SUSTAINABILITY briefing

University of New Hampshire
The Sustainability Institute

New Hampshire's Changing Climate: Heat Waves, Downpours, and Rising Seas

"One of the brightest gems in the New England weather is the dazzling uncertainty of it." Mark Twain

HIGHLIGHTS

- New Hampshire has been getting warmer and wetter over the last century, and the rate of climate change has increased over the last four decades.
- As heat-trapping gases continue to accumulate in the atmosphere, New Hampshire's climate will become even warmer and wetter, with more hot days and more downpours.
- Sea levels are expected to continue to rise over the course of the 21st century. Where there is little tolerance for risk, communities should commit to manage for 1.3 feet of sea level rise by 2050, but be prepared to manage for as much 2.0 feet of sea level rise by 2050.
- Climate change will likely have a wide range of impacts on human health. See Table 1 for details.
- To effectively address the challenges posed by our changing climate, scientists, decision makers, planners, and entrepreneurs will have to work together on integrated solutions that increase the energy security and weather resilience of our region.

Climate changes. It always has and always will. This is as true for New Hampshire as it is for the globe. And an extensive and ever growing body of scientific evidence proves that human activities (especially the burning of coal, oil, and natural gas, clearing forested lands, and raising livestock) are now the primary force changing the Earth's climate system.[1] Based on an examination of the evidence, 97% of climate scientists have concluded that human caused global warming is happening.[2] The United States military is also very concerned about global warming, which they identify as a threat multiplier because it exacerbates a range of risks that affect our national security.[3]

What does a warming globe mean for New Hampshire? The Granite State is known for its wide range of weather conditions that shape our lives and our landscape. This includes sugar maples and evergreen forests, ski slopes and fisheries, riverside and coastal communities, plentiful clean water and beautiful beaches. However, we are now entering a "new climate normal" that is rather different compared to the climate of the last century. More hot days, more extreme precipitation events, and rising sea levels are already impacting our daily lives, our communities, our ecosystems, and our health. And projections of future

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climate change call for even more frequent heat waves, downpours, and higher seas.

Four recent reports released by Climate Solutions New England (CSNE)[4] document past and potential future climate change across the Granite State and the potential consequences for our communities and our health. The reports also provide insight into how we can address these challenges. All reports are available on the CSNE website.[5] In addition, historical climate data and downscaled future climate simulations can be downloaded from the NH EPSCoR Data Discovery Center.[6]

Historical Climate Change and Sea Level Rise

The CSNE reports detail how the climate of New Hampshire has changed over the past century and how the future climate of the region will be affected by a warmer planet due to human activities. Overall, southern New Hampshire has been getting warmer and wetter over the last century, and the rate of change has increased over the last four decades. In addition, sea level is rising along the New Hampshire coast. Detailed analysis of high quality environmental data from across NH show that, since 1970:

- Average maximum temperatures have warmed, especially in fall and winter.
- The number of days below freezing has decreased.
- The length of the growing season is two to four weeks longer.
- Annual precipitation has increased by 7 to 20 percent.
- Extreme precipitation events are on the rise, dramatically in some places. The impact of this increase is evident in the several large floods have occurred across NH over the last decade.
- The number of snow-covered days has decreased.
- Spring ice-out dates are occurring one to two weeks earlier.
- Relative sea levels have been rising at a rate of about 0.7 inches per decade since the 1920s, similar to the global average rate of sea level rise over the past century.

One measure of the impact of weather disruption across New Hampshire is the money that the Federal Emergency Management Administration (FEMA)

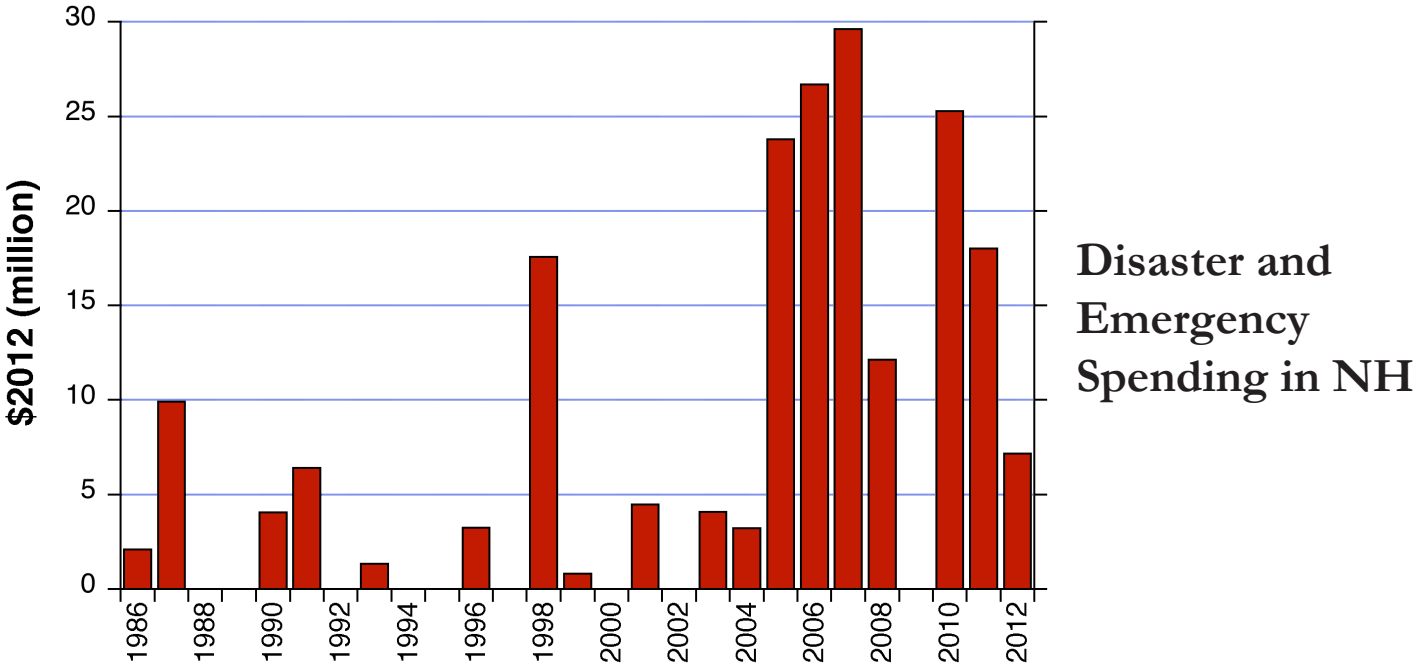

FIGURE 1. Federal expenditures on Presidentially Declared Disasters and Emergency Declarations in New Hampshire from 1999 to 2012. Expenditures adjusted to $2012 using the consumer price index. Note increase in expenditures since 2005.

has spent on Presidentially Declared Disasters and Emergency Declarations (Figure 1).[7] From the period 1986 to 2004, there was only one event (the 1998 ice storm) where damages paid out by FEMA were greater than $10 million (in 2012 dollars). Conversely, five of the seven years between 2005 and 2012 had weather events where damages paid out by FEMA were greater than $10 million (in 2012 dollars). The most significant damages between 2005 and 2012 resulted from floods and ice storms. The shift in 2005 is not only due to an increase in extreme weather events, but also reflects the fact that our infrastructure (e.g., buildings, roads, electrical grid) has been developed in ways that make them vulnerable to damage from these extreme events

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Projected Climate Change and Sea Level Rise

To generate future climate projections for New Hampshire, simulated temperature and precipitation from four global climate models (GCMs) were statistically downscaled using historical weather observations. We accounted for a range of potential future fossil fuel use by using two very different future global emission scenarios. As heat-trapping gases continue to accumulate in the atmosphere, New Hampshire's climate will become warmer and wetter, and seas will continue to rise. Specific projected impacts include the following:

- By mid-century, average annual temperatures are projected to increase between 3 to 5°F, and by end-of century may increase as much at 4 to 8°F.
- Warming winters will reduce opportunities for snow and ice related recreation (and related economic activity), and will also reduce cold temperature constraints that currently limit the spatial extent of some marginally over-wintering pests and invasive species.
- The number of extreme hot days are projected to increase and will be hotter than in the past, with potential impacts to human health, infrastructure, and to the power grid.

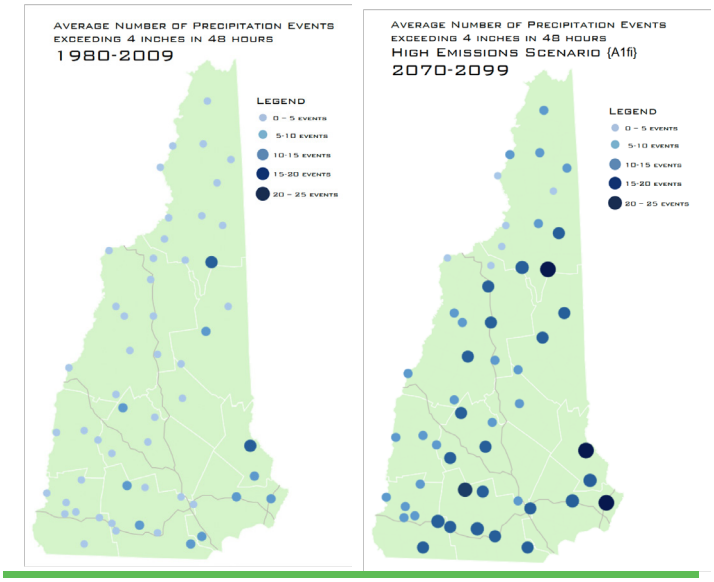


FIGURE 2. Historical (left) and projected (2070–2099) average number of precipitation events per decade (averaged over three decades) that drop greater than 4 inches in 48 hours across New Hampshire.

- The growing season is projected to get longer. However, many existing crops will likely experience yield losses associated with increased frequency of high temperature stress, an increase in soil erosion and crop failure resulting from more frequent extreme precipitation events, inadequate winter chill period for optimum fruiting, and increased pressure from invasive weeds, insects, or disease.
- Annual precipitation is projected to increase, but more of it will fall in fewer events. For example, extreme precipitation events that drop more than four inches of precipitation are projected to increase two- to three-fold across much of New Hampshire by the end of the century (Figure 2).

Sea levels are also expected to continue to rise over the course of the 21st century and beyond. Rising seas pose significant risks to coastal areas around the globe and here in New England and New Hampshire. Higher sea level will mean higher storm surges (which occur primarily during nor'easters and hurricanes) that will result in flooding over greater coastal land area. The flooding caused by storm surge will also take longer to abate than in the past.

There is a wide range in the amount of projected sea-level rise that will occur by 2100, due primarily

to uncertainty in the timing and amount of ice loss from the Greenland and West Antarctic Ice Sheets.[8] The recommendation to the New Hampshire Coastal Hazards and Risk Commission[9] is where there is little tolerance for risk in protecting new infrastructure or existing coastal settlements, infrastructure or ecosystems, communities and municipalities should consider a range of sea level rise from 1.3 to 2.0 feet by 2050, and 3.9 to 6.6 feet by 2100. They should commit to manage to the lower range, but be prepared to manage and adapt to the higher range if necessary. Also, they should be aware that the projected sea-level rise ranges may change and adjust if necessary.

Impacts of Climate Change on Human Health

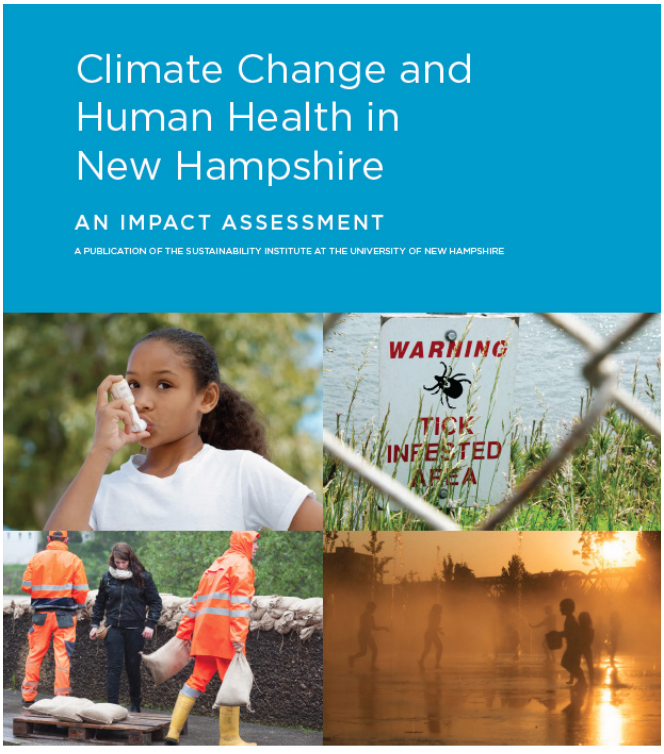
One of the CSNE reports[10] is focused on the impact of climate change on human health in New Hampshire. The Centers for Disease Control and Prevention (CDC) Building Resilience Against Climate Effects (BRACE) framework[11] provides guidance to states and cities to develop strategies and programs to confront the health implications of climate change. The potential impacts of climate change on human health are summarized in Table 1.

A key component of the BRACE framework is building resilience. In public health, resilience is a measure of a community's ability to utilize available resources to respond to, withstand, and recover from adverse situations. More generally, people think of resilience as the ability to recover, persist, or thrive amid change.

The importance of the way we plan our built environment, including land use, transportation, and water management decisions, as well as how we interact with our natural environment and preserve its life-supporting functions, must be emphasized as pivotal points of intersection as we develop climate adaptation strategies. Notably, a resilience-based approach to climate change adaptation should align with New Hampshire's transformative State Health Improvement Plan.[12] That plan underscores the importance of cross-sector collaboration and coordinated strategies to address the social and environmental determinants of health. These strategies not only support healthy communities for all New Hampshire residents, but are also critically important for reducing health care costs[13] and reducing the burden of disease.

Preparing for the "New Normal"

While climate change is a global phenomenon, its direct and indirect impacts on local communities are complex and therefore challenge familiar approaches to managing risk and uncertainty. Spurred on by damages from the growing number of extreme weather events (e.g., Figure 1), communities and decision makers have begun to realize that they can no longer assume that the climate over the 21st century will be similar to climate over the past century and that occasional "surprise" events are anomalies that can only be responded to by improvising. Instead, expectations of increased damages in the



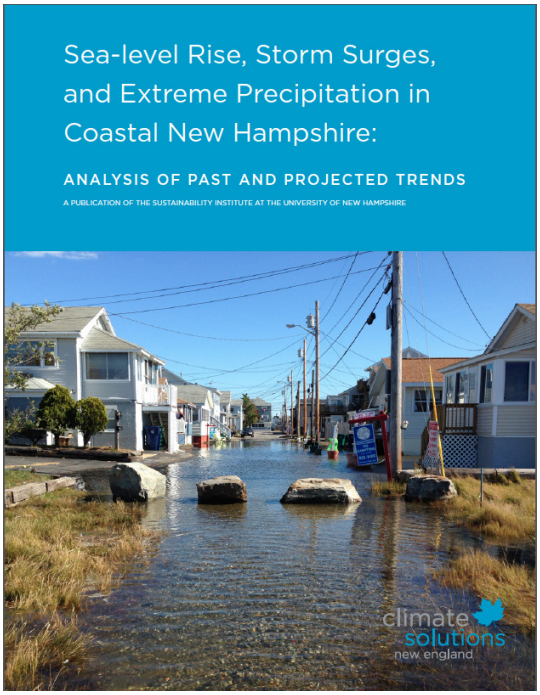
Health/Climate Indicator	Climate Change Indicator	Health Impact		Equity Considerations/Vulnerable Populations
		Primary	Secondary*	
Heat stress	Increase in number of hot days	Increase in heat related illness and death	Increase in cardio-vascular impacts; violence; suicide	Persons who: live in urban areas with little green-space (heat island effect); are vulnerable due to age (children, elders), socioeconomic status, race/ethnicity, comorbidities/pre-existing health conditions, social/linguistic isolation, or occupations; homelessness
Extreme weather	Increase in coastal and inland flooding	Physical injury & death; displacement, contaminated water supply; increase in mold	Lost work days; mental health impacts; increase water-borne disease	Same as for vulnerable populations under Heat Stress; also persons living in manufactured housing and flood-prone areas; emergency response personnel
	More severe ice storms	Physical injury & death; displacement	Loss of heating; CO poisoning; lost work days; increase food-borne disease	
Air Quality	More ozone events	Increase in pulmonary (including asthma) and cardio-vascular impacts; death	Reduced outdoor physical activity; lost work days	Persons with pre-existing asthma or other respiratory illnesses; other vulnerabilities as listed above
	Longer pollen season, higher pollen conc., more allergenic pollen	Increased allergies and allergic reactions	Lost work days, reduced physical activity	Persons with pre-existing allergies
Vector-borne disease	Warmer, wetter	Increased incidence of lyme WNV, EEE and other emerging VB diseases	Chronic illnesses; reduced outdoor physical activity	Persons who work or play outside, especially without proper clothing.
Foodborne Illnesses	Warmer air temperatures & more heat waves	Increase in spoiled food; Gastrotintestinal illness	Dehydration; Increase in shelfish disease/ closures	Same as for vulnerable populations listed under Heat Stress; particularly those who may have pre-existing issues with food access
Waterborne disease	Warmer water temperatures	Gastrointestinal illness (i.e., Giardiasis)	Dehydration; Increase in shellfish disease/ closures; Red tide & cyanobacteria blooms	Same as for vulnerable populations listed under Heat Stress; people who frequently recreate outside
Health behavior & chronic disease	Integrated	Reduced outdoor physical activity; increased sedentary behavior and associated diseases (e.g., obesity, diabetes, Cardio-Vascular Disease)	Negative mental health impacts	Same as for vulnerable populations listed under Heat Stress
Mental Health	Integrated	Mental health	Negative impacts on other diseases and social impacts (e.g, violence) that can be associated with poor mental health	Vulnerable populations listed under “heat stress”; those with pre-existing substance abuse/mental health issues; those living where there are limited providers and treatment options (e.g., northern NH and rural areas).
*Secondary impacts also include social & economic disruption, lost work days, & lost revenue				

TABLE 1. Summary of potential health impacts associated with climate change organized using the CDC-BRACE framework.

future, driven by larger and more frequent weather disruptions, have begun to take hold. As a result, a growing number of decision makers across New England are attempting to integrate climate change mitigation (i.e., reducing emissions of heat trapping gases) and adaptation strategies into planning for their communities, their families, and their businesses.

Scientific knowledge is essential, but by itself insufficient to meet this need until it is integrated with practitioner and broader community knowledge and values and contextualized within the critical drivers of community health and well-being across the region. Communities have different strengths and vulnerabilities and therefore different needs and capabilities when it comes to climate change, and contextualized information must, by definition, reflect those conditions. In addition, mitigation (reducing greenhouse gas emissions) is an essential element of adaptation because if we do not figure out how to meet our energy needs and manage our landscapes while significantly reducing emissions, we will simply outstrip our ability to adapt. So our region's communities are in search of integrated approaches to adaptation and mitigation and they require information and collaborative networks that are responsive to local and regional conditions. The challenge, then, is to establish the process and mechanisms by which these multiple forms of knowledge can be integrated to support diverse communities' mitigation and adaptation effectiveness. This is a central challenge for New Hampshire and New England.

In order to transition risk management approaches to effectively address climate change impacts, scientists, decision makers, planners, and entrepreneurs will have to work closely together on *integrated solutions* that increase the resilience of our region's ecological, economic, and community health. Integrated solutions that address the challenges posed by climate change should address multiple challenges simultaneously,[14] are responsive to changing local, regional, and global conditions,[15] and are flexible.



CSNE is now organized around the central challenge of developing, implementing, and evaluating a range of integrated climate change solutions throughout New England—an effort that will help ensure a more weather resilient and energy secure New England in the face of continued changes in the years to come.[16]

Endnotes

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5 All CSNE Reports available from the Climate Solutions New England: website: http://www.climatesolutionsne.org

6 Climate Data and model output for NH available from the NH EPSCoR Data Discovery Center: http://ddc-climate.sr.unh.edu.

7 Data from FEMA: www.fema.gov/disasters/grid/state-tribal-government

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11 Five steps of the CDC - BRACE framework: Step 1: Forecasting Climate Impacts and Assessing Vulnerabilities; Step 2: Projecting the Disease Burden; Step 3: Assessing Public Health Interventions; Step 4: Developing and Implementing a Climate and Health Adaptation Plan; Step 5: Evaluating Impact and Improving Quality of Activities. More information at: http://www.cdc.gov/climateandhealth/BRACE.htm

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16 SHOULD WE CITE OUR CSNE WHITE PAPER AND MAKE IT BROADLY AVAILABLE ON THE CSNE WEB SITE??

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