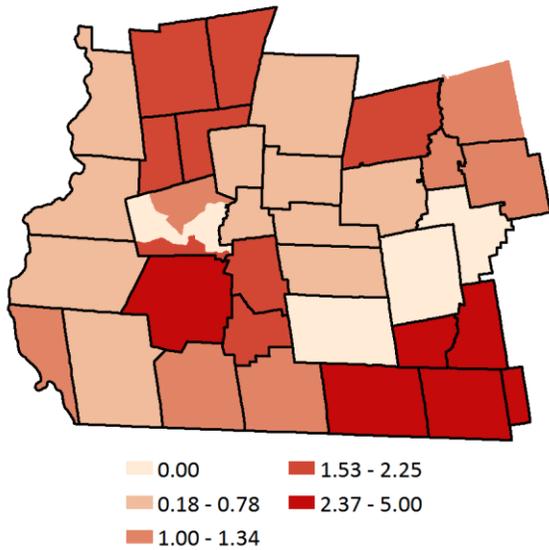
**FIGURE 38 - MOBILE HOMES—PERCENT OF HOUSING UNITS**



**FIGURE 40 - NO VEHICLE—PERCENT OF HOUSEHOLDS WITH NO VEHICLE**



**FIGURE 39 - CROWDING—PERCENT OF HOUSING UNITS WITH MORE THAN ONE PERSON PER ROOM**



**FIGURE 41 - GROUP QUARTERS—PERCENT OF POPULATION LIVING IN GROUP QUARTERS**

