

Planning for the Public Health Impacts of Climate Change in Northampton, Massachusetts

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City of Northampton
Office of Planning and Sustainability
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This report was researched and written by Human Impact Partners



Human Impact Partners works to transform the policies and places people need to live healthy lives by increasing the consideration of health and equity in decision-making.

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Table of Contents

Executive Summary	4
Preface	6
Background	7
Co-benefits and co-harms	8
Climate change vulnerability and resilience	8
Current and projected climate changes for the Northeast U.S. region	10
Heat.....	10
Hydrologic changes.....	11
Infrastructure and living conditions	12
Public health impacts of climate changes	13
Heat-related illness and death	13
Air pollution-related illness and death	13
Heat and hydrologic-related infectious and vector-borne diseases.....	14
Extreme weather-related injury, displacement, and mental health	14
Disruption of health-supportive services and infrastructure.....	15
Climate-relevant health and infrastructure existing conditions	16
Climate relevant health outcomes	16
Climate relevant social vulnerabilities.....	23
Climate relevant infrastructure	25
Projected Changes in Health and Infrastructure: Northampton	30
Strategies to Address Climate and Health in the Region, State, and Northampton	33
Conclusion.....	36
References.....	41

Executive Summary

Over the remainder of this century, Northampton will experience climate changes that include: a substantial increase in days of extreme heat; more precipitation, severe weather events, power outages, and potential for flooding; and shorter winters with milder average temperatures and longer summers. These changes are already underway in Northampton and throughout Massachusetts.

Climate changes lead to health and societal impacts. From the best available research, we expect the following in Northampton:

- Increased hospitalizations and emergency department visits from heat stress, asthma, and cardiovascular disease.
- Increased incidence of seasonal allergies, Lyme disease, Eastern Equine Encephalitis, and West Nile Virus.
- Due to the potential for flooding, a small increased risk for water-borne illness and a small risk of displacement, loss of home, and difficulty evacuating.
- Increased stress and anxiety due to extreme weather events, which can disrupt power, sanitary, and health care services, and cause damage to homes and property.
- An decrease in utility costs, with home heating costs decreasing and cooling costs increasing over time.

In Northampton, we are healthier than the average Bay State resident in some ways and in other ways we are not. We have, for example, fewer heart attacks, less cardiovascular disease and less obesity, but we have more childhood asthma and elderly suicide. The City of Northampton, its residents, and its private and nonprofit partners need to keep in mind the numerous studies that find that there are populations that are more vulnerable to health and social risks resulting from climate change than others: those who have lower incomes, the elderly, children, those who are linguistically isolated, people of color, those who are homeless and marginally housed, and those with mental health issues and substance abuse disorders. Consideration of these populations should be elevated during adaptation planning discussions, and extra effort made to include their voices.

Fortunately, Northampton is actively engaged in mitigation strategies for some of these climate change impacts. There are a range of specific near term and longer term strategies that the City, the region, and the state can employ to ensure that Northampton residents can avoid or decrease catastrophic health impacts as well as those that will simply increase slowly, as the climate continues to change. The good news is that responding to climate change provides opportunities for “co-benefits” - ways that we can mitigate and decrease the impacts of energy use, transportation patterns, and agriculture systems but also improve human health and well-being. One example of a co-benefit is land use planning that encourages people to walk and bike instead of drive; this decreases auto emissions *and* improves health. Northampton has been actively engaged in implementing this strategy already.

Public health actions, especially in emergency preparedness and prevention of chronic and infectious diseases, can protect people proactively from some of the impacts of climate change. Early action provides the largest health benefits; as threats increase, our ability to adapt to future changes may be limited. This ***Climate and Health: Northampton, Massachusetts*** report recommends the following public health strategies:

1. Reduce vulnerabilities to climate change health impacts by focusing on prevention, healthy built environments, identification and closure of gaps in health care access, and increase in emergency room capacity.
2. Educate, empower, and engage Northampton residents, organizations, and businesses to reduce vulnerability through targeted outreach and education about the health impacts of climate change and what can be done to address them.
3. Improve public health preparedness and emergency response through evacuation planning, conducting exercises for the public, improving utility company response to power outages, and improving surveillance of disease.
4. Work in multi-sectoral partnerships (local, regional, state, and federal) to identify and prioritize mitigation and adaptation planning strategies with public health co-benefits.
5. Conduct applied research to inform promotion and protection of human health, such as quantification of the projected proportion of childhood asthma incidence due to climate change in Northampton and surrounding towns.
6. Implement policy, systems, and environmental changes at local, regional, and national levels, integrating climate, health, and equity considerations into all policies and processes.
7. Strengthen public health, health care system, and general infrastructure capacity to prepare and respond to climate change events (e.g., power outages and hospitals closures) and provide continuity of medical care following extreme events (e.g., access to medication and medical records).

For additional detail and specific examples of each recommendation, please see the “*Strategies to Address Climate and Health In the Region, State, and Northampton*” section in the full report.

By working together, planning thoughtfully, and taking action, our region can decrease our risk of negative health outcomes from climate change, and can lead the way for others. Nationally, there are few local health departments that have taken action on the effects of climate change, and yet this global metamorphosis will play out very locally. The City of Northampton, through the Office of Planning and Sustainability and the Northampton Department of Health, has can continue to lead the way.

Preface

The City of Northampton is committed to both climate change mitigation (reducing greenhouse gas emissions) and adaptation (adapting to the change that is coming) by revising its investments, policies, regulatory approaches and other actions. This report supports that effort by helping the city understand the health impacts of climate change.

Through the Global Warming Solutions Act of 2008, the State of Massachusetts has mobilized to meet the challenge of climate change. Efforts to reduce carbon and greenhouse gas emissions are imperative to preventing or slowing further climate change. Because carbon dioxide takes centuries to dissipate in the atmosphere, the increased levels already present will cause a certain amount of global warming and climate change in the immediate future that cannot be reversed. Therefore, efforts to adapt, prepare, and respond to these inevitable climate changes are also necessary. Many strategies can achieve both mitigation and adaptation goals.

This report represents a synthesis of information on climate change and health for the Northeastern Region and for Northampton, based on recently published reports of government agencies, the best available climate science and health research, and other public data. We have compiled this information from technical documents, and created a report accessible to public health professionals, planners, their partners in other sectors, and private and community-based organizations and stakeholders. We describe the connections between climate change and health, projected climate changes to our region, identify climate-related health risks and populations vulnerable to these impacts, compile climate and health relevant data for Northampton, and provide qualitative projections of health and infrastructure impacts. Finally, we provide a list of public health and city planning interventions and strategies to mitigate and plan for these impacts, and key messages for communicating about climate and health.

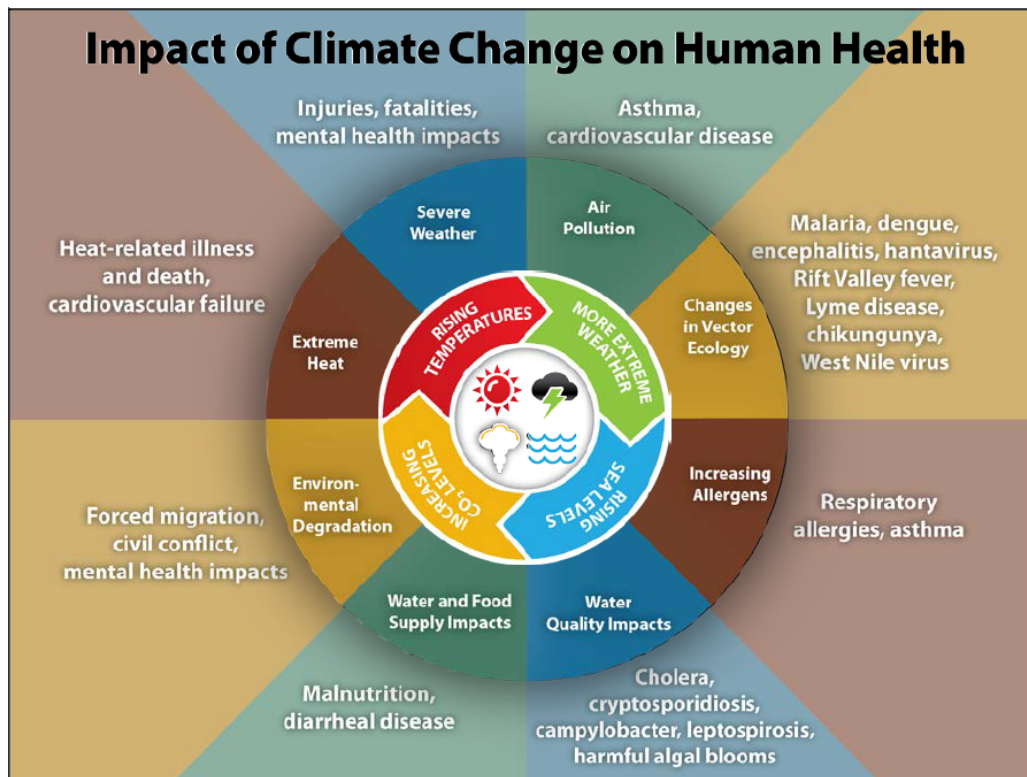
The Northampton Office of Planning and Sustainability, the Northampton Health Department, and Human Impact Partners collaborated on this report. The City of Northampton Health Department, under the guidance of the Board of Health, assesses and addresses the needs of the community in order to help protect and improve the health and quality of life of residents and visitors. The Northampton Office of Planning and Sustainability has been charged with coordinating the implementation of the existing Sustainable Northampton Comprehensive Plan and overseeing the 2018 revisions to that plan. As part of that process, the Office of Planning and Sustainability is coordinating a climate adaptation plan to create a comprehensive framework for the disparate work of many city agencies (e.g., Health, Planning, Public Works, Police, Fire and Emergency Services, IT, Central Services). Human Impact Partners works to transform the policies and places people need to live healthy lives by increasing the consideration of health and equity in decision-making.

We hope you will be inspired to participate in these planning efforts, which can build Northampton residents' resilience to the impacts of a changing climate, reduce existing social and health inequities, and improve community health and wellbeing across a number of outcomes.

Background

Climate change threatens human health and well-being in numerous ways; many are already in evidence.^{1,2} Climate change threatens to disrupt the life support systems on which humans depend (food, air, water, shelter, security), and therefore, in concert with other global environmental changes, threatens our health and survival. The diagram below illustrates the numerous ways that global climate change changes local environmental and living conditions, which in turn negatively impacts a variety of human health outcomes.

Figure 1. Impact of climate change on human health



Source: Centers for Disease Control

While climate change is a threat to everyone's health, it disproportionately impacts the health of vulnerable populations and disadvantaged communities, including elderly, young low-income communities and communities of color,^{3,4,5} thus amplifying existing social and health inequities. Not only are these communities the most susceptible to the cumulative health impacts of unequal environmental exposures and social stressors, they are historically the least likely to be represented in climate change decision-making and planning processes. Based on medical reviews of individuals who died during heat waves and other extreme weather events, the very old and very young, individuals who have chronic medical conditions and psychiatric illness, people taking multiple medications, those without means for evacuation (i.e., no access to public transit or private cars), the medically fragile or those living in institutions or who are socially isolated are particularly vulnerable to the direct effects of climate change.⁶ Communities of color, concentrations of poverty, and any low income communities are also more vulnerable to climate change's impacts. A much larger part of the population is vulnerable to indirect effects and socio-economic disruption through preexisting physical and mental health conditions, cultural or physical isolation, residential segregation and other forms of structural racism, occupations involving outside or high risk work, a precarious socioeconomic status, lack of

social cohesion and lower ability and resources to organize to effectively to acquire needed services. Social inequities are a driver and outcome of climate change, inhibit effective governmental action on climate change⁷, and drive adverse health outcomes⁸ and health inequities.

Co-benefits and co-harms

Despite these threats, policies and strategies that help with climate change mitigation and adaptation could have significant and immediately beneficial effects on public health and health equity, or “co-benefits.” Addressing climate change provides opportunities to improve social and environmental determinants of health across many sectors such as transportation, land use, agriculture, energy, and housing.^{9, 10, 11} Because the sectors included in climate change planning (e.g., land use, transportation, housing) also impact health—and equitable or inequitable distribution of health across a region – planning documents and policies have great potential to impact population health and health inequities in regions. Climate change planning can impact many determinants of health, such as public transportation, active transportation, affordable housing, air pollution, residential displacement, and access to jobs.

For example, investments in walking and biking infrastructure and public transportation (“active transportation”) to reduce greenhouse gases from driving could result in a decrease in obesity, chronic disease, respiratory illnesses, and injury, as well as improved community cohesion and mental health.^{12, 13} Some examples of land use planning with health co-benefits include plans that aim to replace short motor vehicle trips with bicycle use, walking, or public transit, which enables communities to both reduce noxious emissions and avoid premature death through improving physical activity. Improving housing stock can increase energy efficiency and also decrease asthma triggers. Equity co-benefits can include increased availability of low-income housing and improved public transportation, economic development, and neighborhood conditions, such as air quality, traffic density, urban greening, and availability of health-supportive resources and services such as groceries and health care. Some public health co-benefits can be achieved more rapidly than many greenhouse gas (GHG) emissions targets. Climate change strategies that prioritize near-term (i.e., achievable in the next five to ten years) health benefits to local communities can increase community commitment to longer-term mitigation efforts.

While most climate change policies could improve overall population health, the distributional impacts of these policies on health inequities varies. Some climate change strategies can *increase* the environmental, economic, and health burdens on communities already bearing the burden of cumulative environmental impacts, discrimination, poor health, and poverty.¹⁴ The distribution of resources and opportunities, environmental pollutants, and risks and exposures from climate change solutions often mirror political, economic, and social power differentials and gradients. For example, transit-oriented development to reduce vehicle miles traveled could drive up the value of real estate, increase rents, and cause displacement of low-income residents.

Climate change vulnerability and resilience

Not all individuals or communities are equally affected by climate change. *Climate change vulnerability* is the degree to which people and places are at risk from the impacts of climate change, and also takes into account how well they can cope with those impacts.¹⁵ *Climate change resilience* is the flip side of vulnerability; it is “the ability to survive, recover from, and even thrive in changing climatic conditions.” Some aspects of resilience include physical and psychological health, social and economic equity and well-being, availability of information and

effective risk communication, integration of governmental and non-governmental organizations, and social capital and connectedness.¹⁶

Characteristics of vulnerability and resilience co-exist in individuals and communities; it is the intersection of these characteristics, risk exposures, and resources that will determine the extent to which climate change impacts health and well-being.¹⁷ But whatever the nature or level of risk exposure, those with more economic, social, or political capital are more likely to survive and thrive in changing climatic conditions. Poor living conditions increase vulnerability to climate change and cause poor health status; poor health status even further increases climate vulnerability. The persistence of health and environmental inequalities in the United States is necessitating innovative policies and practices to understand and address the cumulative, and potentially synergistic, effects of environmental, physical, and social stressors on the health of working class, low-income, socially or politically marginalized communities and communities of color.¹⁸

Current and projected climate changes for the Northeast U.S. region

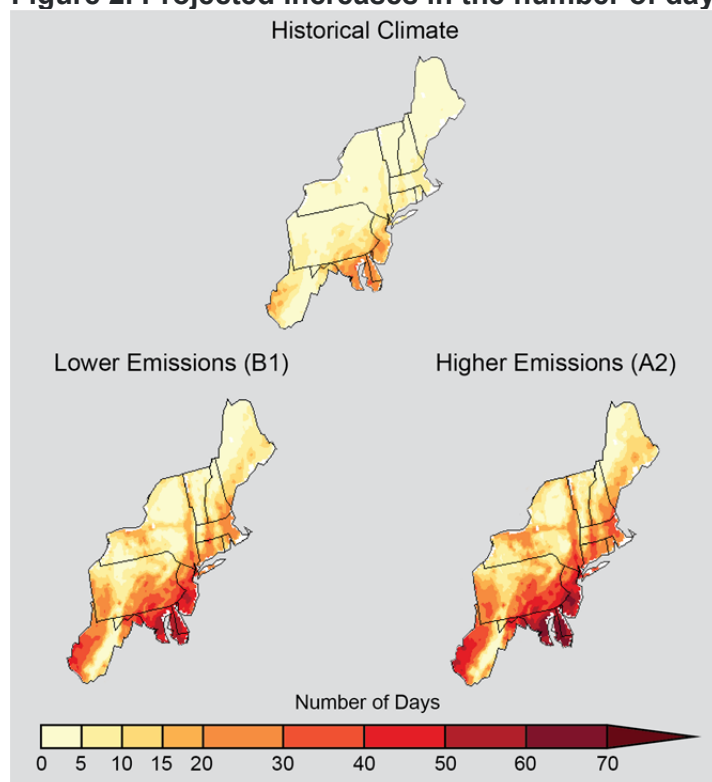
Increased temperatures and hydrologic extremes can impact health through direct and indirect exposures and socioeconomic disruption. Based on a review of climate projections and health research specific to the Northeast region, we present the main climate changes and associated health impacts likely to affect Northampton. The Northeastern region of the U.S. is projected to experience more heat waves, heavy downpours, and sea level rise, along with associated compromises to the infrastructure, agriculture, fisheries, and ecosystems that currently support human well-being. Sixty-four million people are concentrated in the Northeast, with the coastal corridor from Washington, D.C. to Boston being one of the most developed environments in the world. The region's large expanses of sparsely populated and agricultural areas support human health by protecting water supplies, buffering shorelines, providing food and economic activity, areas for physical activity, and sequestering carbon in soils and vegetation. This section outlines the current and projected changes likely to occur in the region, followed by the health impacts associated with those changes.

Heat

Between 1895 and 2011, temperatures in the Northeast increased by almost 2°F (0.16°F per decade).¹⁹ If global emissions continue to increase, warming of 4.5°F to 10°F is projected by the 2080s; if global emissions reduce substantially, projected warming ranges from about 3°F to 6°F by the 2080s.²⁰ Under both emissions scenarios, the frequency, intensity, and duration of heat waves is expected to increase, with larger increases under the higher emissions scenario. **In Northampton, the projected increase in number of days over 90 degrees Fahrenheit is from 5-10 days currently to 20-30 days (lower emissions scenario) or 30-40 days (higher emissions scenario).**²¹ Figure 2 shows the projected number of days per year with a maximum temperature greater than 90°F averaged between 2041 and 2070, compared to 1971-2000 (left), assuming substantial reductions in future emissions (middle), and continued increases in global emissions (right).

The frequency, intensity, and duration of very cold weather is expected to decrease as the century progresses.

Figure 2. Projected increases in the number of days over 90°, Northeast United States



Source: NOAA NCDC/Cooperative Institute for Climate and Satellites-NC. Available at <http://nca2014.globalchange.gov/report/regions/northeast>

Hydrologic changes

Between 1895 and 2011, precipitation increased by approximately five inches, more than 10% (0.4 inches per decade).²² The Northeast has experienced a greater recent increase in extreme precipitation than any other region in the U.S. **Between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events** (defined as the heaviest 1% of all daily events).

Winter and spring precipitation is projected to increase, especially in the northern part of the region.²³ * **Depending on the emissions scenario, increases in winter precipitation range from about 5% to 20%.**²⁴ The frequency of heavy downpours is projected to continue to increase as the century progresses. Seasonal drought risk is also projected to increase in summer and fall as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt.²⁵

Throughout the Northeast, populations and development are concentrated along rivers and their flood plains. Northampton's zoning laws do not currently allow for building in the 500-year flood zones (defined as the area with at least a 0.2% chance of experiencing a flood in a given year). However, due to sea level rise, increased hurricanes and other storm events, and increased flooding from high amounts of rainfall in short time periods, populations, property, public

* Projections of precipitation changes are less certain than projections of temperature increases.

infrastructure, businesses, and agricultural areas that have historically fallen outside the 500 year flood zone may find themselves in that zone. Northampton's Multi-Hazard Mitigation Plan rates the probability of flooding as "High" in the next year, with a limited impact – mostly loss of key transportation routes.²⁶

Although individual hurricanes cannot be directly attributed to climate change, Hurricanes Irene and Sandy nevertheless provided "teachable moments" by demonstrating the region's vulnerability to extreme weather events and the potential for adaptation to reduce impacts.

Infrastructure and living conditions

The condition of human settlements (e.g., type of housing and construction, infrastructure, transportation systems, utilities, and access to lifelines and opportunity) and the built environment are important determinants of climate change resilience or vulnerability, especially given the fact that these characteristics influence potential economic losses, injuries, and mortality.²⁷ **Vulnerability increases as key infrastructure, including electricity for potentially life-saving air conditioning and transportation systems for evacuation, is more likely to fail precisely when it is most needed.**

Public health impacts of climate changes

The public health impacts of the above-described climate changes include the direct and indirect health impacts of heat, hydrologic and air quality changes, and socio-economic disruptions that are health determinants, such as increased costs of energy, transportation, and housing.

Heat-related illness and death

Increased temperatures manifested as heat waves and sustained high heat days directly harm human health through heat-related illnesses (mild heat stress to fatal heat stroke) and the exacerbation of pre-existing conditions in the medically fragile, chronically ill, and vulnerable.²⁸ Increased health-related impacts and costs, such as premature death and hospitalization due to even modest increases in heat, are predicted in the Northeast's urban centers.^{29,30,31,32 33}

Since the hottest days in the Northeast are often associated with high concentrations of ground-level ozone and other pollutants, the combination of heat stress and poor air quality can pose a major health risk to vulnerable groups: young children, the elderly, and those with pre-existing health conditions including asthma.³⁴ Vulnerability to heat waves is not evenly distributed throughout areas; outdoor versus indoor air temperatures, air quality, baseline health, and access to air conditioning are all dependent on socioeconomic factors.³⁵ Socioeconomic factors that tend to increase vulnerability to such hazards include race and ethnicity (being a minority), age (the elderly and children), gender (female), socioeconomic status (low income, social status, or poverty), and education (low educational attainment). Although Northampton has a high prevalence of air conditioning in new housing and a moderate to high prevalence of at least one room air conditioning in older housing stock, vulnerability to heat may become a health equity issue if low-income or otherwise vulnerable populations do not have access to air conditioning. Winter heating needs, a significant expense for many Northeastern residents, are likely to decrease as the century progresses.³⁶ The closing of the Holyoke Coal-powered generation plant and the increase in installed solar photovoltaics will at least very partially address this issue.

Air pollution-related illness and death

Increased heat also intensifies the photochemical reactions that produce smog and ground level ozone and fine particulates (PM_{2.5}), which contribute to and exacerbate respiratory and cardiovascular disease in children and adults. Numerous studies document an increase in asthma associated with reduced air quality resulting from climate change.^{37 38} The Northampton region is already often considered "non-attainment" for ozone levels, and EPA is in the process of lowering the expected level of ozone.

Increased heat and carbon dioxide enhance the growth of plants that produce pollen, which are associated with allergies. Changing distributions of temperature, precipitation, and carbon dioxide could affect the potency of plant allergens. There has been an observed increase of 13 to 27 days in the ragweed pollen season at latitudes above 44°N since 1995.³⁹ Studies from around the world find that climate change would lead to: earlier flowering, higher pollen counts, greater concentration of pollen, and longer pollen seasons.⁴⁰ And while the last three to four decades have seen a fairly substantial increase in, for example, ragweed allergies (up to 75% of hay fever sufferers are sensitive to ragweed), what remains unknown is to what extent recent trends in pollen seasons may be linked with upward trends in these types of allergic diseases.⁴¹

Heat and hydrologic-related infectious and vector-borne diseases

Climatic changes alter the range, biogeography, and growth of microbes and the vectors of food, water, and vector-borne illnesses.

Most occurrences of Lyme and related tick borne disease in United States are in the Northeast, especially Connecticut,⁴² with less prevalence in Northampton. However, prevalence rate may not be an accurate pulse of the rate of disease in the City or County, as a significant number of people who contract Lyme disease are misdiagnosed during the early stages, leading to a chronic form of the disease which is even more difficult to diagnose and treat. While it is unclear how climate change will impact Lyme disease,⁴³ several studies in the Northeast have linked tick activity and Lyme disease incidence to climate change, specifically abundant late spring and early summer moisture.^{44,45} A recent study predicts that, nationally, the average annual onset week of Lyme disease is projected to become 0.4 – 0.5 weeks earlier for 2025-2040 and 0.7 – 1.9 weeks earlier for 2065-2080.⁴⁶

West Nile Virus (WNV) is another vector-borne disease that may be influenced by changes in climate. Suitable habitat for mosquitos transmitting West Nile and other vector-borne diseases is expected to increase in the Northeast from the current 5% of the region to 16% in the next two decades and to 43% to 49% by the end of the century, exposing more than 30 million people in the Northeast to the threat.⁴⁷

Eastern Equine Encephalitis (EEE) is Massachusetts' most severe vector-borne disease, having a 30-50% mortality and lifelong neurological disability among many survivors. There is no treatment for EEE. Like WNV, precipitation and temperature are the two most important contributors to EEE's spread. Warmer temperatures shorten the time it takes mosquitos to develop from egg to adult and to transmit a pathogen after ingesting an infected blood meal; warm and wet winters will mean higher spring mosquito numbers. Like WNV, EEE relies on an infected bird population, and less is known about what leads to infection in birds.⁴⁸ The *Culex Melanura* mosquito, a vector for EEE, now breeds in the western part of Massachusetts, whereas up to a few years ago, it was only found in the eastern part of the state. Since 2000, most cases of EEE have occurred in Bristol and Plymouth counties, but in 2012 EEE was found in Essex, Middlesex, Worcester, Franklin, and Hampshire Counties.⁴⁹

Generally an extended summer season means an increased risk of vector-borne diseases.

Extreme weather-related injury, displacement, and mental health

Extreme weather events (e.g., storms and flooding) cause fatal and nonfatal injuries from drowning, being struck by objects, fire, explosions, electrocution, or exposure to toxic materials.

Chronic flooding can lead to damp basements, which harbor mold and affect structural soundness. Property damage due to flooding can lead to exposure to lead, asbestos, mold, and pests. Mold and pest infestation are asthma triggers. Damage caused to buildings can make them unsafe or undesirable places to live or work; "flood blight" can decrease property values and tax bases. A widespread weather-related natural disaster may destroy or ruin housing, schools and businesses and cause temporary or permanent displacement. Individuals and families may experience post-traumatic stress, depression, and increased risk of suicide.^{50,51}

Flooding can also impair the quality and availability of locally produced food. Flood water may also carry raw or untreated sewage, as well as chemicals, petroleum products, or other hazardous releases from upriver or upstream facilities.

Disruption of health-supportive services and infrastructure

Disruptions to services provided by public and private infrastructure in the Northeast both interrupt commerce and threaten public health and safety.⁵² Widespread social and economic disruption includes damage to the infrastructure for the delivery of health services and for general economic well-being. Health care facilities, water treatment plants, and roads for emergency responders and transportation for health care personnel can be damaged in climate-related extreme weather events. During heavy rain events, sewer systems can be overwhelmed and untreated water may be released into local water bodies.

Increased burden of disease and injury will test the surge capacity of health care facilities. Economic disruption can increase income loss and income insecurity, food insecurity, housing insecurity, and mental health problems, which in turn may increase substance abuse, family instability, suicide, and other health problems. Energy production and distribution are also threatened by heat (e.g., loss of efficiency, generating capacity, and fires disrupting transmission lines).

The 2014 National Climate Assessment for the United States⁵³ supplies a helpful matrix when considering transportation system impacts of climate change.

Table 1. Illustrative Risks of Climate-related Impacts to Transportation Systems

		Likelihood of occurrence			
		Low	Medium	High	Virtually Certain
Magnitude of Consequences	High	Subway and tunnel flooding	↑ Widespread flooding of transportation facilities	Major localized flooding disrupts transportation systems	Inundation of coastal assets due to storm surge
	Medium	↑ Rock/mud slides blocking road and rail facilities	Train derailment due to rail buckling	Disruption of barge traffic due to flooding	Short-term road flooding and blocked culverts due to extreme events
	Low	↓ Visibility from wildfires due to drought conditions	Northern shift of ag production = ↑ demand and stress on roads not prepared for higher volumes	Pavement heaves and reduced pavement life due to high temperatures	Inundation of local roads due to sea level rise
	Beneficial	↓ □ Flight cancellations due to fewer blizzards	↓ Maintenance costs for highways and airports due to warmer winters	↓ Great Lakes freezing = longer shipping season	Longer seasonal opening of Northwest Passage

Source: Adapted from McLaughlin et al 2011⁵⁴ in the Third National Climate Assessment.

Climate-relevant health and infrastructure existing conditions

The following section details the existing conditions with regard to health outcomes, social vulnerabilities, and infrastructure, and includes conditions relevant to climate change adaptation. Inclusion of the following existing conditions was guided by local knowledge of the priority concerns related to climate change as discussed with the Northampton Office of Planning and Sustainability and the Northampton Department of Health. Where possible, Northampton-specific data was compiled. Occasionally we rely on region- or county-specific data. When possible, we include either a comparison to an area that Northampton could be like in the future, based on changing agriculture zones, or an estimate of how expanding seasonality might affect disease incidence.

Climate relevant health outcomes

Heat related illness

Data from the Massachusetts Department of Public Health Environmental Public Health Tracking database indicate that there were very few heat-related hospitalizations and emergency department visits in Northampton from the years 2002 - 2012.

Table 2. Heat related hospitalizations and emergency department visit rates (per 100,000 people) in Northampton, Hampshire County, and Massachusetts (2000-2012)

Heat related illness	Northampton	Hampshire County	Massachusetts
Hospitalization	NS	NS	From .4 to 1.7 / year
Emergency Dept. visit	NS	From 7 to 16 / year	From 6 to 16 / year

Source: Massachusetts Department of Public Health Environmental Public Health Tracking. Heat Stress Illness. Available at <https://matracking.ehs.state.ma.us/Health-Data/heat-stress-hospitalization.html>. / CDC. 2014. Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2012. Available at http://www.cdc.gov/nchs/data/series/sr_10/sr10_260.pdf
 NS: Not shown due to small numbers

The Northeast region of the U.S. has the lowest incident rate in the country, with the Northeast incident rate of heat-related hospitalizations at 0.80 per 100,000, whereas the South is the highest at 1.61 per 100,000.⁵⁵ A CDC study found Massachusetts to be one of five states that showed a *decrease* (from 5% - 12% in those states) in heat stress hospitalizations between 2001 to 2010. This study also found that Massachusetts, however, showed the strongest statistical correlation between monthly average number of heat stress hospitalizations and average monthly maximum temperature and average monthly heat.⁵⁶

Prediction: For comparison, the USDA Hardiness Zone for Northampton is predicted to change to Hardiness Zone 7 (See Appendix), similar to current conditions in the semi-rural region of western North Carolina. Current conditions in this region of North Carolina can offer a picture of what may happen in the future in Northampton.

In a two-year period (2007-2008), the western region of North Carolina had 158 Emergency Department (ED) visits for heat-related illness, or about 7.5 per 100,000 people. In that same period, there were three heat waves. During the heat waves, there were between 0 and 31 ED visits per day in the region. For temperatures between 90 and 98 degrees Fahrenheit, there were between 10 and 18 ED visits per day statewide. At 99 degrees and above, the number increased significantly, with 100 degrees showing about 50 ED visits per day statewide.^{57 58 59} Comparing Hampshire County, MA to the western region of North Carolina shows that both

areas have a similar rate of heat-related emergency department visits per 100,000 people. Hampshire County shows between 7 and 16 ED visits per 100,000 people, and western North Carolina had 7.5 ED visits per 100,000 people. **If the Northampton region changes its Hardiness Zone such that it's similar to western North Carolina, based on this comparison it is unlikely that there will be a change in heat-related illness.**

Seasonal allergies

Commonly known as hay fever, seasonal allergies show a slightly higher prevalence in the Northeastern United States (9.3% of the population) than on average in the country (7.3%). The rate of hay fever prevalence is slightly lower for those whose annual household income is less than \$35,000, African Americans and Latinos, and those with a high school degree or less, and it is quite a bit lower (6%) for those who live in more rural areas.⁶⁰

Prediction. Rates of seasonal allergies in western North Carolina are not available, so no comparison is possible.

Asthma

In Massachusetts in 2008 almost 15% of adults had ever had asthma in their lives, and current asthma prevalence was just under 10%. This was slightly higher than the U.S. prevalence. The prevalence of ever having had asthma for children was almost 14%, and the current childhood asthma prevalence was 10%. Again, this is slightly higher than the national averages.⁶¹

The Community Health Assessment done by the Cooley Dickinson Hospital found that in 2008 in Hampshire County, a slightly higher percentage of adults have asthma than in Massachusetts statewide. More females have asthma (20%) than males (14%), and it is slightly higher in people who make over \$50,000 per year (19%) than people who make less than \$50,000 per year (16%).⁶²

The Community Health Assessment also noted that asthma prevalence in school-age children was higher in Northampton than in the state in all six years recorded (2002 – 2007), sometimes more than 10% higher. Certain elementary schools in Northampton had higher levels of asthma than others: Bridge Street and Jackson Street Schools are consistently higher than RK Finn Ryan and Leeds.⁶³

The rate at which Northampton residents are hospitalized for asthma was available only for people aged 35 – 64 and for 65+. (For those who are younger than age 34, the numbers were too few in Northampton to identify for confidentiality purposes.) The rates in Northampton track with rates statewide, and are fairly low.

Table 3. Asthma Hospitalization Rates (crude rate), Northampton and Massachusetts, 2002 - 2014

	North- ampton	MA	North- ampton	MA
Year\Age	35-64	35-64	65+	65+
2002	NS	NS	33	18
2003	NS	NS	33	22
2004	14	13	33	23
2005	NS	NS	31	25
2006	13	14	46	26

2007	12	13	41	28
2008	13	14	46	27
2009	13	16	34	26
2010	15	14	NS	25
2011	14	14	NS	23
2012	9	13	NS	19

Source: Massachusetts Department of Public Health Environmental Public Health Tracking.
 NS: Not show due to small numbers

The rate of people who use the emergency department for asthma is higher. Looking at trends in the table below, children under 5 go to the Emergency Department at about the same rate as the statewide rate, and people over age 65 use the ED at a slightly higher rate. However, in all other ages, Northampton rates tend to be lower than the state. Additionally, the crude rates indicate a general decrease in use of the ED overall through the years, except for children under age 5.

Table 4. Rates (crude rate) of Emergency Department Visits for Asthma, Northampton and Massachusetts, 2002 - 2014

	North- ampton	MA	North- ampton	MA	North- ampton	MA	North- ampton	MA	North- ampton	MA
Year\Age	<5	<5	5-14	5-14	15-34	15-34	35-64	35-64	65+	65+
2002	137	165	71	81	91	85	55	68	48	41
2003	216	186	71	89	57	89	42	61	48	41
2004	166	166	58	78	46	74	42	61	48	41
2005	123	160	109	77	52	76	58	63	46	42
2006	115	180	85	84	38	75	63	63	67	46
2007	170	175	82	81	42	73	55	60	51	42
2008	99	198	60	88	66	78	56	63	67	46
2009	NS	169	49	85	52	78	49	64	62	43
2010	NS	178	42	78	29	67	42	58	31	40
2011	NS	164	NS	86	38	71	40	59	NS	40
2012	168	163	NS	84	40	75	36	62	34	39

Source: Massachusetts Department of Public Health Environmental Public Health Tracking.
 NS: Not show due to small numbers

Prediction. A complex mix of factors leads to asthma: climate change factors such as change in ground level ozone, PM2.5, mold produced due to flooding, increased days of high heat, and non climate-change factors such as old or poorly constructed housing, exposure to smoking, distance from traffic sources. Due to this complexity it is not possible to draw comparisons to another geography.

Premature mortality and chronic conditions

Premature mortality is considered one of the best indicators of the health of a population. Data from the Cooley Dickinson Hospital Community Health Assessment indicate that the premature mortality rate was slightly higher in Northampton (330 per 100,000 people) in 2006 when compared to the state of Massachusetts (300 per 100,000). Adult overweight and obesity is lower in Hampshire County than the state, although still over half of people report being overweight or obese in the county. Individuals who have chronic medical conditions and psychiatric illness are at higher risk for health impacts of climate change

Table 5. Rates and percentages of select chronic conditions in Northampton, Hampshire County, and Massachusetts

Chronic conditions	Rate per 100,000 people		
	Northampton	Hampshire County	Massachusetts
	Perceptions and report of health, 2007		
% of adults with fair or poor health (2007)		9%	13%
% of adults with poor physical health (2007)		9%	9%
Premature mortality		330	300
Heart disease			
Male/Female		8% / 6%	8% / 5%
Income < \$50,000 / > \$50,000 per year		13% / 3%	11% / 4%
Adult obesity (2009)			
Overweight or obese		51%	58%
Obese		18%	22%
Deaths due to Injury (2008)	51		47

Source: Western Massachusetts Center for Healthy Communities. 2011. Community Health Assessment. Cooley Dickinson Hospital.

Of special interest is cardiovascular disease, given the impact that days of extreme heat has on it. According to the Cooley Dickinson Hospital report, deaths due to heart disease in 2008 in Northampton were slightly lower (151 per 100,000) than Massachusetts (157 per 100,000). Hospital data for myocardial infarction (heart attack) through the years indicates slightly lower or similar rates among 35 – 64 years olds in Northampton as compared to the state, and slightly higher rates among those aged 65 + in Northampton. There is a clear trend statewide and in Northampton of a decrease in heart attacks over time.

Table 6. Hospital Admission Rates per 10,000 for Myocardial Infarction, Northampton and Massachusetts, 2002 - 2012

Year\Age	Northampton 35-64	MA 35-64	Northampton 65+	MA 65+
2002	18	24	156	138
2003	10	24	162	143
2004	24	21	107	126
2005	20	20	122	115
2006	25	20	115	108
2007	26	19	146	102
2008	12	18	100	98
2009	15	17	85	95
2010	17	17	142	91
2011	NS	17	56	81
2012	17	17	56	78

Source: Massachusetts Department of Public Health Environmental Public Health Tracking. Heat Stress Illness. Available at <https://matracking.ehs.state.ma.us/Health-Data/heat-stress-hospitalization.html>.

Prediction. Due to the complex epidemiology of chronic conditions, including both cardiovascular disease and obesity, it is not possible to draw comparisons to another geography.

Vector-borne disease

We considered rates of Lyme disease, Eastern Equine Encephalitis, and West Nile Virus.

Table 7. Rates (per 100,000) of vector-borne diseases, Massachusetts and United States

	Massachusetts	United States
Lyme disease rate per 100,000, 2014	54	8
Eastern Equine Encephalitis rate per 100,000, 2012	0.11	<0.01
West Nile Virus Rate per 100,000, 2012	0.38	0.92

Sources: Centers for Disease Control and Prevention^{64 65}

Table 8. Rates and cases of vector-borne diseases Pioneer Valley towns

Vector-borne Disease		
		Rate per 100,000 people, 2010 - 2014
Lyme disease		
Northampton		82
Amherst		60
Easthampton		64
South Hadley		39
Hadley		38
	# of cases, 2014	
Hampshire County	136	
	# of cases in MA 2004-2013	
Eastern Equine Encephalitis	24	
West Nile Virus	# of reported cases, 2004-2014	
Hampshire County	0	
Franklin County	0	
Hampden County	5	
Worcester County	10	

Sources: 1) Massachusetts Department of Public Health (MDPH), as reported in the Boston Globe⁶⁶; 3) CDC. Eastern Equine Encephalities. Centers for Disease Control and Prevention. Available at <http://www.cdc.gov/EasternEquineEncephalitis/index.html>; 4) MDPH. 2015.Arbovirus surveillance in MA 2014.

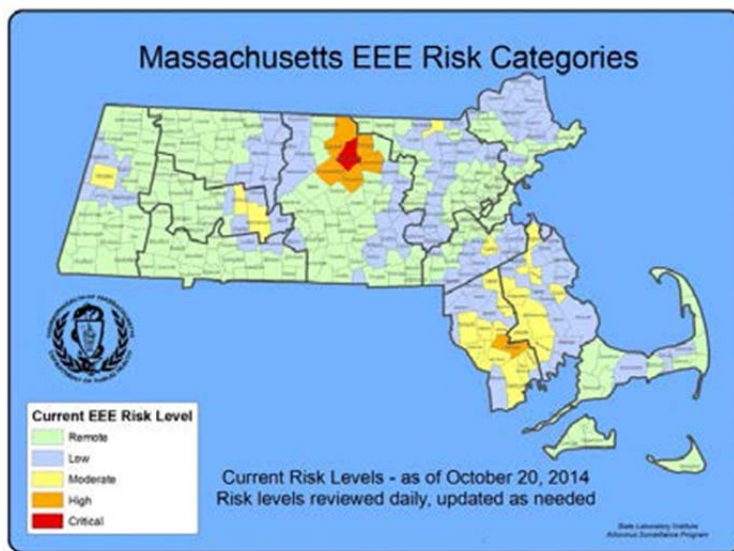
Lyme disease is the most common vector-borne illness in the United States,⁶⁷ and incidence has increased 101% between 1992 to 2006.⁶⁸ The 2014 rate of Lyme disease in Massachusetts is 54.1 per 100,000 cases, which is 6.8 times higher than 2014 national incidence rate of 7.9 per 100,000.⁶⁹ In 2013, 95% of confirmed Lyme disease cases were reported from only 14 states, Massachusetts being one of them; most are East Coast and a few are Midwest states.⁷⁰ While Northampton has higher rates of Lyme disease, according to 2013 data, then neighboring Amherst, Hadley, Easthampton and South Hadley, they are still far below the hot spots of Lyme in the state, which are Cape Cod and the Berkshires.⁷¹ There is some indication that Lyme disease may be underreported because of the high percentage of false negatives on Lyme disease tests.⁷² The Massachusetts Department of Public Health estimates a 5 – 10% underreporting rate for Lyme disease.⁷³

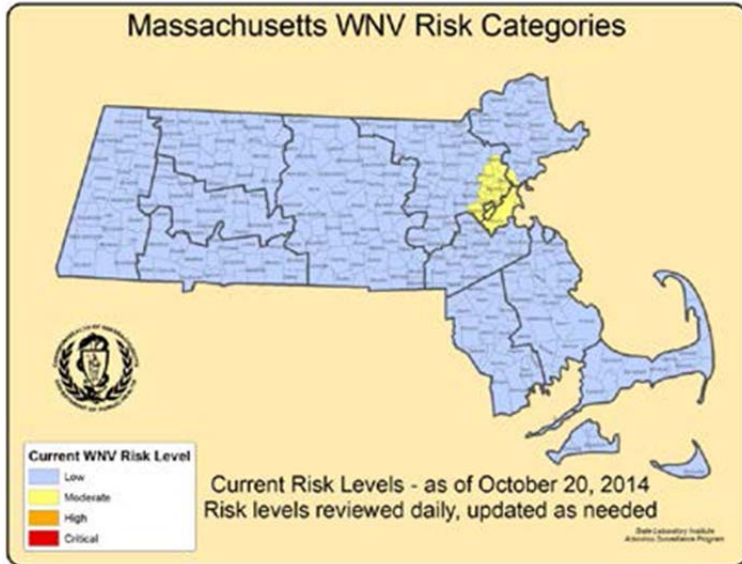
Prediction. A study looking at the changing season for the Lyme disease-carrying tick notes that the average annual onset week of Lyme disease will start will start 0.2 – 2.3 weeks earlier

by 2065-2080.⁷⁴ Given an average of 6.5 cases of Lyme disease reported per week in Hampshire County (for methodology, see the Appendix), we predict that future climate change will result in about 13 more cases per year in Hampshire County.

Eastern Equine Encephalitis is a mosquito-borne disease that is fairly rare because it tends to happen around swampy environments where there is not a large human population. However, the disease is severe, causing death in about one-third to one-half of all people who contract it. Of those who survive, they may be left with brain dysfunction, severe intellectual impairment, personality disorders, seizures, paralysis, and cranial nerve dysfunction. In the U.S., about 8 human cases of EEE are reported annually. Massachusetts has the most EEE cases reported; 24 cases reported from 2004 – 2013; 2012 had the most cases reported in the state at 7 cases. In 2014 there were no cases of EEE infection identified in Massachusetts, and only one in 2013. Of over 5,000 mosquito samples collected, 0.7% were positive for EEE. While cases are higher in Massachusetts compared to the rest of the U.S., they tend to be concentrated along the coastal counties.⁷⁵ In October 2014, Northampton’s risk category for EEE was “remote” (the lowest), while some other parts of Hampshire County were “low” and a small eastern part of Hampshire county was “moderate”.

Figure 3. Massachusetts EEE and WNV Risk Categories





Source: Massachusetts Department of Public Health

West Nile Virus is another mosquito-borne disease. Nationally, 2,122 human cases of WNV neuroinvasive disease (meningitis and encephalitis) and WNV fever were reported to the CDC in 2014. The majority of people who are infected with WNV (approximately 80%) will have no symptoms. A smaller proportion of people who become infected (~20%) will have symptoms such as fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands. They may also develop a skin rash on the chest, stomach, and back. Less than 1% of people infected with WNV will develop severe illness, such as encephalitis or meningitis.

In Massachusetts, there were at least six fatal WNV human cases identified between 2002 and 2014. All but one of these fatalities was in individuals 80 years of age or older. Five of these cases were in Middlesex County and one was in Essex County, i.e., on the coast. From 2004 - 2014, there were no cases of people infected with WNV reported in Hampshire and Franklin Counties, 5 in Hampden County, and 10 in Worcester County.^{76 77}

Prediction. Similar to Lyme disease, it is likely if the mosquito season begins earlier there will be more cases of EEE and WNV.

Mental Health

Mental health indicators showed that the elderly in Western Massachusetts had a dramatically higher rate of suicide than the rest of the state, however, overall the suicide rate in Northampton is slightly lower than the state level. Alcohol-related discharges from hospitals were much higher in Northampton than the state, however binge drinking in Hampshire County was a little lower than in the state. In addition, the proportion of adults with poor mental health was slightly lower in Hampshire County than in the state. Individuals who have psychiatric illness are at higher risk for health impacts of climate change.

Table 9. Mental Health in Northampton, Hampshire County, and Massachusetts

	Northampton	Massachusetts
Suicide (per 100,000) Average per year using 2000-2004 data)		

Overall	5.2	6.5
Elderly	25	7
Alcohol-related hospitalization (2003)	706	306
	Hampshire County	Massachusetts
Binge drinking (average per year, 2002-2007)	16%	17%
Adults with poor mental health (2008)	6%	9%

Sources: 1) Western Massachusetts Center for Healthy Communities. 2011. Community Health Assessment. Cooley Dickinson Hospital 2) Pioneer Valley Planning Commission. 2006. Northampton Indicator Report.

Climate relevant social vulnerabilities

Population characteristics

Those who are vulnerable to the health impacts of climate change are the very old and very young, who make up about 30% of Northampton's population. Communities of color and geographically segregated communities are also more vulnerable to climate change's impacts; people of color make up about 12% of Northampton's city-wide population and a much higher percentage of the youth population. Additionally, those without means for evacuation are at higher risk; 11% of Northampton residents do not have a car. Those with lower incomes or who are living in poverty are at higher risk and Northampton has a higher rate of people living under the poverty level than in the state at 14% of the residents. While Northampton has a lower rate of people who are linguistically isolated than in the state (13% versus 22%), this is still a fairly large proportion of the population to consider in emergency management planning.

Table 10. Population characteristics, Northampton, Massachusetts, 2014 estimate

	Northampton	Massachusetts
Total population	28,554	
Persons under age 18	16%	21%
Persons age 65 and over	13.5%	13.8%
Females	57%	52%
Race		
White alone	88%	80%
Black / African American	3%	7%
Hispanic	7%	10%
Asian	4%	5%
Foreign born	11%	15%
Language other than English spoken at home	13%	22%
Education		
High school graduate	93%	89%
Bachelor's degree or higher	56%	39%
Income		
Median household income	\$57,991	\$66,966
Person < poverty level	14%	11%
Unemployment (2009)	6%	8.4%

Source: United States Census. Northampton Quick Facts. Available at <http://quickfacts.census.gov/qfd/states/25/2546330.html>

Housing

In the table below, we see that about one-quarter of Northampton residents are housing cost-burdened, or pay more than 30% of their income on housing, with renters shouldering a higher cost burden than owners. The large proportion of people struggling with the cost of housing suggests a vulnerability to climate change effects – higher likelihood of health outcomes such as asthma due to poor quality housing, housing infested by mold and pests due to flooding, lack of air conditioning to combat heat and pollen exposure, and difficulty of displacement in a weather emergency.

For a non-urban area, there are a fairly high number of homeless residents, due to the availability of support housing and social services, the Veteran’s Administration Medical Center, the Hampshire County Jail, and the now-closed Northampton State Hospital. There is also a fairly large university residential population.

Table 11. Housing in the Pioneer Valley

People paying > 30% of income on housing	26%
Renters	30%
Owners	22%
Homelessness	
Male	60%
Between age 26 - 44	48%
Minority	62%
Live in a shelter	44%
Live on the street	15%
One night homelessness count in Franklin, Hampshire and Hamden counties	<ul style="list-style-type: none"> ➤ 1,000 (349 individuals; 636 people in families) ➤ 25% are chronic; 75% are episodic homeless
Emergency homeless shelters or transitional housing	11 w/ capacity for 232 individuals and 52 families
People in group quarters in Northampton (2010)	
University student housing	2,015
Nursing facilities/skilled-nursing facilities	527
Local jails (adults and youth)	273
Residential treatment centers (adults & youth)	213
Non-institutional facilities	67
% of housing units w/ no car	11%

Sources: Northampton Housing Partnership. 2011. Northampton MA Housing Needs Assessment and Strategic Housing Plan. City of Northampton. Table 3.34; Health Care for the Homeless at Mercy Hospital, Springfield MA. Homelessness Facts and Stats. Available at <http://www.hamphomeless.org/homeless-resources/homelessness-facts-and-stats/>; and Cities of Springfield, Holyoke, Northampton. 2008. All roads lead home: The Pioneer Valley’s Plan to End Homelessness; Northampton City-Data at <http://www.city-data.com/city/Northampton-Massachusetts.html>

Additionally, heavy rain or snowstorms can increase housing costs for residents. For example, in summer 2015, the state’s homeowner’s insurance agencies raised their rates an average of 9% due to winter storm damage claims on housing.⁷⁸ Costs for heating and cooling one’s home also respond to climate changes, see below in “Utilities.”

Given that a large proportion of Northampton residents are challenged with regard to housing affordability, the city’s ongoing efforts to provide affordable housing are an excellent climate change strategy.

Utilities

The table below shows some characteristics of residential heating and cooling; of interest due to the concern about more days of extreme heat, more severe and frequent winter storms, but also shorter and more temperate winters, on average. Only about 1% of Massachusetts' residents energy expenditure costs are put toward cooling, and the largest proportion of energy costs, 59%, are allocated to heating. Most people in Massachusetts heat their homes with natural gas and oil. Most homes do not have central air conditioning, relying on window units if anything at all to cool their homes. With combined window units and central air, 79% of homes in the state of Massachusetts have air conditioning.⁷⁹ We also include average cost of fuel in the context of the burden that a low-income population might face if there are more extreme winter storms, although in general the prediction is that winter temperatures in general will decrease.

Table 12. Home energy use in Massachusetts, heating fuel and cooling equipment used

Home energy use, MA		
% of expenditure on heating	59%	
% of expenditure on cooling	1%	
Type of heating fuel used		2014/2015 cost for the winter
Natural gas	55%	\$2,000
Oil	31%	\$3,600
Electricity	10%	\$1,800
Other	4%	\$3,900 (propane)
Cooling equipment used		
None	21%	
Window units	58%	
Central air conditioning	21%	

Sources: 1) United States Energy Information Administration. 2009 Residential Energy Consumption Survey. Household Energy Use in MA. Available at http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ma.pdf; 2) Massachusetts Energy and Environmental Affairs. 2015. Household Heating Costs. Available at <http://www.mass.gov/eea/energy-utilities-clean-tech/misc/household-heating-costs.html>

Heating costs have varying impacts on residents' pocketbooks. In the 2014-2015 winter, heating costs increased. In the projected 2015-2016 winter, heating costs are projected to decrease between 13% to 23%, depending on what type of heating fuel used.⁸⁰ The average electrical bill in Massachusetts in 2012 was \$94, and in 2014 was \$106.94.⁸¹ There is likely to be a shift in utility costs from heating to cooling. Because the larger cost by far is heating, this will probably result in a net decrease in costs.

Climate relevant infrastructure

Transportation

Public transportation. There are 85 bus trips a day, that go round trip from Northampton to Amherst, Hadley, South Hadley, Florence, the Holyoke Mall, Easthampton, and Greenfield. There are also demand-response services for the elderly and disabled.

Air and rail transportation. Bradley International Airport is about 60 minutes away in Hartford, CT, and Northampton has a municipal airport in town. Northampton also has a stop for Amtrak that travels south to Springfield, MA, New York City and north to Burlington, Vermont with stops in between.

Roadways. Northampton is serviced by Interstate 91, which has four exits in Northampton and is not a flood risk due to its elevation. Other major roadways are Route 9, connecting east to

Hadley, Amherst, Belchertown, Ware and west to hill towns; Routes 5 and 10, connecting to Hatfield, Greenfield, Deerfield, Brattleboro Vermont, Holyoke, Springfield and Enfield, CT. Northampton's 2015 Hazard Mitigation Plan has identified flooding as a high probability event with limited impact, but the impact is mainly on temporary loss of transportation routes.⁸²

The Hazard Mitigation Plan notes that in the course of any given year, several incidents happen at railroad underpasses that result in large semi-trucks becoming lodged and blocking traffic, indicating an emergency evacuation route concern. There is no quantification of the adequacy of evacuation routes, nor a public evacuation plan.

Medical facilities

Northampton has one full service hospital, Cooley Dickinson Hospital. Most Northampton and Florence residents are a 5-8 minute drive from the hospital and a 10-minute bus ride once on the bus. The Emergency Department is open 24 hours a day, 365 days a year. There are 86 beds, and in a recent year there were 36,500 ED visits, almost 8,000 admissions, 1,400 inpatient surgeries, and 2,400 outpatient surgeries. The average wait time to see a doctor at the ED was 48 minutes. The average time before being sent home was 2.5 hours; to be admitted was 5 hours; and to be taken to a room was 6.25 hours. Two percent of ED visitors left without being seen.⁸³ There are 223 doctors at Cooley Dickinson. Of those, 9 are cardiologists, 5 are allergists; and 42 are Family Medicine.

The closest hospitals for pulmonology are Mercy Medical Center (301 beds, 8 pulmonologists, 14 miles away) and Baystate Medical Center (716 beds, 13 pulmonologists, 16 miles away), in Springfield, MA and Holyoke Medical Center (198 beds, 1 pulmonologist, 8 miles away) in Holyoke, MA.

The VA Central Western Massachusetts Healthcare System is a psychiatric hospital in Leeds, MA (167 beds, 43 doctors, 12 of which are psychiatrists, 16 are internists, 3 are family medicine).

Given the state of epidemiological research relating to quantification of health outcomes, it is not possible to conclude if the current capacity is adequate for public health emergencies in the future.

Public health capacity

The Northampton Health Department has five staff; a full time (35 hours) health director, a full-time sanitarian, a part-time sanitarian, a public health nurse, and a full-time administrative assistant. There is also a 5-member volunteer Board of Health, members of which are appointed by the Mayor and serve for three years on a rotating schedule.⁸⁴ Very few communities in Western Massachusetts have any local Board of Health members with formal public health training although at least one physician is required by law to be on the Board. Paid Health Department staff tend to have these credentials. It is more likely, though, that a Board of Health member has FEMA (Federal Emergency Management Association) training; in the larger towns of Western Massachusetts, about 65% of local boards of health have people who are FEMA trained.⁸⁵

Electrical power

Northampton has 17 emergency electrical power facilities, meaning that these facilities have generators that will work in case of a power outage. They are located at facilities such as hospitals, emergency operations centers, the fire department, the wastewater treatment plant and the flood control system.

There were 18 power plants in the Pioneer Valley in 2013. The largest of those, a coal fired plant in Holyoke, closed in 2015. Four of these produce over 100 megawatts of power. The majority of the region's power lines are above ground, with small sections buried in more urban areas, like Springfield. The summer peak loads have consistently increased over time, from about 21,500 megawatts in the summer of 1992 to 28,800 in 2011.⁸⁶

While a "typical" response time to downed wires was not available, all utility companies are required to have an Emergency Response Plan. They delineate storms as events that range from Level I (small impact, affecting less than 4,000 customers with 1 to 20 trouble spots requiring 1 to 10 crew, and with an expected outage duration of no more than 12 hours) to Level V (catastrophic system event, affecting over 18,000 customers with over 200 trouble spots requiring more than 100 crews and the outage duration could be over 72 hours).

In an investigation of the October 29, 2011 storm that dropped more than 32 inches of wet, heavy snow in Western Massachusetts, there were over 200,000 customers who lost power, one public utility (Eversource, previously Western Massachusetts Electric Company[†]) received more than 10,000 "wires down" calls, and complete service was not restored for over one week.⁸⁷ The number of major outages from 2007 – 2012 has quadrupled, and while once they were somewhat rare, they are now annual occurrences. The investigation concluded that there are too few front-line repair crews at major power companies, with National Grid, NStar, and Eversource having only 3 or fewer linemen for every 10,000 people in the service area. There have been eight major power outages in Massachusetts since 2007, and winter storms have been the major culprit. All involved the state's large electric companies. In contrast there were only 2 major outages during the previous five years (2001 – 2006).⁸⁸

It is likely that the frequency and severity of future storms will bring down the electrical system for many, so a recommendation has been included in the Strategies section of this report to increase the number of emergency workers per shift during power outages. Significant investments may be required to ensure that power generation keeps up with rising demand associated with rising temperatures.⁸⁹

Water quality and infrastructure at risk of flood

There are no combined sewer overflow (CSO) systems in Northampton. CSOs are a single pipe system that collects both sewage and urban water runoff from streets and roofs, creating a public health concern during storms. There are 64 CSOs south of Northampton in Holyoke, Chicopee, and Springfield. Water quality in some section of the Connecticut River in Massachusetts and Connecticut does not meet fishable and swimmable standards due to discharges from CSOs and urban stormwater runoff, but this is likely downstream from Northampton.⁹⁰ The website "Connecticut Rivers.us" reports regular water quality testing on the Connecticut River and its tributaries, however there are no long-term reports noting number of water contamination events over time. However, the Mill River, Northampton site "at the rope swing" between 5/31/2012 – 10/1/15 (39 months) had 15 days that the water was not clean for

[†] Northampton has National Grid as the provider of electricity. WEMCo statistics cited only to give an indication of the magnitude of the effects of storms.

boating or swimming. The Connecticut River site at Damon Road had 6 days that the water was not clean for boating or swimming.⁹¹

Northampton's Multi-Hazard Mitigation Plan identifies facilities and residences at risk in case of a flood: the Northampton Airport; sections of Route 10 which provides southbound entry and exit from the city and are in the 10-year floodplain; water and sewer lines on the city's bridges in case of bridge destruction; the road adjacent to the Mill River; and power substations at Smith College, King Street, and Route 5 at the Easthampton line. Additionally there is a group home/assisted living facility and the Paradise Pond Transitional Apartments in Mill River's 500-year floodplain. While protected by Northampton's levee system, if the levees should fail the power facilities on West Street, the wastewater treatment facility, and much of downtown would be at risk.⁹² While there is a low risk of water quality issues in the face of a flood, it is somewhat unlikely, according to current planning and hazard mitigation documents.

Air quality

Between 2001 and 2011, the number of days that Hampshire County has exceeded the National Ambient Air Quality Standards for ozone, set by the Environmental Protection Agency, ranged from 1 to 23. Since 2007, the number of days of exceedance have generally declined, however it is likely too few years to draw any conclusions. Unfortunately, no data was available for PM2.5.

Table 13. Hampshire County, Days exceeding National Ambient Air Quality Standards for Ozone, 2001 - 2011

Year	Number of days exceeding NAAQS
2001	23
2002	17
2003	3
2004	8
2005	12
2006	10
2007	18
2008	7
2009	4
2010	5
2011	1

Source: Massachusetts Department of Public Health. Environmental Public Health Tracking: Air Quality. Available at <https://matracking.ehs.state.ma.us/Environmental-Data/Air-Quality/index.html>

Emergency shelters and cooling center

There are four designated emergency shelters – three schools (Smith Vocational, Northampton High, and JFK Middle) and the Senior Center on Conz Street. The Senior Center is also a designated emergency cooling center, although the Health Department notes that it is not an ideal emergency cooling center. There are no designated emergency heating centers, although Smith Vocational has been used as a heating center as recently as January 2015 for the winter storm at the end of that month. Smith Vocational is also the Regional Shelter for the surrounding towns.

Emergency communications

Northampton maintains an accurate and comprehensive system of notification of snow emergency and water usage emergencies to Northampton residents. This is part of the Reverse 911 – CODE RED program. Residents sign up and are notified if there is a need for emergency evacuation or other emergency management issues.

Tree Canopy

Trees provide shade and cooling during extreme heat days. Forty-nine percent of Northampton is forested. There was not a readily accessible map of where trees exist in Northampton. The Sustainable Northampton Plan (2014) targets that the city plant or replace a minimum of 25 trees per year, with a goal of one-for-one replacement, and that street trees should be planted every 20 feet.⁹³ Northampton’s Shade Tree Commission states that “To help reverse a recent decline in public shade trees and improve Northampton’s livability, the Public Shade Tree Commission, in collaboration with Tree Warden Rich Parasiliti, is organizing the planting of 160 public shade trees this Fall, quadrupling the annual number of trees that the City typically plants.”⁹⁴

Projected Changes in Health and Infrastructure: Northampton

Health Outcome	Direction & magnitude of change in health outcome	Severity of health impact	Populations that are vulnerable	Prediction
Heat related hospitalizations and death	↑	***	Elderly Children Low-income without air conditioning Homeless Outdoor workers People w/ chronic conditions	Rates per 100,000 of heat related hospitalization in a region that Northampton may be like in the future are similar – about 7 per 100,000 people per year.
Heat related deaths and hospitalizations are related to the increase in number of days of extreme heat. A large increase in extreme heat days in Massachusetts is predicted, however few people in Northampton are currently hospitalized for heat-stress illness. Heat stress will increase but it is difficult to predict how much; comparisons to North Carolina show an equal amount.				
Asthma hospitalizations and death	↑	***	Families in older homes Children Elderly People of color	No prediction possible
Asthma hospitalizations are related to extreme heat days and ground level ozone concentrations, as well as a variety of non-climate change related factors such as housing quality. There will be more extreme heat days, however exceedances of national standards of ground level ozone in Massachusetts has been on the decline, thus we predict only a small increase in asthma hospitalizations and deaths.				
Seasonal Allergy Prevalence	↑↑	*	Children Elderly Low income	No data available in comparison geography
The increase in days of extreme heat, extension of the warmer season, and decrease in the colder season will result in an increase in seasonal allergies. There will likely be a moderate increase in people affected by seasonal allergies and incidence of symptoms, however this is not a severe health impact.				
Cardiovascular Disease hospitalizations and death	↑	***	Elderly Low income	No prediction possible
CVD is exacerbated by extreme heat and poor air quality. Predicted increases in extreme heat days are large, but there has been an ongoing decline in myocardial infarction over the last decade in Massachusetts. While there may not be a large increase in number of CVD events due to climate change, the possibility of death from such events is high.				
Lyme Disease			Outdoor workers	Approximately 13

Prevalence	↑↑	**	People who exercise outside People living in the woods	more cases per year.
The extension of the warmer season and decrease of the colder season will result in more exposure to ticks as well as less tick die off, thus more Lyme disease. The consequences of having Lyme disease can be extensive, with it lasting for the rest of one's life and holding the potential to severely decrease one's quality of life.				
Eastern Equine Encephalitis	↑	***	Outdoor workers People who hike outside People living in the woods	No prediction possible
The extension of the warmer season and decrease of the colder season will result in more exposure to mosquitos. While the incidence of EEE is currently very low, there will likely be an increase. EEE is fatal in one-third to one-half of cases, so the severity is high.				
West Nile Virus	↑	**	Outdoor workers People who hike outside People living in the woods	No prediction possible
The extension of the warmer season and decrease of the colder season will result in more exposure to mosquitos. Incidence of WNV is not large and only 20% of those infected have symptoms, thus the lower severity rating.				
Water-borne diseases	~	**	Recreational water users	No prediction possible
Sea level will rise and there will be an increase in precipitation in Massachusetts. However, there is little evidence about incidence of water-borne illness in the rivers, lakes, and ponds surrounding Northampton.				
Injury and displacement from flooding	↑	**	Low income Elderly	No prediction possible
There is significantly more precipitation projected in the Northeast United States, and the Northampton Hazard Mitigation Plan cites risk of flood as one a high risk. While risk of death is low, there is potential for injury as well as difficulty in evacuating, loss of home, and displacement.				
Heating and cooling costs	--	*	Low income Elderly	No prediction possible
Heating and cooling costs are not a health outcome, but the money one has leftover after paying for housing, transportation, and utilities affects how much one has for medical care, nutritious food, and other healthful choices. Because of warmer winters, the largest energy expense (heating costs) will decrease. Because of hotter summers, costs of cooling will increase, but these are currently only 1% of family energy budgets on average. Residents facing health inequities may be most at risk of increases in cooling costs.				

See next page for Table Legend

Table Legend:

Direction and magnitude of change in health outcome

↑ = small increase - small decrease

↑↑ = moderate increase -- moderate decrease
↑↑↑ = large increase --- large decrease
~ no change due to climate change

Severity of health impact

- * health outcome causes mild discomfort, potential to see medical practitioner
- ** health outcome will probably need the attention of a medical practitioner
- *** health outcome may result in hospitalization and possibly death

Strategies to Address Climate and Health in the Region, State, and Northampton

Of the 12 states in the Northeast, 11 have developed adaptation plans for several sectors and 10 have released, or plan to release, statewide adaptation plans.⁹⁵ Given the interconnectedness of climate change impacts and adaptation, multi-state or regional coordination could help to ensure that information is shared efficiently and that emissions reduction and adaptation strategies do not operate at cross-purposes. The Massachusetts Climate Change Advisory Committee was formed in May 2009 to study and make recommendations on strategies for adapting to climate change. The Massachusetts Climate Change Adaptation Report provides a comprehensive overview of observed and predicted changes to Massachusetts' climate and the anticipated impacts of, and potential adaptation strategies to prepare for, climate change. Potential approaches include conducting vulnerability assessments of public health, infrastructure, natural resources, and economic sectors, to inform future planning, development, and management of existing and planned resources.⁹⁶

Local and state governments in the Northeast have been leaders in utilizing legal and regulatory opportunities to foster climate change mitigation and adaptation policies. The Regional Greenhouse Gas Initiative (RGGI) was the first market-based regulatory program in the U.S. aimed at reducing greenhouse gas emissions; it is a cooperative effort among nine northeastern states. Massachusetts became the first state to officially incorporate climate change impacts into its environmental review procedures by adopting legislation that directs agencies to “consider reasonably foreseeable climate change impacts, including additional greenhouse gas emissions, and effects, such as predicted sea level rise.” In 2014, the Pioneer Valley Planning Commission created a Pioneer Valley Action Plan⁹⁷ for a sustainable and resilient Pioneer Valley, and a Pioneer Valley Climate Action and Clean Energy Plan⁹⁸ that outline the climatic and weather effects of climate change on the region, inventories greenhouse gas emissions for the region, and provide in-depth recommendations for each sector for reducing emissions, adapting to climate change, and achieving the vision of a more “vibrant, competitive, sustainable, and equitable region.” Many of the mitigation and adaptation recommendations suggested in these action plans are co-beneficial to community health, equity, and climate change, such as improving food security, increasing active transportation infrastructure, safeguarding water quality, and planning for housing that increases access to health-supportive resources and opportunities.

The Northampton Health Department and the Northampton Office of Planning and Sustainability are working together to identify and address climate change impacts on health, and the health department collaborates with other local health departments, community based organizations, and agencies. The Northampton Health Department currently engages in Risk Communication, Emergency Preparedness, Education and Community Engagement, Disease Surveillance, and Health Equity analysis. The Northampton Department of Planning and Sustainability currently works on a variety of climate adaptation strategies, such as ensuring that natural systems, built environments, and transportation systems are ready for climate change, and creating regulatory strategies to adapt to climate change. They have written the City of Northampton Multi-Hazard Mitigation Plan⁹⁹ and the Sustainable Northampton Comprehensive Plan (2008-2028).¹⁰⁰ The Multi-Hazard Mitigation Plan identifies the numerous hazards that Northampton could face, including climate change, and outlines the critical facilities, services, vulnerable populations, and mitigation strategies for each. It is worth noting that there is not a mitigation plan specifically for climate changes such as heat, vector-borne disease, or changes to air quality.

This section provides strategies and guidance for public health, planning, partners in other sectors, and stakeholders on which to collaborate in planning and implementation. Given that there are innumerable opportunities for such synergistic work, the strategies we provide are illustrative rather than exhaustive. We also acknowledge that with reduced funding to public health, some of these recommendations may be aspirational. Climate change will happen over time and these recommendations may be phased in over a number of years.

1. Promote community resilience to climate change to reduce vulnerability.

- Focus on prevention, reducing existing health inequities, and building healthy communities, targeting resources on those with existing vulnerabilities to climate and health impacts. For example, use resources to build social networks among low-income residents.
- Promote healthy built environments, food security, opportunities for active transportation and physical activity, and other health-promoting actions outlined in the Pioneer Valley Action Plan, with special attention to impacts on vulnerable populations.
- Support social and community engagement by implementing the steps and guidance toward meaningful public participation outlined in the Pioneer Valley Action Plan.
- Increase emergency room capacity and decrease emergency room wait times.
- Identify gaps in access to health care for climate and health-vulnerable populations.

2. Educate, empower, and engage Northampton residents, organizations and businesses to reduce vulnerability through mitigation and adaptation.

- Develop an educational outreach campaign (e.g., about the health impacts of climate change, preparedness, opportunities to get involved), tying into existing efforts in Northampton, state-wide, and nationally.
- Develop a communications campaign with public health messages using the executive summary for this report as guide.
 - Develop specific public health messages to prevent climate health impacts (e.g., Lyme disease prevention education, reducing mosquito habitat).
 - Develop and implement a proactive social marketing campaign.
- Identify, communicate, and provide specific outreach to vulnerable populations about the risks and emergency planning needed.

3. Improve public health preparedness and emergency response.

- Refine existing preparedness and evacuation plans and conduct exercises with the public.
- Improve the electrical company staffing and response to power outages due to major weather events.
- Improve surveillance of tick- and mosquito-borne disease in Northampton and Massachusetts.
- Increase involvement from the Northampton's local Board of Health in implementing public health preparedness.
- Align and couple emergency response systems throughout city agencies to increase all-staff capacity to identify, outreach, and response to vulnerable populations (e.g., link public health nursing and community health worker

flagging of electronic medical records when the planning department identifies a “code red” heat day).

- Develop a “Buddy Program” of individuals who will work with the most vulnerable community members in the advent of an emergency.
- Decide what public health interventions should be done locally and what should be done through regional collaboration.

4. Work in multi-sectoral partnerships (local, regional, state, and federal), identifying and prioritizing mitigation and adaptation planning and strategies with public health co-benefits, such as:

- Partner with Northampton Planning and Sustainability, Department of Public Works, Northampton Tree Committee, School Department, public utilities, Pioneer Valley Planning Commission, hospital systems, Community Health Centers, Economic Department, Northampton Transportation and Parking Commission, Massachusetts Department of Transportation, Valley Community Development Corporation, and other relevant sectors to analyze and prioritize health, equity, and climate change considerations in planning, funding, and decision-making.
- Support and promote active transportation, including through support of increased funding for pedestrian and bicycle infrastructure, programs such as Complete Streets and Safe Routes to School, and incentives (e.g., tax breaks, transit subsidies).
- Integrate climate change and health risk reduction activities (e.g., heat mitigation, combined home health and climate assessments).
- Integrate health risk reduction into climate risk reduction activities (e.g., address indoor air quality in energy efficiency and weatherization retrofits).
- Expand training, funding, and education to build collaborative capacity across sectors and agencies.
- Formally incorporate a health lens into local and regional transportation, land use, housing, and other-sector planning, routinely integrating health co-benefits and co-harms (e.g., chronic illness, bike injuries) into models used in planning (e.g., See I-THIM transportation model in Resources section).
- Expand health elements throughout the Sustainable Northampton Comprehensive Plan and other planning documents.

5. Conduct applied research to enable enhanced promotion and protection of human health.

- Continue to monitor vulnerable populations, and plan for periodic updates to vulnerability assessments.
- Collaborate on research with local agencies, community based organizations, and colleges/universities to encourage studies that quantitatively forecast future health outcomes from climate change.
- Assess local impacts on health of proposed policies, plans, and changes to environmental or living conditions using health lens analysis (e.g., Health Impact Assessment).

6. Implement policy, systems, and environmental changes at local, regional, and national levels, integrating climate, health, and equity considerations into all policies and processes. For example:

- Subsidize energy efficiency upgrades and weatherization for low-income

homeowners and renters, advocate for development of energy-efficient multi-unit and low-income housing, and expand outreach and access to Low Income Home Energy Assistance Program (LIHEAP).

- Promote integrated local and regional land use, transportation, and housing planning that reduces social, environmental, and economic harms such as sprawl, displacement/gentrification, traffic, noise, air pollution, and loss of agricultural land and natural habitat.

7. Strengthen public health and health care system capacity to prepare and respond to climate change events (e.g., power outages and hospitals closures) and provide continuity of medical care following extreme events (e.g., access to medication and medical records).

- Strengthen health care systems' capacity to respond to climate change health impacts (e.g., outreach to vulnerable populations during heat event or emergency response).
- Increase health care and provider capacity to respond to health impacts, considering wait time, hospital beds, knowledge of rare vector- and water-borne diseases, etc.
- Train public health workforce (e.g., Public Health Nurses, Community Health Workers) to identify populations vulnerable to climate health impacts (e.g., heat, asthma, allergies), and link to health management and emergency preparedness systems, and preventive resources (e.g., CODE RED, LIHEAP).
- Identify, develop, and maintain adequate funding for public health infrastructure; training and education of public health sector; research, planning, and implementation of public health aspects of climate change mitigation and adaptation strategies.

What can residents do to get involved?

The City is committed to community involvement in planning. For example, its current pedestrian and bicycle comprehensive planning process contains an enormous effort (30% of the total budget) to engage low income, minority, and traditionally disengaged populations in the process and build longer term participation. This kind of effort builds stronger and deeper participation, but requires extensive resources. Interactive workshops take place for several planning projects a year; these are an effective and ongoing way for community to get involved in climate change planning, to the extent that each planning process incorporates climate change into the planning effort. One upcoming planning effort where the Northampton community's input will be sought is the 2018 update to the Sustainable Northampton Comprehensive Plan.

To the extent that some of the recommendations above are implemented, they include elements for community involvement. If funded and prioritized, public health emergency preparedness exercises with the public are an excellent way for community members to be involved. The recent Sustainable Design Action Team effort in November of 2015 drew an excellent crowd of residents interested in climate change planning; moving forward there will be no dearth of engaged residents to participate in thinking through and implementing the best public health recommendations for Northampton's climate change adaptation and mitigation.

Conclusion

Given the data available on climate science and the impacts on public health, it is clear that over the remainder of this century, Northampton will see changes that include a substantial increase in days of extreme heat, more precipitation, more severe weather events, shorter winters with milder temperatures on average, and longer summers.

These climate changes will result in health and social impacts. We expect there will be a small increase in hospitalizations and emergency department visits from heat stress, asthma, and cardiovascular disease. We also expect to see more incidence of seasonal allergies, Lyme disease, Eastern Equine Encephalitis, and West Nile Virus. There is a potential for flooding, which carries a small increased risk for water-borne illness due to recreational use of lakes, ponds, and rivers. Also due to flooding there is a small risk of displacement, loss of home, and difficulty evacuating. While home heating costs over time will decrease, costs for cooling homes will rise. Given that heating costs are a majority of utility costs, this will likely result in a net decrease in annual costs.

For all of these health and social risks, the City of Northampton and its private and nonprofit partners need to keep in mind that there are populations that are more vulnerable to these risks than others: those who have lower incomes, the elderly, children, those who are linguistically isolated, people of color, those who are homeless and those with mental health issues and substance abuse disorders. Consideration of these populations should be elevated during adaptation planning discussions, and extra effort made to include their voices.

Fortunately, Northampton is actively engaged in mitigation strategies for some of these impacts. There are a range of specific near term and longer term strategies that the City, the region, and the state can employ to help ensure that Northampton residents can avoid or decrease catastrophic health impacts from climate change.

Resources and References

- [CDC's Climate Ready Initiative](#)
- [National Climate Assessment](#)
- [Massachusetts Climate Change Adaptation Report 2011](#)
- [Our Next Future: An Action Plan for Building a Smart, Sustainable, and Resilient Pioneer Valley](#)
- [Pioneer Valley Climate Action and Clean Energy Plan](#)
- [Cooley Dickinson Hospital Community Health Assessment 2011](#)
- [Sustainable Northampton Comprehensive Plan](#)
- [The City of Northampton Multi-Hazard Mitigation Plan](#)
- [Climate Change, Health, and Equity: Opportunities for Action](#)¹⁰¹
- Integrated Transport and Health Impacts Model (ITHIM)¹⁰²

Disclaimer

This report incorporates information and data from several governmental agencies and their contractors, whose work included the following disclaimers. This information is being made available for informational purposes only. Users of this information agree by their use to hold blameless the City of Northampton, and its respective officers, employees, agents, contractors, and subcontractors for any liability associated with its use in any form. This work shall not be used to assess actual hazards, insurance requirements, or property values and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

Appendix: Heat Related Illness and Lyme Disease Prediction Rationale

Heat related illness prediction methodology

Some climate change scholars include the change in the United States Department of Agriculture's (USDA) "Hardiness Zones" as evidence of how climate change has already changed environments for varying plant life.^{103 104} Change in average annual minimum temperature, first frost, length of productive season and other climate factors make up hardiness zones.¹⁰⁵ These are the same climate factors that affect certain health-related outcomes such as allergies and asthma, heat-related illness, and vector borne disease.^{106 107 108}

The map below, with Massachusetts enlarged below it, shows that since 1990 to 2015, the Pioneer Valley region has changed from Zone 5 hardiness to Zone 6.¹⁰⁹ The USDA uses hardiness zones to guide growers about the types of plants that will grow best in their zones. Based on nation-wide and region-specific observed and projected changes in precipitation, very heavy precipitation events (storms), frost-free season length, temperature change, number of extreme cold days and extreme heat days, flood magnitude, the Pioneer Valley's agriculture zone, in the future, will eventually look somewhat like the northern part of the Southeast.^{110 111}

Given that these climate change impacts will affect human health, we considered several climate change related health outcomes and researched incidence of those outcomes in regions in North Carolina that are rural or semi-rural. We had to choose a geography where some of the health outcomes are tracked in areas outside of large cities, and North Carolina tracks such outcomes with the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT).

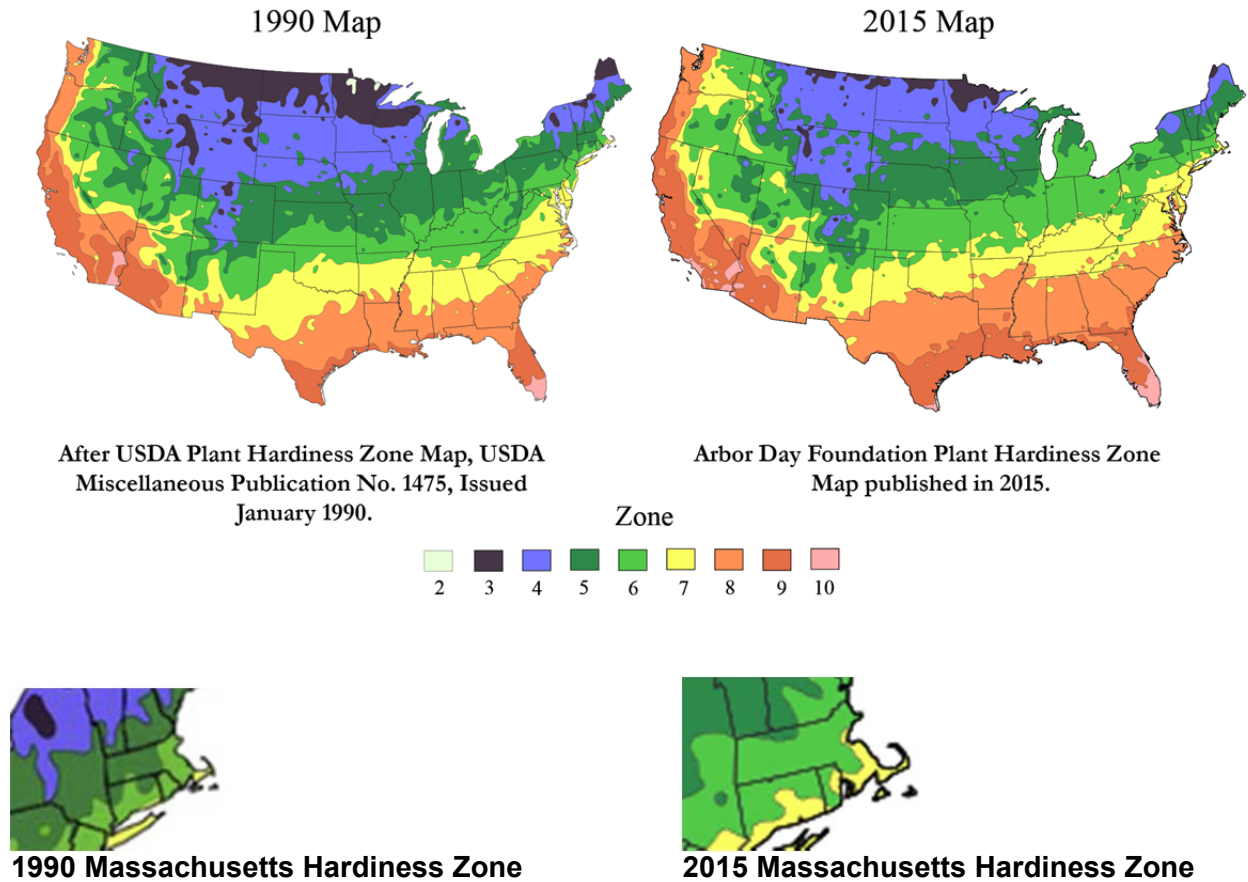
As a point of comparison but not prediction, for basically one health outcome (heat related illness) that has valid relation to the hardiness zone, we provide comparison numbers of illnesses in North Carolina. Rationale for this comparison is two-fold. First, the Union of Concerned Scientists cite that the climate in the US Northeast could in the future be more like current-day North or South Carolina.¹¹² Second, western North Carolina is one hardiness zone higher (Zone 7) than Northampton currently is, and western North Carolina is similarly inland, mountainous, and semi-rural.

This is not meant to be predictive, simply a comparison and a start to discussion. We were only able to choose the heat related illness, given the wide degree of variables that affect some of the health outcomes that have been discussed in this report. For example, asthma has been associated with air quality changes due to climate change, age of housing, maintenance of housing, and proximity to freeways. Given this wide array of factors that cause or exacerbate some diseases, it is not possible to give comparisons of every disease we have considered in this report.

Heat-related illness and death is closely tied to temperature rise and number of days of extreme heat, and so it is valid to compare. Even so, there are caveats to comparing heat-related illness, which include physiological adaptations to increased temperatures in a geography and municipal and private mitigation strategies. Supporting the idea that people adapt as temperatures rise, a study found that in many regions of the country, heat-related deaths have actually declined in the 1990's as compared to the 1960's-70's. On average nation-wide, in the 1960's and 70's there were 41 heat related deaths per year, and in the 1990's there were 17. Regions where there have been less of a change in the death rate from heat tend to be regions

that are already hot – the southeast, New Orleans, Phoenix, and others.¹¹³ For this reason we give heat related emergency department visits in North Carolina only as a comparison.

Figure 4. Changes in the USDA Hardiness Zones from 1990 to 2015 due to warming climates



Lyme disease prediction methodology

About two-thirds of Lyme disease cases take place during the “Lyme disease season”. In Hampshire County, 136 confirmed and probable cases were reported in 2014. In Massachusetts the onset of Lyme disease season (the week when the number of cases increases at its most rapid pace) is week 22 (first week of June) and the end is week 35 (last week of August), with the peak week being the middle of week 27 (first week of July), making the current Lyme disease season about 14 weeks.¹¹⁴ Using 2014 numbers, that means that on average there are 6.5 cases per week in Hampshire County. The earlier part of the summer is likely to have a larger number of cases because more infection occurs with the nuvae stage of ticks rather than the adult tick, so averaging all weeks is valid. The two-week earlier onset of the Lyme disease season will mean approximately 13 more cases (two weeks X 6.5 cases per week).

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