New Jersey Climate and Health Profile Report

DRAFT FOR COMMENTS

February 2017

NJ Climate Adaptation Alliance
http://njadapt.rutgers.edu/

This draft report was prepared by Rutgers University in consultation with the New Jersey Climate Change and Public Health Working Group of the New Jersey Climate Adaptation Alliance. The report is issued as draft to provide an opportunity for stakeholders to provide insights and comments on its content. Comments may be sent to njchp@ejb.rutgers.edu by February 28, 2017.
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The individuals and organizations that participate in the New Jersey Climate Adaptation Alliance Advisory Committee agree that the content of this report speaks to compelling issues associated with efforts to enhance preparedness in the public health community with regard to climate change impacts. While individual members of the Alliance Advisory Committee do not necessarily endorse each and every insight outlined in the report, the Alliance Advisory Committee concurs that the content of this report presents critically important issues facing public health practitioners, planners, and decision makers addressing climate-related health outcomes. Rutgers University serves in a defined role as the facilitator of the Alliance. In this role, staff at Rutgers, at the direction of the Advisory Committee, undertook the research that informed development of this report and, as such, recommendations in the report do not represent the position of the University.
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Section I: Executive Summary

Purpose, Partners, Planning and Action

The United States Global Climate Change Research Program’s 2016 report, “The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment,” summarizes that climate change is a significant threat to the health of the American people (USGCRP 2016). The U.S. Centers for Disease Control and Prevention (CDC) developed the Building Resilience against Climate Effects (BRACE) framework to support its Climate-Ready States and Cities Initiative to help decision makers prepare for the public health impacts of a changing climate. The New Jersey Climate Adaptation Alliance (NJCAA), which is facilitated by Rutgers University, has developed this Climate and Health Profile Report in accordance with the BRACE Step 1 guidelines (CDC 2014) and in consultation with its Climate Change and Public Health Working Group. The report provides a framework to utilize existing data, epidemiological studies, and models of weather patterns to assess the future public health burden from climate risks and to lay the foundation for developing best practices for adaptation.

A Changing Climate: Temperature, Precipitation, Rising Sea Levels

New Jersey’s climate is changing. There has been a long-term upward trend of 2.7 °F per century (NCEI 2016). The statewide average temperature for New Jersey in 2012 was the highest in 118 years of records. Nine of the ten warmest calendar years on record have occurred since 1990 and the five warmest years have occurred since 1998, consistent with the long-term upward trend (Broccoli et al. 2013). Unusual summertime warmth has also been a marked impact, with nine of the 15 warmest summers on record occurring since 1999 (Robinson 2016). The summer of 2010 was the warmest on record since statewide record keeping began in 1895; three of four warmest summers on record for New Jersey have occurred since 2010 (Robinson 2016).

There has also been an upward trend in annual precipitation in New Jersey. Since 1895, annual precipitation has increased at a rate of 2.4 inches per century (NCEI 2016a). Increases in the amount of precipitation falling in heavy precipitation events have been noted throughout the northeastern United States; there is reason to expect the trend in heavier precipitation events to continue as the climate warms (Broccoli et al. 2013).

Another observed trend in New Jersey is a rising sea level. Globally, sea levels have risen at an average rate of 1.2 inches per decade since the early 1990s (Alexander et al. 2013).
While rates vary globally, the rate of sea level rise is greater along the New Jersey coastal plain, due primarily to land subsidence associated with natural sediment compaction and groundwater withdrawal (Miller et al. 2013). Historically, in Atlantic City, where records extend back to 1912, sea level has risen by an average rate of 1.5 inches per decade over the period of record. (Broccoli et al. 2013). Looking to the future, New Jersey coastal areas are likely (about 67% probability) to experience sea-level rise of 0.6 to 1.0 ft. between 2000 and 2030, and 1.0 to 1.8 ft. between 2000 and 2050. There is about a 1-in-20 chance (5% probability) that sea-level rise will exceed 1.1 ft. by 2030 and 2.0 ft. by 2050 (Kopp, et. al. 2016).

**Impacts on New Jersey**

Ongoing climate science points to important trends that can affect New Jersey. These changes in climate have the potential to affect population health through both direct and indirect pathways. A direct impact may be an increased rate of heat-related morbidity and mortality as a result of extreme exposures like heatwaves, while indirect impacts of a heatwave might include changes in the pattern of infectious diseases and fluctuation in water flows and food yields. Health consequences resulting from the environmental, ecological, and social impacts of climate change are therefore an equal consideration when planning for climate change and public health (Mcmichael & Lindgren 2011). The most recent research issued by the United States Global Climate Change Research Program (USGCRP 2016), *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, identifies climate drivers that impact health, exposure pathways, health outcomes and factors that influence health outcomes, as well as environmental, social and institutional contexts for conditions to address health outcomes of climate change. The report concludes that climate change is a “significant threat” to the health of Americans and it serves as a critically important assessment and culmination of current science to inform ongoing collaborative efforts in New Jersey. (USGCRP 2016).

Anticipated health impacts from changing climate conditions in New Jersey are summarized in Table 1 below.
### Table 1. Overview of Projected Climate Change and Health Impacts in New Jersey

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Climate Impact</th>
<th>Health Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Quality Changes</td>
<td>• Increased ground-level ozone&lt;br&gt;• Fine particulate matter changes&lt;br&gt;• Pollen and allergen production</td>
<td>• Respiratory illness&lt;br&gt;• Cardiovascular disease&lt;br&gt;• Mortality</td>
</tr>
<tr>
<td>Extreme Heat</td>
<td>• Increased frequency and intensity of heat waves</td>
<td>• Heat-related illness and mortality&lt;br&gt;• Exacerbation of existing medical conditions&lt;br&gt;• Greater stress on electricity systems potentially leading to health outcomes associated with power outages</td>
</tr>
<tr>
<td>Precipitation Changes and Storms</td>
<td>• Flooding&lt;br&gt;• Storms&lt;br&gt;• Drought&lt;br&gt;• Wildfire</td>
<td>• Injuries and fatalities&lt;br&gt;• CO2 poisoning&lt;br&gt;• Food and water contamination&lt;br&gt;• Stress and mental health impacts&lt;br&gt;• Respiratory illnesses&lt;br&gt;• Mold exposure&lt;br&gt;• Food insecurity</td>
</tr>
<tr>
<td>Ecosystem Changes and Threats</td>
<td>• Changes in Disease Vector Reproduction and migration patterns</td>
<td>• Vector borne illnesses&lt;br&gt;• Food and water borne illnesses&lt;br&gt;• Harmful Algae Blooms (HABs)</td>
</tr>
</tbody>
</table>

While climate change is likely to affect everyone, not all subgroups will be equally affected. New Jersey is one of the top three most diverse states in the country with respect to race and ethnicity and foreign-born populations, which poses important challenges to delivery of public health systems (NJDOH 2015). Additionally, some populations will be more affected than others, especially the elderly, very young, individuals with existing medical conditions, poorer residents, urban residents, residents of coastal communities, outdoor laborers and workers in the agricultural, fishing, and tourism industries. In a diverse population like that of New Jersey, it is important to understand the
way risk and vulnerability vary across groups in order to target prevention and intervention strategies appropriately.

**Next Steps**

The Climate and Health Profile report is intended to provide an initial point of reference to inform a targeted set of “next steps” to incorporate conditions of a changing climate into public health planning, programs and policies in New Jersey. Along with insights gained from the New Jersey Climate Change and Public Health Workgroup’s June 3, 2016 workshop, *Preparing for the Impacts of a Changing Climate on Public Health in New Jersey: A Workshop for Public Health Practitioners*, the workgroup has outlined a set of next steps forward for its own efforts. In general, the Workgroup concludes that the most effective and efficient approach to protect the public health of New Jerseyans from changing climate conditions is to build consideration of changing climate conditions and the anticipated impact and consequences of those conditions into existing public health programs and systems, rather than creating a new overlay of initiatives on top of existing public health programs and services.

The Workgroup has identified a five-part framework to strategically focus its efforts moving forward and it recognizes that advancing these efforts is dependent on a collaborative approach among public health practitioners, state and local decision makers, the research community, healthcare providers, and the nongovernmental community. Overall, success in advancing this framework will be measured by the extent to which changing climate conditions, and the resulting impacts from those conditions, are fully integrated into planning, decision making and delivery of public health programs, policies and services statewide:
Central among these efforts is fostering collaboration among climate scientists and public health practitioners. In its service role as the state university, a multidisciplinary team at Rutgers has been working to develop and deploy climate science-based decision support tools to aid coastal communities in developing resilience planning efforts. A similar collaborative approach including climate scientists, public health practitioners, planners and public health experts can provide similar opportunities to take the insights gained from this Climate and Health Profile Report and identify specific and tangible provisions for incorporation into existing planning mechanisms. This effort will be most impactful if done in close collaboration with those agencies and authorities that oversee execution of planning provisions.

Overall, there are significant opportunities to improve health and well-being among New Jerseyans through consideration of climate-related health outcomes. This Climate and Health Profile Report provides an important step forward for development of collaborative initiatives engaging climate scientists, public health practitioners, public policy decision makers, and subject area experts. The Climate Change and Public Health Workgroup provides a helpful forum for advancing work in this important area.

- **Act**
  - Implement specific initiatives identified in consultation with public health community

- **Plan**
  - Integrate climate science and consideration of climate change impacts into existing public health planning, programs and decision making processes

- **Assess**
  - Assess disease burden as a result of a changing climate and identify vulnerable populations and appropriate interventions

- **Support**
  - Develop and assist in the deployment of tools and other resources to support local public health practitioners

- **Build Capacity**
  - Expand the ability of NJ’s public health practitioners to undertake interventions to address public health-related climate change impacts
About this Report

This report begins with a review of NJCAA’s history of engagement on climate change and health issues and gives a background on New Jersey’s geographic features including climate regions. The next section is a baseline assessment of New Jersey’s climate and an analysis of recent trends related to temperature, precipitation and sea-level rise. This is followed by an overview of various climate projections for temperature and precipitation in New Jersey based on different emissions scenarios. Next, the direct and indirect health impacts of climate change for New Jersey’s populations are reviewed, organized by four major categories of climate hazards: air quality, extreme heat, precipitation changes and storms, and ecosystem changes and threats. The particular groups within New Jersey’s population that will be vulnerable to these four climate hazards are also reviewed. Finally, the report ends with a preliminary discussion of possible next steps for planning and action in New Jersey as developed by the NJCAA Climate and Public Health Working Group in accordance with the BRACE framework. These “next steps” are presented as preliminary because we are inviting input and comment from New Jersey’s public health, clinical and environmental health communities. A revised final version of this report will be made available once all comments are incorporated. Collectively, this report is intended to guide New Jersey’s decision makers and stakeholders in understanding the implications of climate change on health and provide the information necessary to develop strategies to address these impacts.
Section II: Introduction

The United States Global Climate Change Research Program’s 2016 report, “The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment,” gives a blunt appraisal of impacts of climate change on public health:

Climate change is a significant threat to the health of the American people. The impacts of human-induced climate change are increasing nationwide. Rising greenhouse gas concentrations result in increases in temperature, changes in precipitation, increases in the frequency and intensity of some extreme weather events, and rising sea levels. These climate change impacts endanger our health by affecting our food and water sources, the air we breathe, the weather we experience, and our interactions with the built and natural environments. As the climate continues to change, the risks to human health continue to grow. (USGCRP 2016)

New Jersey is one of many states around the country studying and planning for the effects of climate change. Of particular concern are the potential health impacts associated with future climate conditions, including warmer temperatures, increases in precipitation, and extreme weather events. New Jersey is not currently a participant in the Centers for Disease Control and Prevention’s (CDC) Climate Ready States and Cities Initiative, but has undertaken initial steps under the climate and health adaptation planning process known as BRACE (Building Resilience Against Climate Effects) to position itself for future climate and public health planning activities. The first step in this process is the development of a Climate and Health Profile Report to assess baseline climate conditions for the state, and observe climate projections to help identify the scope of health outcomes and vulnerable populations (see Figure 1).

The New Jersey Climate Adaptation Alliance (NJCAA), is a network of public, private and nonprofit organizations that have come together to enhance New Jersey’s preparedness for the conditions of a changing climate. The NJCAA, which is facilitated by Rutgers University, has

Figure 1: Building Resilience Against Climate Effects (BRACE) Framework. CDC, 2012.

Source: Centers for Disease Control and Prevention (CDC) http://www.cdc.gov/climateandhealth/brace.htm
developed this **Climate and Health Profile Report** in accordance with the BRACE guidelines and with input from several current BRACE grantees around the country. This report accomplishes several important goals: (1) provides a framework to assess current and future climate and health conditions in New Jersey, utilizing existing data, epidemiological studies, and climate projection models to help inform planning activities for adaptation, (2) seeks to identify gaps in existing datasets that could affect future efforts to develop quantitative measures of health burden in New Jersey, and (3) serves as a foundation for future, more detailed assessments that analyze social vulnerability and project the disease burden associated with changing climate conditions.

While the primary audience of this report is state and local planning and public health staff and policy-makers, the information contained herein may also be a powerful tool for a variety of individuals and organizations in New Jersey working to address climate change as well as organizations that are working to improve the health and well-being of New Jerseyans. The New Jersey Climate and Health Profile Report is intended to be a broad statewide assessment and not a quantitative predictive model of anticipated disease burden as a result of a changing climate.

**History of Engagement Efforts**

Starting in 2015, the New Jersey Climate Adaptation Alliance (NJCAAA) began a concerted effort to implement BRACE in New Jersey. The NJCAAA was formed in response to a diverse group of stakeholders who came together on November 29, 2011 at Rutgers University to participate in the conference "Preparing NJ for Climate Change: A Workshop for Decision Makers." The 2011 meeting highlighted the devastating impacts that a changing climate and rising sea levels will have on New Jersey's economy, the health of our residents, the State's natural resources, and the extensive infrastructure system that delivers transportation and communication services, health care, energy and clean water to millions of New Jerseyans. The gathering pointed to the need to undertake proactive climate change preparedness strategies in order to forestall serious public health, economic, ecological and infrastructure investment impacts. Additionally, the workshop pointed to the need to focus New Jersey's preparedness efforts on key areas affecting the State's economy and quality of life: public health; watersheds, rivers and coastal communities; built infrastructure; agriculture; and natural resources. Recommendations clearly pointed to a strong role for Rutgers, as the State University, to work through a stakeholder process to build capacity in New Jersey. Just one year later, In October 2012, New Jersey experienced the devastating effects of Hurricane Sandy. The severe and deadly destruction experienced across the state reinforced the already evident need for action.
Subsequently, a series of analyses were undertaken on behalf of the NJCAA which address climate change and public health for New Jersey. These include two reports on vulnerable populations which help to identify areas around the State where there are concentrations of socially vulnerable groups and their nexus to floodplains, and a report on coastal flood risk to New Jersey’s senior citizens (Bickers, 2014; Pflicke et al. 2015; Yamanaka et al. 2015). Bickers (2014) and (Pflicke et al. 2015) borrow the methodology from the Social Vulnerability Index (SOVI) used by the Hazards and Vulnerability Research Institute at the University of South Carolina along with United States Census data. In March 2014, NJCAA released two reports: a “working brief” that summarizes potential impacts to health in New Jersey from the conditions of a changing climate based on a review of public health and scientific data as well as efforts in other states, and a summary of perspectives from members of New Jersey’s public health community on challenges and opportunities facing public health professionals in the State with regard to preparing for and responding to the impacts of a changing climate (NJCA 2014; NJCA 2014a). The stakeholder engagement report includes input from a post-Sandy focus group of local public health officers, an online survey, and one-on-one interviews targeted at stakeholders and experts. Further, NJCAA also released a “best practice” guide for public health officers in concert with the New Jersey Chapter of the Association of County and City Health Officials (NJCAA, 2014b).

Rutgers staff, through their work on behalf of the NJCAA, were welcomed by CDC to join the national “community of practice” to build adaptive capacity for the public health effects of climate change in New Jersey beginning with their participation in a national meeting of BRACE grantees at CDC in Atlanta to learn about what states and cities are currently doing to address climate change and public health. This opportunity allowed Rutgers staff to connect with and glean guidance from a variety of public health officials around the country. In addition to work being done by Rutgers on behalf of the NJCAA, public health officials and academics in New Jersey have conducted a variety of epidemiological studies to assess the health implications of climate impacts. In particular, a variety of studies were conducted post-Sandy to evaluate the myriad of health impacts of extreme storms.

In the fall of 2015, to further and coordinate these efforts, NJCAA formed a Climate Change and Public Health Working Group to work in partnership with New Jersey’s public health community to help enhance the public health community’s climate preparedness. The working group will follow the BRACE framework to address climate change effects on public health in New Jersey.
**Geographic Scope**

Despite being a small state in land area, New Jersey has several distinct climate regions that each exhibit unique variations in temperature and precipitation due to differences in land use, terrain, and other geographic components. Understanding the potential variability among climate regions may help in assessing the risk of climate change hazards throughout the state.

New Jersey can be divided into five distinct climate regions: Northern, Central, Pine Barrens, Coastal, and Southwestern (see Figure 2). These regions, exhibited below, were determined with guidance from the Office of the NJ State Climatologist based on the work of David Ludlum (1983). A more in depth description of these five regions are explained in Ludlum’s publication, New Jersey Weather Book, and on the Office of the NJ State Climatologist (ONJSC) website. The following descriptions are excerpted from these sources:

**The Northern Region**

The northern climate region includes the elevated highlands and valleys that are part of the Appalachian Uplands. Climate in this region differs from the rest of the State due to the minimal influence of the Atlantic Ocean on ambient conditions, as well as the orographic effects on clouds and precipitation that occur as air is forced to rise over the highlands. Distance from the ocean contributes to the near double rate of thunderstorms in this region compared to coastal zones, where the ocean helps to stabilize the atmosphere. Temperatures in this northern region are generally cooler than the rest of the State, especially in winter, when average temperature can be as much as ten degrees cooler. The cooler climate results in a shorter growing season in the north compared to other regions.

**The Central Region**

The central region runs from New York Harbor and the Lower Hudson River to the great bend of the Delaware River near Trenton. This region is characterized by urban...
corridors that produce large amounts of air pollutants due to the volume of industrial processes and car traffic. The urban environment contributes to warmer temperatures than surrounding suburban and rural areas, as paved surfaces with minimal green space create an “urban heat island effect” (Oke 1982).

The northern edge of the central region is often the boundary between freezing and non-freezing precipitation during winter, and marks the boundary between comfortable and uncomfortable sleeping conditions in summer. Areas to the south of the central region tend to have nearly twice as many days with temperatures above 90°F than in the region as a whole.

**The Coastal Region**
Climate conditions in the Coastal Region are invariably influenced by proximity to the Atlantic Ocean. In autumn and early winter, when the ocean is warmer than the land surface, the Coastal Region will experience warmer temperatures than interior regions of the state. Likewise, in the spring months, ocean breezes keep temperatures along the coast cooler than the warming land surface. The high heat capacity of the ocean limits the capacity for extreme variations in year round temperature.

Sea breezes play a major role in the coastal climate. When the land is warmed by the sun, heated air rises, allowing cooler air at the ocean surface to spread inland. Sea breezes often penetrate 5-10 miles inland, but under more favorable conditions, can affect locations 25-40 miles inland. They are most common in spring and summer. Coastal storms, often characterized as nor’easters, are most frequent between October and April. These storms track over the coastal plain or up to several hundred miles offshore, bringing strong winds and heavy rains. Rarely does a winter go by without at least one significant coastal storm and some years see upwards of five to ten. Tropical storms and hurricanes are also a special concern along the coast. In some years, they contribute a significant amount to the precipitation totals of the region. Damage during times of high tide can be severe when tropical storms or nor’easters affect the region.

**The Pine Barrens Region**
The Pine Barrens region is named for the region of scrub pine and oak forests throughout the southwestern portion of New Jersey. Porous, sandy soils have a major effect on the climate of this region. On clear nights, solar radiation absorbed during the day is quickly radiated back into the atmosphere, resulting in surprisingly low minimum temperatures. The porous soil also allows precipitation to rapidly evaporate, creating very dry surfaces. In addition to allowing for a wide range in daily maximum and minimum temperatures, the
dry conditions created by porous soil also make this climate zone very vulnerable to wildfires (Ludlum 1983).

**The Southwestern Region**

The Southwest Region of New Jersey lies between 0-100 feet above sea level. This location and the close proximity to Delaware Bay contribute to a maritime climate in this region. This region experiences the highest average daily temperatures in the State, and without the porous soils that characterize the Pine Barrens, tends to have higher nighttime minimum temperatures. This region receives less precipitation than the Northern and Central regions of the State as there are no orographic features and it is also far enough inland to be away from the heavier rains of some coastal storms. The Southwest therefore receives less precipitation than the neighboring Coastal Region. These precipitation features also allow for a longer growing season. In the fall, frosts usually occur about four weeks later here than in the North and end four weeks earlier in the spring, giving this region the longest growing season in New Jersey.

It is worth noting that the climate regions described above do not follow county boundaries. As shown by Figure 2, many counties are divided across regions. Somerset County, for example, is partially in the Central region and partially in the Northern region. Because many of the climate datasets used in this report are aggregated to the county level, we are unable to show them in terms of regions. We make an effort to talk about regional variability where possible but this is simply a limitation of the available data.
Section III: Baseline Climate Assessment

This Section reviews the association between climate change and human activity, and uses historical data to demonstrate the changes that have been observed in New Jersey’s climate. Retrospective climate data for the State of New Jersey are available through the Office of the New Jersey State Climatologist (ONJSC), located at Rutgers University, which serves as the State’s primary resource for statewide weather and climate data. New Jersey climate data are also archived at the National Oceanic and Atmospheric Administration’s (NOAA) National Center for Environmental Information.

**Human Activity and Climate Change**

A wide range of indicators show that global climate is changing. The average carbon dioxide concentration in the atmosphere topped 400 parts per million (ppm) in 2013, which far exceeds the range experienced over the last 650,000 years (See Figure 3). The overwhelming majority of scientists agree that the primary cause of climate change in the past 50 years has been human activity (Melillo, Richmond, and Yohe 2014). These changes are influenced by the by-products of human energy production and consumption called greenhouse gases (GHGs) (Marinucci et al. 2014) The most common sources of GHGs today include CO2, nitrous oxide, methane, and CFCs (Broccoli et al. 2013). GHGs create a barrier for solar radiation and heat produced by the sun to escape the Earth’s surface. Global climate change is projected to continue through the 21st century and beyond, though the specific changes we see will depend primarily on the GHGs emitted and the adaptation practices - a term used to describe preparatory and responsive measures - we put into place (Melillo, Richmond, and Yohe 2014).

**Temperature**

Like other states across the Northeast, New Jersey experiences pronounced seasonal cycles, each with unique meteorological conditions. However, some seasonal characteristics have been changing in recent decades, most notably through rising
temperatures. As a whole, the Northeast has experienced an increase in temperature of about 2°F since 1895, or 0.16°F per decade (Horton et al. 2014).

As shown in Figure 4, there has been a long-term upward trend of 2.7°F per century (NCEI 2016). Nine of the ten warmest calendar years on record have occurred since 1990 and the five warmest years have occurred since 1998, consistent with the long-term upward trend (Broccoli et al. 2013). Unusual summertime warmth has also been a marked impact, with nine of the 15 warmest summers on record occurring since 1999 (Robinson 2016). The summer of 2010 was the warmest on record since statewide record keeping began in 1895; three of four warmest summers on record for New Jersey have occurred since 2010 (Robinson 2016).

**Figure 4: New Jersey Statewide Average Annual Temperature, 1895-2015**

In a northeastern state such as New Jersey, the variation in temperature throughout the State throughout the year is significant in understanding the potential impact of climate change. To give a sense of this seasonal temperature variation, Figures 5 and 6 show the average summer maximum and average winter minimum temperatures based on
monthly station averages for 1981-2010. Summer is defined here as the months of June, July and August. Winter is defined as December, January, and February.

Figure 5: New Jersey Summer Maximum Temperature, 1981-2010 in °F

Data source: PRISM Climate Group, Oregon State University 2016

On average, the southern portion of the state experiences slightly warmer summer and winter temperatures while the northern portion is cooler. However, the area around Newark in the northern part of the state experiences slightly warmer temperatures than the rest of that region likely due to its urban character. The average January minimum temperature for the State ranged from 15°F to about 28°F, while the average July maximum temperature was between 84°F and 88°F (PRISM Climate Group 2016).
It is important to note that because we are observing temperature differences based on station averages, it is likely that some microclimates within the state are being masked, in particular, areas where urban heat island effect is causing warmer average temperatures. Heat island is a term used to describe the phenomenon of urban areas experiencing warmer temperatures than surrounding suburban and rural areas. This is due to the amount of built up environment and concrete typically found in urban settings (EPA 2015c). Urban heat island effect may be particularly pronounced around some New Jersey cities including Newark and Camden.

In addition to increases in annual and seasonal temperatures, the number of hot and extremely hot days has been increasing throughout the Northeast and is expected to continue increasing in the coming decades (Horton et al. 2014).1

The Southwestern and Pine Barrens regions of the State tend to experience a warmer average temperature and less annual precipitation than other areas—particularly the Northern region, which is much cooler and wetter on average. Like most northeastern states, New Jersey experiences a wide spectrum of weather conditions—from the low temperatures of spring and winter to the pronounced heat of the summer months. However, the past few decades have been characterized by more unusually warm months than it has by unusually cold months (Broccoli et al. 2013). With increases in both average temperature and extreme heat days projected over the next several decades, summertime heat will be a particularly dangerous impact for the State’s vulnerable populations including the elderly and the urban poor.

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1 Extremely hot days are defined here as days with daily maximum temperatures that exceed 95°F. Hot days are defined as days with daily maximum temperatures that exceed 90°F. The literature is inconsistent in its definition of these terms and some sources define extremely hot days as daily maximum temperatures above 100°F.
Table 2: Selected Weather Station Normals, 1981-2010

<table>
<thead>
<tr>
<th>Station</th>
<th>Region</th>
<th>Annual</th>
<th>Mean Precipitation (inches)</th>
<th>Mean Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flemington</td>
<td>Northern</td>
<td>48.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Brunswick</td>
<td>Central</td>
<td>48.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indian Mills</td>
<td>Pine Barrens</td>
<td>46.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape May</td>
<td>Coastal</td>
<td>41.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philadelphia Airport</td>
<td>Southwestern</td>
<td>41.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Precipitation (inches) | Mean Temp (°F)

<table>
<thead>
<tr>
<th>Station</th>
<th>Region</th>
<th>Annual</th>
<th>Annual</th>
<th>Jan Min</th>
<th>July Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flemington</td>
<td>Northern</td>
<td>48.8</td>
<td>52.1</td>
<td>19.7</td>
<td>85.6</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>Central</td>
<td>48.9</td>
<td>53.0</td>
<td>21.7</td>
<td>85.6</td>
</tr>
<tr>
<td>Indian Mills</td>
<td>Pine Barrens</td>
<td>46.9</td>
<td>54.7</td>
<td>22.8</td>
<td>87.8</td>
</tr>
<tr>
<td>Cape May</td>
<td>Coastal</td>
<td>41.8</td>
<td>55.5</td>
<td>27.9</td>
<td>84.5</td>
</tr>
<tr>
<td>Philadelphia Airport</td>
<td>Southwestern</td>
<td>41.5</td>
<td>55.9</td>
<td>25.5</td>
<td>87.1</td>
</tr>
</tbody>
</table>

Data Source: The Office of the New Jersey State Climatologist (ONJSC) supplemented by NOAA Regional Climate Centers Applied Climate Information System (ACIS)

**Precipitation**

There has been an upward trend in annual precipitation in New Jersey (See Figure 7). Since 1895, annual precipitation has increased at a rate of 2.4 inches per century (NCEI 2016a). It is important to note, however, that the decade-to-decade variability in annual precipitation is quite large and can overwhelm any long-term trends. Precipitation was well below average during the drought of the early 1960s, but much wetter conditions prevailed during the 1970s (Broccoli et al. 2013).

**Figure 7: New Jersey Statewide Annual Inches of Precipitation, 1895-2016**

Source: NOAA National Center for Environmental Information (2016a)
The last decade has also been unusually wet. The heaviest precipitation amount for six of the twelve calendar months (March, April, June, August, October and December) has occurred since 2003, with August 2011 weighing in as the all-time wettest month since statewide records began in 1895. Increases in the amount of precipitation falling in heavy precipitation events have been noted throughout the northeastern United States. In fact, the Northeast has experienced the greatest increase in extreme precipitation of any of the other U.S. regions (Horton et al. 2014). There is reason to expect that this trend may continue, as the Intergovernmental Panel on Climate Change (IPCC) projects that “extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will very likely become more intense and more frequent by the end of this century, as global mean surface temperature increases” (Alexander et al. 2013; Broccoli et al. 2013).

**Sea-Level Rise**

Another important climate change impact in New Jersey is sea-level rise, given the state’s large coastal zone. Coastal areas are particularly susceptible to flood inundation. Global sea level rose at an average rate of 0.6 inches per decade during the 20th century, driven primarily by two processes: the thermal expansion of a warming ocean, which makes the same amount of water take up more space, and melting glaciers and ice sheets, which add water to the ocean (Broccoli et al. 2013). The rate of global sea-level rise has increased in recent decades, with an average rate of 1.2 inches per decade since the early 1990s (Broccoli et al. 2013). This trend is expected to continue into the next century, due in part to the melting of the Greenland and West Antarctic ice sheets that add water to the ocean basins (Joughin et al. 2014).

Rates of sea-level rise vary globally and sea levels along the New Jersey shore have risen faster than the global average due primarily to land subsidence associated with natural sediment compaction and groundwater withdrawal (Miller et al., 2013). Historically, in Atlantic City, where records extend back to 1912 (see Figure 8), sea level has risen by an average rate of 1.5 inches per decade over the period of record (Broccoli et al. 2013).
Air Quality

Changing climate conditions that affect air quality include:

- Increasing atmospheric carbon dioxide
- Increasing temperatures
- Changes in precipitation patterns
- Extreme weather events
- Changes in cloudiness, humidity and wind speed (USGCRP 2016).

The most recent report from the United States Global Climate Change Research Program (2016) points to three key findings where, with high confidence, changing climate conditions are expected to affect air quality resulting in health impacts:

- Increases in formation of ground level ozone as a result of meteorological conditions that are more conducive to ozone-formation, leading to premature deaths, hospital visits, lost school and work days, and increases in incidence of acute respiratory conditions;
- Increases in the number and severity of naturally occurring wildfires leading to increased emissions of particulate matter and ozone precursors causing additional chronic and acute cardiovascular and respiratory health outcomes; and
- Increases in temperature, changes in precipitation patterns and increased atmospheric carbon dioxide concentrations leading to increases in airborne allergies, asthma and other allergy-related illnesses.
Three changing climate conditions can affect health outcomes through exposures from three pathways: outdoor air pollution, indoor air quality and aeroallergens:

Outdoor air quality
Changing climate conditions influence the level and concentration of pollutants such as ground-level ozone (O3), and particulate matter. Ground level ozone, a major component of smog, is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. NOx and VOC emissions, referred to as ozone precursors, come from industrial operations, electric utilities, motor vehicles and chemical solvents (USEPA 2016a). In addition to ozone precursors emitted by sources within the state, transported pollution brought into the region by the wind also adds to ground-level ozone concentrations in New Jersey (NJDEP 2016a). Breathing ground-level ozone can trigger health problems such as asthma, chronic obstructive pulmonary disease (COPD), and bronchitis (USEPA 2016). Ground level ozone formation is affected by weather and climate and warming temperatures are expected to increase the concentration of ground level ozone in outdoor air.

The term "non-attainment" is used by the United States Environmental Protection Agency to designate geographic regions that do not meet one or more National Ambient Air Quality Standards (USEPA 2016a). The entire state of New Jersey is classified as being in “non-attainment" by the USEPA for ozone, meaning it does not meet the federal standard established pursuant to the Clean Air Act and which was updated in 2015. Due to pollution reduction efforts within the state, as well as reductions in transported pollution entering the states, New Jersey has been experiencing an overall improvement in ozone levels as indicated below in Figure 9 which shows the statewide annual ozone average from 1990-2015.

In 2015, the EPA promulgated a final rule lowering the 8-hour ozone standard to 70 ppb. Despite the overall statewide decline in ozone, the number of days that exceeded the 70 ppb standard was 32 in 2015 and 25 in 2016 (NJDEP 2017). The EPA Clean Air Science Advisory Council (CASAC) had recommended a health-based standard of 60 or 65 ppb, arguing that scientific evidence points to little margin of safety for the protection of public health, particularly for sensitive subpopulations at a standard of 70 ppb. The Committee indicated that “although a level of 70 ppb is more protective of public health than the current standard, it may not meet the statutory requirement to protect public health with an adequate margin of safety.”

Figure 9 reflects trends on an annual basis, however,
Ozone is exacerbated in warmer temperatures such as the summer season. Increases in temperature resulting from changing climate conditions are expected to contribute to increases in the concentrations of ground level ozone in outdoor air.

**Figure 9: Ozone Trends in New Jersey, 1990-2015**

![Ozone Trends in New Jersey](source: New Jersey Department of Environmental Protection (NJDEP 2017))

Efforts to reduce ground level ozone concentrations in New Jersey include establishment of standards aimed at reducing VOCs in products such as paints and on requiring gasoline vapor recovery systems at gas stations. Other efforts have included regulatory standards on motor vehicles and off-road equipment, solvent decreasing, asphalt paving, fuel loading at marine terminals, and controls on refineries. Additional efforts have focused on ensuring reductions in NOx through standards set to promote low emissions vehicles, power plant and refinery mandatory requirements and motor vehicle standards. Ongoing efforts to address emissions resulting from high electric demand days, power plants and vehicles as well as standards to address mercury and air toxics pollutants from electric power generating units are expected to further reduce NOx emissions (NJDEP 2016a).
Particulate matter air pollution (PM) is a mixture of solid and/or liquid particles that are either directly emitted from sources as “primary pollutants,” or are formed in the atmosphere from reactions of gas-phase precursors as “secondary air pollutants,” often along with ozone as components of smog. Direct sources of PM include factories, power plants, cars and trucks, wood-burning stoves and forest fires. Sources of precursor compounds for secondary formation of PM include sulfur dioxides, nitrogen oxides, and VOCs emitted from power plants, industries and automobiles. Principal constituents of particulate matter include sulfate, nitrate, ammonium, organic carbon, elemental carbon, sea salt and dust (Fann et al. 2016). Particulate matter is regulated by the USEPA as mass concentrations in different size fractions: PM10 includes the mixture of PM with aerodynamic diameters of less than 10 microns, and PM 2.5 includes particles less than 2.5 microns. PM2.5 includes mainly particles arising from combustion sources and secondary particle formation, whereas PM10 includes these sources as well as crustal materials like dust and particle of biological origin such as small pollen and spores. Both PM10 and PM2.5 are so small that individual particles cannot be detected with the human eye. PM2.5 is hazardous to health because it is small enough to embed itself deeply in the lungs, and can potentially make its way into the bloodstream. Inhalation of particulate matter can therefore cause a range of negative health impacts, including coughing and difficulty breathing, chronic bronchitis, heart attack, arrhythmias, decreased lung function, and aggravated asthma (EPA 2015b). Additionally, these small particles can also adversely affect vegetation and aquatic ecosystems (EPA 2016).

The United States Environmental Protection Agency has established both an annual and a 24-hour standard for fine particulates (PM 2.5). Statewide, New Jersey is designated by EPA as “unclassifiable/attainment” meaning no area monitored in the State violates the 2012 federal standard. Figure 10, below, shows the annual average concentration of PM 2.5 in New Jersey from 1999-2015. The blue line is the trend of the highest PM 2.5 Annual Average concentrations measured by a NJ monitor for that particular year and, conversely, the green line is the trend of the lowest PM 2.5 annual average concentration measured by a NJ monitor for that year, and conversely, the green line is the trend of the lowest PM 2.5 Annual Average concentrations measured by a NJ monitor for that year. The red line is the average PM 2.5 annual average concentration from all the NJ monitors.
As is the case with ozone and its health effects, there is also no known threshold level below which PM air pollution does not cause adverse health effects (WHO 2016). Reductions in emissions of particulate matter are attributed to state and federal controls on sources of emissions such as sulfates, regulatory controls on vehicles and off-road equipment, state and federal mercury and air toxics standards and rules regarding low sulfur fuel (NJDEP 2016b). Additionally, in New Jersey alone, millions of federal grant dollars have been focused on reducing emissions from non-road construction equipment and other non-road sources in NJ (NJDEP 2017a). Currently, scientists are not yet certain as to whether climate change will increase or decrease fine particulate concentrations and how increases in temperature from changing climate conditions will affect PM concentration levels. Additionally, as particulate matter can be removed from the air by rainfall, it is uncertain as to how changes in precipitation will affect particulate matter concentrations. Similarly, it is uncertain as to how anticipated changes in stagnant air episodes and wind patterns may affect particulate matter concentrations in outdoor air (USGCRP 2016).
Another important consideration with regard to anticipating public health impacts of climate change due to outdoor air exposure is that, with increasing temperatures, electricity demand for air conditioning use is expected to increase which, in turn, will increase emissions of pollutants, such as ozone precursors and particulates, which can affect health outcomes (NJDOH 2013, NYDOH 2011). Analyses of measured air quality data for New Jersey show that increases in both particulate matter (PM2.5) and ozone can exceed national air quality standards during high electricity demand days (Farkas 2016).

**Aeroallergens**

Changing climate conditions can affect the production, distribution and timing of airborne substances that cause allergic responses such as pollen, mold spores, dust mites and dander. Allergic responses can cause worsening of asthma, allergic rhinitis (hay fever), and other respiratory conditions in sensitized (allergic) individuals. These health outcomes may have the greatest impact on young children and the elderly. Although the causes are largely unknown, hay fever prevalence in the U.S. has increased from 10% of the population in 1970 to 30% in 2000 and asthma rates have increased from approximately 8 to 55 cases per 1,000 persons in 1970 to approximately 55 to 90 cases per 1,000 persons in 2000. (USGCRP 2016).

**Indoor air quality**

Changing climate conditions can affect indoor air quality as a result of changes to outdoor conditions that affect indoor ones, reduced dilution of indoor air by outdoor air, as well as the increase in conditions that support the spread of pests, disease vectors and infectious agents. Poor indoor air quality affects respiratory and other health affects since, on average, people spend 90% of their time indoors. Pollutants affected by climate and weather conditions that may enter indoor air spaces from outdoors may include ground level ozone, dust, pollen and fine particulate matter. Climate-related impacts resulting in increased drought and dust storms may increase concentrations of dust and dust-carried pathogens such as bacterial and fungal spores in indoor air. For example, diseases such as Legionnaires’ are contracted from water-borne bacteria in building cooling systems which can increase in warmer conditions. Pollutants generated indoors may include carbon monoxide (CO), formaldehyde, molds, pollen and other known contaminants that can affect health. As dampness increases indoors from severe weather events and/or changes to outdoor humidity, concentrations of indoor pollutants may increase. Power outages from more frequent extreme weather events could make it difficult to maintain indoor temperatures and humidity leading to increases in indoor mold growth and increases in indoor air pollutants such as volatile organic compounds and formaldehyde. Additionally, changing climate conditions may lead to increases in rodent
populations as well as drive rodents to indoors increasing exposures to rodent-related allergens (Fann et al. 2016).
Section IV: Climate Projections

This section details a range of projected changes to New Jersey’s climate based on current climate science and modeling techniques. Climate model projections illustrate how the climate system is expected to behave under specific scenarios of greenhouse gas emissions. The goal of presenting climate projections is to better understand the spectrum of effects and the range of possible impacts of climate change, particularly with regard to health hazards and vulnerabilities.

As with any effort to predict into the future, there is inherent uncertainty in climate projections. This uncertainty is caused, in large part, by the range of possible future scenarios based on various human decisions. If we as a society increase our efforts toward greenhouse gas mitigation and severely reduce our greenhouse gas emissions, the future will look different than if we do little or nothing to curb emissions. Additional factors including population growth, economic activity, energy conservation, and land use will impact the future as well (EPA 2015d). To account for this, climate projection models use a wide range of emissions scenarios. Emissions scenarios help train the models by estimating the amount of greenhouse gases in each time period being projected, among other factors. It is important to take into consideration the range of possible climate impacts that result from these different models and emissions scenarios.

Understanding Climate Modeling and Emissions Scenarios

The Intergovernmental Panel on Climate Change (IPCC), the international body for assessing climate change science, provides assessments of the scientific basis of climate change. In 2000, the IPCC published a set of emissions scenarios intended to guide climate change projections called The Special Report on Emissions Scenarios (SRES). The report included 40 separate emissions scenarios that comprised unique combinations of assumptions for future greenhouse gas pollution and other driving forces. The scenarios were organized into four families: A1, A2, B1, and B2. Additional assessments were published in 2001 and 2007 using the same framework and emissions families (World Meteorological Organization, n.d). The SRES was subsequently replaced by Representative Concentration Pathways (RCPs) in the IPCC fifth assessment. RCPs differ from SRES in that they do not have detailed socioeconomic narratives or scenarios and are instead based on radiative forcing. RCP scenarios are names after the possible range of radiative forcing values in 2100 relative to pre-industrial values—RCP 2.6, RCP 4.5, RCP 6, and RCP 8.5 (Weyant et al. 2009). Figure 11 shows temperature projections for various emissions scenarios.
Changes in Temperature, Precipitation, and Sea Level

Observed climate changes for the Northeast and New Jersey demonstrate that the region is getting warmer and wetter. Future climate projections, both under SRES and RCP scenarios, predict that these trends will continue through the end of the century. One set of projections used in the National Climate Assessment predicts that the Northeast could experience warming ranging from 3 to 10 °F by the 2080s (see Figure 12) (Kunkel et al. 2013). Temperatures in the region are projected to increase the most in the winter and the least amount of warming is projected for the spring (Kunkel et al. 2013). The number of annual days with maximum temperatures greater than 90 °F are expected to increase 30-40 days in high elevation areas of northern New Jersey and to 60-70 days in south central areas of the State by the period 2041-2070; this is an increase of about 20 to 30 more days in the northern part of New Jersey and about 40 more days in south central New Jersey above an historic baseline of 1971-2000 (see Figure 13) (Horton et al. 2014). In addition, the frequency, intensity and duration of heat waves is expected to increase.
Projections of precipitation changes are less certain than projections of temperature increases (Kunkel et al. 2013). However, projections for the Northeast predict that under a high emissions scenario, the region could experience an increase in winter precipitation between 5% and 20% by the end of the century. Summer and fall precipitation projections, as well as precipitation for the entire year are generally small at the end of the century compared to natural variations (Horton et al. 2014). Summer time and fall droughts could become more frequent as temperatures rise, resulting in increased evaporation and earlier winter and spring snowmelt (Horton et al. 2014). Projections also
show that there is likely to be an increase in the occurrence of heavy precipitation events in the Northeast, which could lead to an increase in annual flood events (Melillo 2014). This trend is currently being observed. Projections made in the 1950s about storms expected to occur once in 100 years are now projected to occur once every 60 years (Horton et al. 2014).

The IPCC has concluded that the global frequency of tropical cyclones is not projected to increase, while maximum wind speeds will likely increase. Precipitation intensity during tropical cyclones is likely to increase. The global frequency of extratropical cyclones is not likely to change substantially. Changes to extratropical storm tracks in the North Atlantic are possible, but have not been reliably established (Stocker et al., 2013).

Changes in temperature and precipitation will also lead to changes in season length. Summer is projected to arrive earlier and extend longer into the fall by mid-century, impacting the length of the growing season (Horton et al. 2014).

The current global trend in sea-level rise is expected to continue into the next century, making coastal communities particularly vulnerable to flood inundation. Looking to the future, New Jersey coastal areas are likely (about 67% probability) to experience sea-level rise of 0.6 to 1.0 ft. between 2000 and 2030, and 1.0 to 1.8 ft. between 2000 and 2050. There is about a 1-in-20 chance (5% probability) that sea-level rise will exceed 1.1 ft. by 2030 and 2.0 ft. by 2050 (See Figure 14). While it is certain that the trend in sea-level rise will continue, projected ranges are relatively wide because we do not know...
what future emissions will be like or how rapidly ice sheets will respond. Regardless, higher sea levels will increase the baseline for flooding from coastal storms.

**Figure 14: Projected SLR Estimates for New Jersey (ft.)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Middle Estimate</th>
<th>Likely Range</th>
<th>1-in-20 Chance</th>
<th>1-in-200 Chance</th>
<th>1-in-1000 Chance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50% probability SLR meets or exceeds...</td>
<td>67% probability SLR is between...</td>
<td>5% probability SLR meets or exceeds...</td>
<td>0.5% probability SLR meets or exceeds...</td>
<td>0.1% probability SLR meets or exceeds...</td>
</tr>
<tr>
<td>2030</td>
<td>0.8ft</td>
<td>0.6 – 1.0ft</td>
<td>1.1ft</td>
<td>1.3ft</td>
<td>1.5ft</td>
</tr>
<tr>
<td>2050</td>
<td>1.4ft</td>
<td>1.0 – 1.8ft</td>
<td>2.0ft</td>
<td>2.4ft</td>
<td>2.8ft</td>
</tr>
<tr>
<td>2100 Low emissions</td>
<td>2.3ft</td>
<td>1.7 – 3.1ft</td>
<td>3.8ft</td>
<td>5.9ft</td>
<td>8.3ft</td>
</tr>
<tr>
<td>2100 High emissions</td>
<td>3.4ft</td>
<td>2.4 – 4.5ft</td>
<td>5.3ft</td>
<td>7.2ft</td>
<td>10.0ft</td>
</tr>
</tbody>
</table>

*Source: Kopp, et. al. 2016*

*Estimates are based on (Kopp et al., 2014). Columns correspond to different projection probabilities. For example, the ‘Likely Range’ column corresponds to the range between the 17th and 83rd percentile; consistent with the terms used by the Intergovernmental Panel on Climate Change (Mastrandrea et al., 2010). All values are with respect to a 1991-2009 baseline. Note that these results represent a single way of estimating the probability of different levels of SLR; alternative methods may yield higher or lower estimates of the probability of high-end outcomes.*
Section V: Causal Pathways

The physical environment is one of the key determinants of health as identified by the World Health Organization (WHO). As such, observed and projected changes to climate pose a serious threat to the health and well-being of New Jersey residents. While some of these impacts will be direct outcomes of climate change, it is important to acknowledge that many of the health effects to be faced are indirect. For example, a direct impact may be an increased rate of heat-related morbidity and mortality as a result of extreme exposures like heatwaves, while indirect impacts of a heatwave might include changes in the pattern of infectious diseases and fluctuation in water flows and food yields. Health consequences resulting from the environmental, ecological, and social impacts of climate change are therefore an equal consideration when planning for climate change and public health (Mcmichael & Lindgren 2011). This section reviews direct and indirect health impacts of four climate change hazards: air quality, extreme heat, extreme precipitation and storms, and ecosystem changes and threats. All of the associations discussed in this section take the geographic and population features of New Jersey in account in order to assess the potential impacts of climate change throughout the state.

Figure 15: Conceptual Pathways of Climate and Health

Image Source: CDC Climate Effects on Health – www.cdc.gov/climateandhealth/effects/
Air Quality

A warmer climate in New Jersey could lead to an increase in levels of ozone at the Earth’s surface where exposure to humans can occur. Meteorological factors influence ozone formation. Higher temperatures can increase the chemical rates at which ozone is formed via precursor emissions from manmade and biogenic sources. Stagnation events, in which a local air mass does not change over a period of several days and allows ozone to accumulate, are increasing in frequency and expected to continue to increase (Fann et al. 2016). Even though other climate factors are expected to reduce ozone formation such as increased water vapor concentrations in some locations, experts find climate-driven changes in ozone favor a likely increase of ozone concentrations in the United States and these changes are more consistently reported for the northeastern United States (Fann et al. 2016). Inhaling ozone can damage the lining of the lungs and result in short-term decreases in lung function (EPA 1999). Chronic exposure to elevated concentrations of ground-level ozone is associated with a variety of health impacts, including pneumonia, chronic obstructed pulmonary disease, asthma, allergic rhinitis and other respiratory diseases, and an increased likelihood of premature death (EPA 2015a; Confalonieri 2007).

Like ozone, the impacts of climate change on PM2.5 will be influenced by competing meteorological factors that will affect the constituents that make up PM2.5. In some cases, climate and air quality studies find PM2.5 is expected to increase, while in others to decrease. Increased stagnation events and humidity, as well as biogenic emissions, are likely to increase PM2.5 levels. Factors that could reduce PM2.5, like precipitation and atmospheric mixing, show more variability in current climate projections; therefore, there is not clear consensus of the net effect of climate change on PM2.5. An increase in wildfires (which are associated with drought) are also projected to increase in the future; wildfires are a major source of PM2.5 formation (Fann et al. 2016).

Climate change poses a risk for allergies and other air-borne respiratory conditions. Some studies indicate that rising temperatures and increased CO2 production could lengthen the ragweed pollen season and increase pollen abundance and potency, increasing the likelihood of allergic diseases such as allergic rhinitis (USCCSP 2008; Bielory et al. 2012). Extreme rainfall and rising temperatures can foster the growth of indoor fungi and molds, leading to increased risk of respiratory and asthma-related conditions (USGCRP 2013).

A study conducted in New Jersey during the warm season (defined as April through September) for 2004-2007 examined the relationship between pediatric asthma
emergency department visits and ozone, PM2.5, several types of pollen (tree, grass and weed), and ragweed. The study found positive associations for four variables: ozone, PM2.5, tree pollen and weed pollen. However, there was a negative association with ragweed and the association with grass pollen was minimal. The authors concluded ozone in their study to be associated with increases in pediatric emergency department asthma visits during the warm weather season and that while different pollen types showed different associations, high levels of tree pollen appear to be an important risk factor in asthma exacerbations (Gleason et al. 2014).

**Extreme Heat**

As average temperatures continue to rise in the Northeast, heat waves are expected to increase in both frequency, intensity and duration (Horton et al. 2014). Exposure to extreme heat can result in heat stress (USCCSP 2008), which manifests itself in several ways including heat stroke, heat exhaustion, heat syncope (fainting), heat cramps, or heat rashes (CDC 2012). In more extreme circumstances, exposure to extreme heat can cause stroke and even death (Gronlund et al 2014; CDC 2013a). Extreme heat is already the leading cause of weather-related death in the United States; from 1999-2003, 3,442 deaths were reported as a result of excessive heat (Luber and Conklin 2006). The extreme heat wave experienced by Europe in the summer of 2003 caused more than 70,000 excess deaths (Robine et al. 2008), showing the extent to which extreme heat can have an impact on public health without proper systems in place. New Jersey data for 1999 and 2002, two of the hottest summers on record in the State report 30 cases of heat-related mortality in 1999 and 18 in 2002 (NJDHHS 2008b). According to the New Jersey Department of Health and Senior Services, “each year more than 1,200 persons are treated in New Jersey emergency departments for heat-related illness or sunburn, and overexposure to summer heat causes between 45 and 170 hospitalizations in New Jersey annually. The majority of those hospitalized in New Jersey are male, ages 65-84, and are hospitalized for 3 or more days” (NJDHHS 2008b).

New Jerseyans are at the highest risk for heat-related illness during the “warm season”, which extends from May through September—with peak temperatures occurring in June and July. Heat-related illness data obtained from the New Jersey Department of Health (NJDOH 2015b) for the warm season for the years 2004 through 2013 show that the number of heat-related illnesses have been rising over the past decade (see Figures 16 and 17).
Figure 16: Adjusted Rates per 100,000 of Heat-related Illness by Region for the Warm Season (May-Sept), 2004 versus 2013

<table>
<thead>
<tr>
<th>Region</th>
<th>2004</th>
<th>2013</th>
<th>Rate Increase</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>0.7</td>
<td>1.9</td>
<td>1.2</td>
<td>171%</td>
</tr>
<tr>
<td>Coastal</td>
<td>1.7</td>
<td>3.1</td>
<td>1.4</td>
<td>82%</td>
</tr>
<tr>
<td>Northern</td>
<td>0.4</td>
<td>1.2</td>
<td>0.8</td>
<td>200%</td>
</tr>
<tr>
<td>Pine</td>
<td>1.1</td>
<td>2.5</td>
<td>1.4</td>
<td>127%</td>
</tr>
<tr>
<td>Southern</td>
<td>1.2</td>
<td>3.6</td>
<td>2.4</td>
<td>200%</td>
</tr>
</tbody>
</table>

Rates have been adjusted to take into consideration age and total population for each geography.

Data source: NJDOH, 2015

Figure 17: Total Number of Heat-related Hospitalizations and Emergency Department Visits for the Annual Warm Season (Sept-May), 2004-2013

Data source: NJDOH, 2015b
Heat-related illness counts include both hospitalizations and emergency department visits. Hospitalizations are more serious, less frequent cases that require hospital admission while emergency department visits are less serious, more frequent cases. Rates of heat-related illness emergency department visits and hospitalizations by county and region show a wide variation across the state. Between 2004 and 2013, the Coastal Region experienced the greatest increase in heat-related emergency department visits, more than doubling. However, the Southern Region experienced the greatest increase in hospitalization over this time period. As shown in Figures 18a and 18b, 2013 rates by county reveal that Middlesex and Somerset Counties are among the areas with the lowest rates of both heat-related hospitalizations (0.99 and 0 per 100,000, respectively) and heat-related emergency department visits (9.8 and 8.0 per 100,000) while Ocean and Salem Counties are among the highest (hospitalizations at 3.8 and 4.5 per 100,000, respectively; emergency department visits at 22.4 and 21.2 per 100,000, respectively)\(^3\) (NJDOH 2015b).

\(^3\) The age-adjusted rate of heat-related hospitalizations for Middlesex and Somerset counties were among the lowest in the state at 0.99 and 0 per 100,000 respectively. Heat-related ED rates for these two counties were also among the lowest in the state at 9.8 and 8.0 per 100,000 respectively. The age-adjusted rates of heat-related hospitalizations for Ocean and Salem counties were among the highest in the state at 3.8 and 4.5 per 100,000 respectively. Heat-related ED rates for these two counties were also among the highest in the state at 22.5 and 21.2 per 100,000 respectively.

<table>
<thead>
<tr>
<th>County</th>
<th>Hospitalizations</th>
<th>E.D. Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic</td>
<td>1.82</td>
<td>23.68</td>
</tr>
<tr>
<td>Bergen</td>
<td>2.21</td>
<td>11.60</td>
</tr>
<tr>
<td>Burlington</td>
<td>2.45</td>
<td>17.61</td>
</tr>
<tr>
<td>Camden</td>
<td>4.48</td>
<td>15.77</td>
</tr>
<tr>
<td>Cape May</td>
<td>3.08</td>
<td>22.62</td>
</tr>
<tr>
<td>Cumberland</td>
<td>4.46</td>
<td>19.76</td>
</tr>
<tr>
<td>Essex</td>
<td>2.81</td>
<td>11.99</td>
</tr>
<tr>
<td>Gloucester</td>
<td>2.08</td>
<td>16.65</td>
</tr>
<tr>
<td>Hudson</td>
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<tr>
<td>Warren</td>
<td>1.84</td>
<td>16.56</td>
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Source: NJDOH 2015b
Two existing studies demonstrate the relationship between heat-related illness, temperature, and heat index for New Jersey. The first, a statewide study conducted by the New Jersey Department of Health, analyzed heat-related illness data for New Jersey between 2010 and 2011. Results of the study showed that daily heat-related illness counts increased as heat index values increased, with similar patterns observed across all regions of the State. Further, the ratios of daily heat related illness counts and heat index levels were greatest at heat index values of 100-102°F and 109°F and higher (Fagliano et al. 2013). The second, a national study conducted across 20 states by the CDC’s Environmental Public Health Tracking Program, found strong correlations between heat-related illness hospitalizations and both average monthly maximum temperature and average maximum heat index. New Jersey had one of the most pronounced effects of any Northeastern state in the study (Choudhary and Vaidyanathan 2014). Data for both studies were limited to the “warm season”, defined as May through September.

Heat can also exacerbate existing chronic health conditions, including cardiovascular, respiratory, and cerebrovascular diseases and diabetes-related conditions and has been shown to increase the risk of kidney stones and renal failure (USCCSP 2008; Sarofim et al. 2016; USCCSP 2008; Semenza 1999). Diabetics have an increased risk of heat-related illness.
related mortality, as do people on certain medications, particularly diuretics, which have a dehydrating effect (USGCRP 2009; Schwartz 2005). Elderly people are especially susceptible to heat-related morbidity and mortality (Basu 2005). Urban heat islands may increase heat-related health impacts for city dwellers by “raising air temperatures in cities 2-10°F over surrounding suburban and rural areas due to lack of vegetation and absorption of heat by paved surfaces and buildings,” (USCCSP 2008). Other indirect health effects include infrastructure failures like power outages, a strain on emergency and health care services, in particular 911 response and emergency department demands, inability to have access to air conditioning and water treatment, and general impacts on mental health and stress. (MDH 2015).

**Extreme Precipitation and Storms**

The intensity of extreme storm events is increasing and is projected to increase further in the Northeast through the end of the century (Horton et al. 2014). Extreme precipitation and storm events can include events such as hurricanes and floods which result in both direct and indirect health impacts. Acute precipitation and storm-related health impacts include direct morbidity and mortality from drowning, downed trees, and carbon monoxide poisoning, food and water contamination in the wake of storm events, and lack of availability of medicines and medical equipment as a result of power outages and business closures. Chronic issues resulting from storm events include mental health impacts and the health effects of mold exposure (NJCAA 2013). An estimated 2,544 people died in the United States or its coastal waters from tropical cyclones in the 50-year period of 1963 to 2012. Approximately 90% of these deaths occurred in water-related incidents, mostly drowning (Rappaport 2013).

Extreme rainfall events can also affect raw water quality by increasing turbidity and bacteriological contaminants leading to gastrointestinal (GI) illnesses. In New Jersey, a statewide study done on hospitalization data for GI illnesses between 2009 and 2013 revealed a positive association between extreme rainfall and GI hospitalizations during the warm season and that study participants residing in an areas served by surface water on the day of an extreme rainfall event were at increased risk, as opposed to those residing in areas served by ground water or “other” water source (Gleason 2015).

Hurricane Sandy demonstrated the wide range of health impacts that can result from widespread flooding and power outages when it hit the east coast of the United States in October 2012. The death toll in New Jersey as a result of Hurricane Sandy was 34; total death toll from the storm was 117 across U.S. states affected by Sandy (NJCAA 2013).
Several studies were conducted in New Jersey post-Sandy to examine the health impacts of the storm. One such study examined hospitalization and emergency department utilization for respiratory complications (chronic obstructive pulmonary disease and asthma) in adults over age 60 to ascertain the vulnerability among individuals with chronic conditions requiring ongoing management with medications and electrical medical equipment during severe weather events. Thomas et al. (2015) report an increase in both emergency department visits and hospitalizations for these respiratory complications during the Sandy period (defined as the two-month period starting the day prior to Sandy’s landfall) compared with pre-hurricane rates and also compared with the same two-month period for the prior four years. They also reported that older women in poorer and minority neighborhoods were especially vulnerable (Thomas et al. 2015). Another study found similar results when analyzing the number of preventable hospitalizations for complications of diabetes following the storm; the authors note such hospitalizations result from inappropriate or interrupted ambulatory care (Rajan et al. 2015). Rajan et al. (2015) reported significantly higher rates of preventable complications from diabetes during the Sandy period compared with the pre-Sandy period or for the same period in the four years prior to the study; they also found that the rates were significantly higher in lower socioeconomic status communities than higher socioeconomic status communities (Rajan et al. 2015). These analyses demonstrate that extreme weather events can easily disrupt the management of chronic conditions like COPD, asthma, and diabetes.

Decreases in precipitation can also result in significant health risks—both direct and indirect. Droughts increase the risk of wildfires, which may increase the potential for widespread ecological and infrastructural damage, as well as mortality (Cannon et al. 2003). Wildfires may also increase the risk of particulate matter in the air (Haikerwal et al. 2015), increasing the risk of associated respiratory problems. Dry conditions and porous soil in the Pine Barrens region of New Jersey make the area particularly vulnerable to wildfires (Ludlum 1983). In September 2015, lack of precipitation was cited by the New Jersey Department of Environmental Protection as a contributing factor to the spread of a wildfire, initially ignited by improper disposal of campfire, which burned over 1,000 acres of Pine Barrens forests (Alexander 2015; NJFFS 2015).

Droughts can contribute to the levels of airborne particulate matter as these conditions increase the risk of wildfire and dust storms. In both cases, there is an increased

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4 Note: “preventable” hospitalizations are defined as: “admissions to a hospital for certain acute illnesses (e.g., dehydration) or worsening chronic conditions (e.g., diabetes) that might not have required hospitalization had these conditions been managed successfully by primary care providers in outpatient settings. (CDC 2011)
likelihood of particulate matter being suspended in the air, which poses a risk to respiratory health (CDC 2015). Extreme conditions like droughts can also have a significant impact on crops and livestock, negatively impacting agricultural production and threatening the security of our food supply (Horton et al. 2014). In addition to food insecurity, a decrease in agricultural sector productivity could amount to significant economic loss. Agricultural commodities in the United States is a nearly $330 billion a year industry (Horton et al. 2014). In New Jersey, this sector is the state’s third largest industry and generates billions of dollars in revenue (NJDA 2012).

Widespread power outages, gas shortages, and flooding after extreme weather events, including hurricanes, is also cause for concern as they can result in toxic exposures and unintentional misuse of medicine. These public health threats should be taken into consideration when evaluating the impact of an increased number of extreme storms. One study measured the calls made to the New Jersey Poison Control Center, also known as NJPIES, in the days immediately preceding, during, and after Hurricane Sandy to determine opportunities for targeted public health education and intervention. The two most frequent reasons for Sandy-related NJPIES calls in 2012 were for gasoline (32%) and carbon monoxide (20%) exposures. The three most other frequent Sandy-related exposures or information were poison information, food poisoning and spoilage information; and water contamination/information. Over 80% of both gasoline and carbon monoxide exposures occurred at the patient’s own residence. These findings point to a need for enhanced public health education and intervention in New Jersey, including proper use of gasoline-powered generators and cleaning and cooking equipment (German 2015).

**Ecosystem Changes and Threats**

As temperatures and humidity rise, certain vector-borne and zoonotic diseases are expected to expand their ranges, including tick-borne illnesses such as Lyme disease, ehrlichiosis, babesiosis, Powassan, and Rocky Mountain spotted fever; rodent-borne hantavirus; and mosquito-borne diseases such as West Nile virus and Eastern and Western equine encephalitis (CDC 2013b; USCCSP 2008). The range of the Asian tiger mosquito, an invasive species with high vector disease potential, continues to expand further north in the Northeastern United States; by the end of the century approximately 30 million Americans will live in areas at risk of dense Asian tiger mosquito infestations (Rochlin et al. 2013). The Asian tiger mosquito is a primary vector for dengue and chikungunya fevers, the latter of which is an emerging disease in the Caribbean that has shown rapid transmission potential (Faraji 2014).
An increase in precipitation and extreme weather events increases the risk of contracting food- and water-borne diseases. “Heavy rain and flooding can contaminate certain food crops with feces from nearby livestock or wild animals, increasing the likelihood of food-borne disease associated with fresh produce” (USGCRP 2009). Flooding also increases the likelihood of drinking contaminated water, which can lead to an increased incidence of gastrointestinal illness. The waterborne Cryptosporidium and Giardia parasites tend to increase in the aftermath of heavy downpours, putting recreational swimmers at higher risk of gastroenteritis (USCCSP 2008). Power outages resulting from severe weather events increase the likelihood of consuming spoiled food. Cases of food poisoning due to Salmonella have been shown to increase with increasing air temperatures, making it likely that increased average temperatures and more frequent heat waves will result in more cases of salmonella. Vibrio, the pathogen responsible for shellfish poisoning, shows a similar positive relationship with warmer temperatures; from 1996 to 2006, the U.S. infection rate increased by 41 percent. The Campylobacter bacteria, responsible for 29% of water-borne outbreaks, has shown a positive but less conclusive relationship with rising temperatures. Increasing temperature may increase the range of leptospirosis, a currently rare bacterial infection typically transmitted through urine contaminated water, while increasing precipitation and run-off makes transmission of leptospirosis more likely (USCCSP 2008). A general challenge posed by food and water-borne diseases is that these incidences tend to be highly underreported, making recognition of disease patterns and administration of proper treatment more difficult for the public health sector (USCCSP 2008).

The Legionella bacterium, is found in freshwater environments and grows best in warm water (CDC 2015). Gleason et al. (2016) conducted a statewide study of legionellosis in New Jersey analyzing the effects of meteorological factors including temperature, dew point, sea level pressure, visibility, wind speed, and precipitation on the number of reported cases. This study revealed positive associations of rates of legionellosis with indicators of wet, humid weather and inverse associations with high sea level pressure and high visibility (which are indicative of fair weather) (Gleason et al. 2016). The authors concluded that it is possible that wet, humid weather may allow proliferation of Legionella in natural environments increasing the rate of legionellosis (Gleason et al. 2016).
Section VI: Vulnerable Populations

This section reviews which of New Jersey’s population subgroups are likely to be particularly vulnerable to the health impacts of climate change hazards discussed in Section 5 (Causal Pathways) of this report. While climate change is likely to affect everyone, not all subgroups will be equally affected. New Jersey is one of the top three most diverse states in the country with respect to race and ethnicity and foreign-born populations, which poses important challenges to delivery of public health systems (NJDOH 2015a). In a diverse population like that of New Jersey, it is important to understand the way risk and vulnerability vary across groups in order to target prevention and intervention strategies appropriately. Climate change may amplify, moderate or otherwise influence climate-related health effects among populations that are experiencing disproportionate, multiple and complex risks to their health and well-being particularly if these effects co-occur. Although this section is structured by distinct categories of climate-related exposures, these exposures can co-occur. Some communities of color, low-income groups, people with limited English proficiency and certain immigrant groups (especially those who are undocumented) live with many of the factors that contribute to their vulnerability to the health impacts and affect their ability to respond to climate change. These populations are at increased risk of exposure given their higher likelihood of living in risk-prone areas (e.g., urban heat islands or flood-prone areas), areas with older or poorly maintained infrastructure, or areas with higher levels of air pollution. Such populations are known to experience relatively greater incidence of chronic medical conditions, like cardiovascular and kidney disease, diabetes, asthma, and chronic obstructive pulmonary disease, which can be exacerbated by climate-related health impacts (Gamble et al. 2016).

Air Quality

Populations vulnerable to experiencing negative health outcomes related to poor air quality include children and low-income residents in urban areas. In its 2015 ‘State of the Air’ Report Card of New Jersey, the American Lung Association ranked the air quality of 15 counties in New Jersey based on the number of high ozone days per year. Eleven of these counties received Fs, indicating that air quality throughout New Jersey is already a health problem (ALA 2015). As temperatures increase and ozone increases, populations in densely populated urban areas with poor air quality are also subject to the urban heat island effect (where manmade surfaces absorb sunlight during the day and then radiate the stored energy at night as heat), combining to increase impacts of high temperatures in urban areas (Sarofim et al. 2016).
Outdoor workers, which include laborers employed in agriculture, construction, maintenance, and repair, make up nearly 10% of New Jersey’s workforce (Bureau of Labor Statistics 2011). People employed in these occupations are at greater risk of negative health impacts from increased ozone and particulates due to their greater level of exposure. Asthma prevalence statewide is 7.2% among adults and 8.6% among children. Among adults, blacks have the highest prevalence estimate by race/ethnicity at 13.1%. About 12.2% of New Jersey children have a history of asthma and 72.4% of these children continue to suffer from the condition (NJDOH 2015a). Research indicates that increases in the levels of pollen in the air result in more asthma-related hospital admissions among New Jersey children (Im and Schneider 2005).

An estimated 15% of children in New Jersey have asthma, 69% of whom suffer from it chronically (NJDHSS 2008). A longer pollen season in New Jersey is already putting people at increased risk of allergic disorders. Coupled with the warming effects of climate change, which may cause increased pollen counts and potency, it is anticipated that asthma and allergy-related hospital admissions are likely to increase in New Jersey, especially among children (NJCAA 2014). People with existing heart and lung diseases, as well as children and older adults, are also more susceptible to the effects of PM2.5 (NJCAA 2014).

Residents in urban areas can be subject to cumulative impacts from multiple sources of air pollution in addition to ozone and particulate matter. Hazardous air pollutants, known as “air toxics” pose greater risks in urban areas due to higher concentrations of emissions sources. The United States Environmental Protection Agency has identified 187 air toxics with 30 of them being of greatest concern in urban areas. Exposures to localized sources of pollution such as operating industries and power plants, as well as from mobile sources, can add to the cumulative impact of climate change faced by populations already vulnerable to changing climate conditions, including low-income residents and people of color that live in urban communities (USEPA 2016b).

Overall statewide trends may not represent localized poor air quality, such as in urban communities, which is an important consideration when anticipating public health impacts of changing climate conditions given that research has pointed to populations that are especially vulnerable to climate impacts. For example, in one study, research that focused on PM 2.5 and ozone found that non-Hispanic blacks reside in areas with the poorest air quality suggesting that areas of the United States have limited localized monitoring data and that populations vulnerable to climate change may experience poorer air quality (Miranda 2011). To promote overall improvements in health outcomes
of people who are vulnerable to climate impacts, such as residents in urban areas, the Environmental Justice Advocacy community has strongly urged climate change policies that have a strong focus on reducing localized air pollutants in urban communities, including reducing emissions of PM 2.5 and investing in energy conservation and renewable energy in urban areas (Sheats 2009).

**Extreme Heat**

Individuals with existing chronic health conditions - including cardiovascular and respiratory conditions and diabetes - are vulnerable to the effects of rising temperatures, as heat can exacerbate these conditions (USCCSP 2008; Schwartz 2005). Individuals on medications, which have a dehydrating effect, particularly diuretics, are also vulnerable to high heat (USGCP 2009). Elderly people, who make up 14% of New Jersey’s population (U.S. Census Bureau 2010), are especially susceptible to heat-related morbidity and mortality, as are young children, obese individuals, those lacking access to air conditioning, and outdoor laborers (USCCSP 2008). According to heat-related illness data obtained from NJDOH for the warm season 2006-2013, the majority of heat-related hospitalizations (69%) and emergency department visits (63%) are male patients, suggesting that men may be more prone to heat-related illness than women (NJDOH 2015b). Additionally, there appears to be an inverse age effect, with young teens and adults (15 – 24 years) making up a greater portion of heat-related emergency department visits and senior citizens (75 and older) making up a greater portion of heat-related hospitalizations (see Figure 19).

**Figure 19: Total Heat-related Hospitalizations (HA) and Emergency Department Visits (ED) for the Warm Season (May-September), 2004-2013 (aggregated) by age group**

- HA’s (9-year Period, Warm Season)
- ED Visits (9-year Period, Warm Season)

*Data source: NJDOH, 2015b - Note that because Hospitalizations are outweighed by Emergency Department Visits, data is presented as the percentage of each Heat Related Illness (i.e. Hospitalizations shows the percent for each age group out of all Hospitalizations over the analysis period).*
As noted, New Jersey's urban residents, who may be subject to the urban heat island effect, or the tendency of paved surfaces and buildings that lack green space to absorb more heat (USCCSP 2008), are at a particular vulnerability to heat-related impacts compounded by warming from climate change. According to the U.S. Census, “New Jersey is the most heavily urbanized state, with 92.2 percent of its population residing within urbanized areas of 50,000 or more,” (U.S. Census Bureau 2010), making the urban heat island effect especially relevant to public health in New Jersey.

Cooling centers in New Jersey are operated by municipalities (NJDHSS 2008b). While resources such as nj211.org compile lists of open cooling centers statewide, it is not clear there is statewide coordination and whether lessons learned are shared among operators of such centers. New Jersey has several cities with high concentrations of low-income residents, such as Newark (Essex County), Camden (Camden County), and Patterson (Passaic County) (U.S. Census Bureau 2010). These counties accounted for nearly 20 percent of all heat-related emergency department visits during the warm season 2004-13 and 25 percent of heat-related hospitalizations during this time period. Note however, that the local health departments in some of these areas have strong outreach programs, whereas the public health infrastructure may not be as well developed in suburban areas. Additionally, elderly residents in suburban areas who do not have access to cars and do not have family members living nearby may be at risk during heat waves (NJCAA 2014).

Finally, the foreign-born population of the State continues to increase, with 21% of New Jersey’s population made up of immigrants in 2010 (Migration Policy Institute 2012). With over 30 languages spoken in the State (Migration Policy Institute 2012), any outreach efforts aimed at reducing heat-related morbidity and mortality must target diverse populations appropriately.

**Precipitation Changes and Storms**

FEMA’s 2004 Map Modernization Business Plan for New Jersey, indicates that approximately 35 percent of New Jersey residents live in floodplains (FEMA 2004). The State of New Jersey indicates that the percentage would most likely be higher if updated today given an increase in definition of areas considered to be special flood hazard. Flooding also puts communities at health risk from water contamination caused by combined sewer overflows; New Jersey has 217 combined sewer outfalls in 21 communities, including Jersey City and Newark (NJDEP 2013a). Infrastructure damage

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5 Personal communication with Joseph Ruggieri, NJDEP; April 22, 2016.
from flooding and storms can increase vulnerabilities among those with existing medical conditions, especially if damage threatens the availability of medicine or electricity to power medical equipment (NJCAA 2013). Chronic issues resulting from storm events include mental health impacts. A longitudinal study of Hurricane Sandy victims found that housing damage from the storm is associated with a risk of Post-Traumatic Stress Disorder (PTSD), and “children living in homes with minor damage were over four times as likely to be sad or depressed, and over twice as likely to have problems sleeping since the storm as were children from homes with no damage,” (Abramson et al. 2015). Finally, increased exposure to mold from storm damage can exacerbate existing respiratory conditions (NJCAA 2013).

Evacuation rates are an important factor in considering populations most vulnerable to the effects of extreme storm and weather events. Residents who do not evacuate may be more likely to experience the negative effects of flooding and extreme winds including drowning, toxic exposure, poor mental health, and injuries. In New Jersey, a substantial number of residents evacuated their homes during Hurricane Sandy. The majority of evacuees evacuated after the storm made landfall and did not return to their homes for one day to one week afterward. However, a post-Sandy study in New Jersey found that females were more likely to have evacuated their homes than their male counterparts, which may suggest that future preparedness efforts should take into consideration demographic differences in educational campaigns and messaging (Kulkarni 2015).

Several studies conducted in New Jersey post-Sandy revealed that residents of lower socioeconomic status had higher rates of preventable hospitalizations and emergency department visits associated with chronic conditions like COPD, asthma, and diabetes. This suggests that residents in the poorest communities may be more likely to experience disruption in the management of chronic conditions during and following severe weather events or natural disasters. Additionally, COPD and asthma hospitalization and emergency department visits were found to be higher among women and older adults (over 75 years) as well (Thomas et al. 2015).

There is often an occupational vulnerability component associated with work-related injuries post disaster. One study conducted in New Jersey post-Sandy demonstrated this by analyzing the occurrence of work-related injuries after Hurricane Sandy compared with corresponding periods from the three previous years using emergency department and hospital discharge data (Marshall et al. 2016). The authors found that the rate of work-related injuries (falls, cut-pierce injuries, struck-by injuries, and overexertion) in Sandy’s high impact areas increased post Sandy. Work-related injuries were highest among Black and Hispanic men. Results of this study also demonstrated a lag time
between the storm and work-related injuries. There was an increase in injuries associated with rebuilding and recovery rather than the initial response to the storm. Occupations that may be particularly vulnerable to work-related injuries as a result of extreme weather and storms include those in construction, demolition, and related industries, as well as tree removal (Marshall, et al. 2016).

**Ecosystem Changes and Threats**

Changes in water quality put New Jersey’s coastal industries, including tourism and fisheries, at risk. Increases in waterborne disease threaten both recreational swimmers, as well as economic prospects for laborers in the fishing industry. Harmful algal blooms (HABs) are also influenced by high temperatures and precipitation changes. HABs also reduce the amount of dissolved oxygen in the water, which can lead to fish kills, affecting subsistence fishing communities and recreation (NCDHHS 2015). The elderly, very young, and those with existing health conditions may also be at particularly high risk of mortality from exposure to waterborne diseases (NCDHHS 2015).

**Assessing Social Vulnerability in New Jersey and Flood Risk**

Pflicke et al. (2015) conducted an analysis for the NJ Climate Adaptation Alliance, which examined the social vulnerability of New Jersey’s population to climate change using exposure to the 100-year and 500-year floodplain as an indicator of flood risk. The analysis builds upon the social vulnerability index or SOVI methodology of Dr. Susan Cutter, University of South Carolina, an approach that recognizes there are underlying social conditions that affect how individuals equally affected by an event can respond and recover differently (Bickers, 2014). A number of factors identified as being correlated with high social vulnerability were included in this analysis such as race, low socioeconomic status, linguistic isolation, Hispanic ethnicity, age (seniors), and percent unoccupied housing; the analysis was conducted by census tract (Pflicke et al. 2015). As represented in Figure 20, a total of 309 out of 2,010 (15%) New Jersey census tracts were ranked as having high social vulnerability populations (Pflicke et al. 2015). Out of the total number of high social vulnerability census tracts in the State for which floodplain data were available (278), 69% percent or 193 high social vulnerability census tracts lie within FEMA’s designated 100-year floodplain or the 1% annual chance flood event, representing a population of 677,771 persons and an average population density of 9,574 persons per square mile; when expanding the scope to include the 500 year floodplain, these exposure values increased to 74% of areas ranked high for social vulnerability and include a population of 724,156 persons with an average population density of 9,596 persons per square mile (Pflicke et al. 2015). These data are a first
approximation of those areas in the state where there are populations that may have
differential ability to respond and recover to the effects of climate change associated with
precipitation; further analysis would be needed to better quantify the relationship between
vulnerable populations in New Jersey and the various health impacts posed by climate
change.

Figure 20: Social Vulnerability in New Jersey by Census Tract
In addition, Yamanaka et al. (2015) undertook an analysis of coastal flood exposure for New Jersey’s senior population to current and future sea-levels and found that Atlantic, Burlington, Cape May, Monmouth, and Salem Counties all had 50% or more of senior populations within areas of high coastal flooding exposure. Further Yamanaka et al. (2015) found that 12 out of 147 hospitals and 26 of 548 nursing homes are located within current coastal flood hazard areas in New Jersey.
Section VII: Next Steps

The Climate and Health Profile report is intended to provide an initial point of reference to inform a targeted set of “next steps” to incorporate conditions of a changing climate into public health planning, programs and policies in New Jersey. Along with insights gained from the New Jersey Climate Change and Public Health Workgroup’s June 3, 2016 workshop, Preparing for the Impacts of a Changing Climate on Public Health in New Jersey: A Workshop for Public Health Practitioners, the workgroup has outlined a set of next steps forward for its own efforts. In general, the Workgroup concludes that the most effective and efficient approach to protect the public health of New Jerseyans from changing climate conditions is to build consideration of changing climate conditions and the anticipated impact and consequences of those conditions into existing public health programs and systems, rather than creating a new overlay of initiatives on top of existing public health programs and services.

As is the case in other states where concerted climate change initiatives have been adopted as part of public health practice, significant opportunities exist in New Jersey to:

- Conduct the analyses needed to identify the most pressing public health impacts of climate change in New Jersey as well as the populations most vulnerable to those impacts;
- Integrate climate science and impacts into public health planning and systems; and
- Build capacity within the State’s public health network for advancing climate change resilience, preparedness and adaptation.

This “adaptive management” approach to integrating climate change adaptation into public health practice is generally consistent with the approaches underway or under development in other states that have adopted comprehensive programs (Hess 2012). This approach recognizes the existing extensive network and organizational infrastructure that already supports public health systems, anticipates that climate change will increase current public health stressors and pose greater burden to the populations that are already most vulnerable to those stressors, and assumes that, with varying types of technical and resource support, current public health practice is well suited to respond to changing climate conditions. Adaptive management elements are intuitive to public health practice including: applying data to assess climate-related health hazards and vulnerable populations; engaging stakeholders to inform development and deployment of public health interventions; and monitoring outcomes (NRC 2004).
The Workgroup has identified a five-part framework to strategically focus its efforts moving forward and it recognizes that advancing these efforts is dependent on a collaborative approach among public health practitioners, state and local decision makers, the research community, healthcare providers, and the nongovernmental community. Overall, success in advancing this framework will be measured by the extent to which changing climate conditions, and the resulting impacts from those conditions, are fully integrated into planning, decision-making and delivery of public health programs, policies and services statewide:

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<th>Act</th>
<th>Implement specific initiatives identified in consultation with public health community</th>
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<tr>
<td>Plan</td>
<td>Integrate climate science and consideration of climate change impacts into existing public health planning, programs and decision-making processes</td>
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<tr>
<td>Assess</td>
<td>Assess disease burden as a result of a changing climate and identify vulnerable populations and appropriate interventions</td>
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<tr>
<td>Support</td>
<td>Develop and assist in the deployment of tools and other resources to support local public health practitioners</td>
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<tr>
<td>Build Capacity</td>
<td>Expand the ability of NJ's public health practitioners to undertake interventions to address public health-related climate change impacts</td>
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With the issuance of the Climate and Health Profile Report, the New Jersey Climate Change and Public Health Workgroup provides an important forum for engaging dialogue among key partners on advancing this framework. Opportunities and areas of focus for the Workgroup include:
**Act – Implement specific initiatives identified in consultation with the public health community**

In 2014, the New Jersey Climate Adaptation Alliance issued a report with more than 45 public policy recommendations to enhance New Jersey’s ability to adapt to and be prepared for changing climate conditions (NJCAA 2014a). Twenty-five of those recommendations have either direct or indirect impacts on public health and public health programs and systems (See Appendix A). The recommendations were prepared based on research conducted over 18 months and with stakeholder engagement including the state’s public health community. Several reports provide important basis and background to the Alliance’s Policy Recommendations report including sector-specific working briefs, a summary of stakeholder engagement efforts including with the public health community and a gap analysis report identifying initial gaps in public policy identified as a result of research and stakeholder engagement (All reports can be found on the Alliance website at: http://njadapt.rutgers.edu/resources/njcaa-reports).

In general, the Alliance’s recommendations called for development of a comprehensive climate adaptation public health strategy informed by guidance from the Centers for Disease Control and Prevention and that, at minimum, includes the following components:

- An assessment of current and future public health risks and vulnerabilities;
- Geospatial localized vulnerability assessments developed collaboratively with regional and local public health agencies and stakeholders, health care institutions and providers, the NJ Department of Health and NGOs; and
- Identification of categories of populations especially vulnerable to climate change impacts and development of strategies to address the needs of those populations throughout the state.

Additionally, the Alliance pointed to a set of specific recommendations that can improve public health outcomes during climate-related events, such as:

- Establishment of a statewide list of electronic medical prescriptions and a coordinated pharmacy plan to ensure that individuals can receive critical prescription medicines if sheltered;
- Creation of an electronic and web-based registration system within the shelter system;

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6 An additional set of recommendations specific to Emergency Preparedness were included in the 2014 NJCAA report and are included herein as Appendix B.
Development of programs to provide proactive resident advocacy, crisis counseling and effective communication among shelter staff and residents;

- Consideration of procedures that would allow the Governor to recruit state and local employees to staff shelters during extreme weather events;
- Development of a more comprehensive plan to address stockpile needs to ensure adequate supplies of food, water, medication, fuel and other supplies are available during emergencies; and
- Expansion of mental health and substance abuse services immediately after a climate-related event, along with proactive outreach and crisis counseling services to those in shelters and the most highly impacted communities.

In addition to the research and policy recommendations issued by the Climate Adaptation Alliance, several other important reports and sets of recommendations have been issued in recent years addressing climate-related public health challenges in New Jersey. Most notably, a team of researchers from several academic institutions in the region undertook the Sandy Child & Family Health Study (S-CAFH) (Abramson 2015). Among an extensive set of findings and recommendations, the S-CAFH provided the following insights related to direct public health impacts:

- Housing damage can be a risk factor for poor health that has an effect on people’s lives remarkably similar to the effect of poverty.
- Exposure to mold was associated with both clinically-diagnosed asthma and with mental health distress.
- Children living in homes that experienced minor damage were at particularly high risk for psychological and emotional issues.

The release of this Climate and Health Profile Report provides an important juncture to review recommendations of previous work including the Climate Adaptation Alliance and S-CAFH in light of projections for climate-related public health impacts for New Jersey as outlined in this report.

Plan – Integrate climate science and consideration of climate change impacts into existing public health planning, programs and decision making processes

An adaptive management approach to addressing public health impacts of climate change necessitates the need to integrate the latest climate science and the anticipated public health impacts of changing climate conditions into existing and ongoing planning processes at the State and local level. This approach allows for full integration of public health-related climate change impacts into planning processes that drive State and local
decision-making including resource allocations, program development, regulatory standards and establishment of preparedness requirements for the private sector.

There is definite synergy between the next steps in this report and relevant provisions in the State Health Improvement Plan. The State Health Improvement Plan (NJDOH 2012), also known as Healthy New Jersey 2020, includes the establishment of baseline data and targets that are intended to be addressed through the provisions of the Plan. The Plan focuses on five leading health indicators that are intended to reflect the State of New Jersey’s major public health concerns based on the benchmarking outlined in Healthy New Jersey 2020. Of those five health indicators, three – birth outcomes, heart disease, obesity - have direct or indirect connections to climate-related health outcomes. This synergy provides valuable opportunities to identify strategies to integrate consideration of changing climate conditions into disease prevention efforts underway and planned as part of the State Health Improvement Plan.

In addition to informing statewide efforts under Healthy New Jersey 2020 and the State Health Improvement Plan, the content of this Climate and Health Profile Report provides a valuable reference point for integration of consistent climate science and articulation of anticipated public health impacts into a variety of other extant planning process including:

- County Health Improvement Plans
- Community Health Needs Assessments
- Municipal Master Plans
- County Master Plans
- Hazard Mitigation Plans
- Regional (multi-municipal) and local Resilience plans.

Another opportunity to consider is whether New Jersey’s efforts to address climate-related public health challenges would benefit from the establishment of a collaborative, partner-driven nonprofit organization dedicated to advancing public health practice and making systematic improvements in population health.

Several actions are needed to advance the objective of integrating climate science and consideration of public health-related climate impacts into existing planning processes, including: guidance, technical assistance and development of decision-support tools that can be used by State and local planners, documentation and education about best practices for planning integration, and demonstration of effective strategies in order to develop a “community of practitioners” statewide.
In its service role as the state university, a multidisciplinary team at Rutgers has been working to develop and deploy climate science-based decision support tools to aid coastal communities in developing resilience planning efforts. A similar collaborative approach including climate scientists, public health practitioners, planners and public health experts can provide similar opportunities to incorporate the insights synthesized in this Climate and Health Profile Report into specific and tangible provisions of existing planning mechanisms. This effort will be most impactful if done in close collaboration with those agencies and authorities that oversee execution of planning provisions. In addition, opportunities should be identified to educate New Jersey practitioners about similar efforts outside New Jersey that may be more fully developed at this time which can augment New Jersey planning provisions.

Assess – Assess disease burden as a result of a changing climate and identify vulnerable populations and appropriate interventions

This Climate and Health Profile Report serves as an important initial tool to further raise awareness among public health practitioners in New Jersey about the potential impacts of a changing climate on public health. The Workgroup intends to use this report as a vehicle to engage the public health community more actively in efforts to quantify additional burdens of health outcomes associated with climate change. In doing so, the Workgroup will advance New Jersey’s application of the CDC BRACE framework. Following Step 1 of BRACE in which climate change impacts and public health vulnerabilities are forecasted resulting in a Climate and Health Profile Report, Step 2 involves a more quantitative process of estimating future burden of disease for climate-related health outcomes so that those outcomes can be ranked for priority action and public health interventions and health adaptation plans can be developed (Jess 2015).
Following CDC guidance (CDC 2014), a projection of disease burden involves six components:

1. Developing a causal pathway in which exposures to climate hazards are linked to health outcomes.
2. Applying climate models to identify mechanisms through which climate hazards may change in intensity and duration into the future.
3. Establishing a baseline disease burden of health outcomes in populations of concern.
5. Applying modeling strategies to combine health outcome estimates to project cumulative health outcomes and consider health outcome scenarios based on potential public health interventions.
6. Using local data to the extent it is available, assessing exposure-outcome associations to estimate how exposure affects health outcomes.

To the extent climate and health outcome data are available, this process of projecting disease burden can result in a quantitative assessment of anticipated health outcomes with an understanding of vulnerable populations. If local climate and/or health data are not available, data from the scientific and public health literature is used resulting in a more qualitative assessment. Nevertheless, the result of this process is the identification of anticipated health outcomes as a result of changing climate conditions that allows decision-makers to identify and prioritize public health interventions.

The Workgroup believes that undertaking the projection of disease burden will allow for a systematic and strategic identification of needed public health interventions to address climate-related health outcomes. Resources permitting, the Workgroup intends to combine a consultative process with climate scientists with a public health expert panel approach in order to identify, project and rank climate-related health outcomes as well as identify especially vulnerable populations that should be priorities for any subsequent identification of public health interventions.
Support - Develop and assist in the deployment of tools and other resources to support local public health practitioners

While an assessment of projected disease burden will yield a systematic and strategic identification of climate-related health outcomes for public health interventions, there is also an immediate need to begin efforts now to support public health practitioners in efforts to undertake programs designed to reduce climate impacts on health. Examples of efforts in other states participating in the CDC Climate Ready States and Cities Initiatives are available and a variety of specific efforts were discussed at the Workgroup’s June 3 conference. Some efforts are designed to raise awareness about climate-related health impacts among public health practitioners, and others are intended to build and provide ready-made tools that local public health practitioners can use to reduce public health impacts of climate change. The objective of this effort is to provide the support needed by State and local public health practitioners in New Jersey for undertaking policies, programs and strategies to address climate-related public health impacts.

Several specific efforts raised at the June 3 conference and discussed by the Workgroup as important initial efforts needed in New Jersey include:

- Create tailored New Jersey-specific data and tracking tools that can be used by public health practitioners using data available under the CDC Environmental Public Health Tracking Program (CDC 2012). Data regarding health outcomes of climate conditions can be tailored to New Jersey to support public health programs and raise awareness in the general population.
- Develop free and easily accessible educational materials that public health practitioners can use for education and outreach of the general public; these should be available in web-based as well as reproducible formats.
- Using existing data and analyses regarding populations in New Jersey that are vulnerable to changing climate conditions (Pflicke 2015), develop guidance and tools that can support efforts of practitioners to consider the needs of such populations when developing climate-related public health interventions.
- Deploy the practice of Health Impact Assessment (HIA) to assess health impacts of decisions associated with climate change and resilience policies and programs. HIA is a tool that can be more widely integrated into assessment processes by non-health decision makers to assess a proposed plan, project or policy that would have traditionally not considered health outcomes. HIA employs a systematic process combining scientific data, health expertise and public health input to
identify and assess the potential positive and negative health effects early in a decision-making process to lead to improved health outcomes in the land use, energy, transportation, and housing sectors (NRC 2011). In New Jersey, HIA has been conducted for resiliency planning in two seminal reports. The first examined a proposed stormwater management plan for the City of Hoboken including the potential health effects of flooding and exposure to polluted stormwater; disruptions in local, emergency and business services due to flooding, changes in water and air quality; and effects on permeability and heating related to green infrastructure solutions (Carnegie and Whytlaw 2016). The second assessed the physical and mental health outcomes associated with implementation of voluntary residential buy-out scenarios for properties repeatedly flooded and at continued risk of flooding from sea-level rise in Little Egg Harbor Township, NJ (Lowrie and Kutner 2016). Policies, plans and projects to address climate change mitigation and adaptation could benefit from integration of HIA to support not only local public health practitioners, but also non-health decision makers with policies, projects or plans to address climate resiliency and greenhouse emissions reductions.

- Summarize downscaled climate science and future climate projections into guidance and communication tools that can be used by public health practitioners as part of local planning and development of interventions. Downscaling is the analytical procedure in which global climate data is assimilated to allow for making predictions at more local levels (UCAR 2016). New Jersey public health practitioners can benefit from a shared set of downscaled data that can consistently be used statewide.

**Build capacity - Expand the ability of NJ’s public health practitioners to undertake interventions to address public health-related climate change impacts**

There is a critical need to build enhanced capacity into existing public health programs and delivery systems as the climate continues to warm. The Workgroup provides an important forum for identifying needs of New Jersey’s public health community to systematically target and address climate-related health outcomes. The objective of building capacity within the state’s existing public health systems and programs is intended to develop a “community of practice” in which public health practitioners: benefit from expert assistance and collaboration with the climate science community; have sufficient access to data and decision-support tools to integrate climate considerations into public health practice; share effective intervention strategies to address climate-related health outcomes; and come together to articulate shared needs in terms of resources, data, and training, among others. Several areas raised at the June 3 workshop and under discussion among the Workgroup include:
• Using existing continuing education programs for public health practitioners (workshops, webinars, etc.) to offer trainings and educational opportunities on specific topics with a strong emphasis on public health practice. Initially, these efforts can benefit from various resources that have already been developed, some of which are mentioned throughout this report;

• Identify resources to support demonstration projects with local public health practitioners in assessing climate-related health outcomes and implementing public health interventions;

• Provide opportunities for New Jersey public health practitioners to participate in national communities of practice within the CDC Climate Ready States and Cities Initiative;

• Identify natural partners in other sectors, such as transportation, emergency management, and natural resource protection, where integrating consideration of changing climate conditions in planning and decision-making for sector-related objectives can create co-benefits of improving health outcomes; and

• Identifying resources to create a mini-grant program to promote innovation among local public health practitioners.

Overall, there are significant opportunities to improve health and well-being among New Jerseyans through consideration of climate-related health outcomes. This Climate and Health Profile Report provides an important step forward for development of collaborative initiatives engaging climate scientists, public health practitioners, public policy decision-makers, and subject area experts.
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Appendix A:
NJCAA Public Policy Recommendations
Resilience
Preparing New Jersey for Climate Change
Policy Considerations from the New Jersey Climate Adaptation Alliance

June 2014

Appendix A
Resilience: Preparing New Jersey for Climate Change: Policy Considerations from the New Jersey Climate Adaptation Alliance is the culmination of a deliberative research and stakeholder engagement process undertaken by the New Jersey Climate Adaptation Alliance ("the Alliance"), a network of policymakers, public and private sector practitioners, academics, nongovernmental organizations, and business leaders designed to build climate change preparedness capacity in New Jersey. The mission of the Alliance is to identify, demonstrate, recommend and communicate policies and activities that can prepare New Jersey’s vulnerable sectors to better meet the anticipated impacts of climate change. The individuals and organizations that comprise the Alliance Advisory Committee agree that the recommendations in this report present the compelling issues to be addressed as part of a statewide climate change adaptation discussion. Rutgers University serves as the facilitator of the Alliance. In this defined role, staff at Rutgers, at the direction of the Committee, undertook the research and stakeholder engagement process that resulted

Rutgers University serves as the facilitator of the Alliance. In this defined role, staff at Rutgers, at the direction of the Committee, undertook the research and stakeholder engagement process that resulted in these recommendations and, as such, these recommendations do not represent the position of the University. While individual members of the Alliance Advisory Committee do not necessarily endorse each and every specific recommendation, the Committee has reached consensus that these recommendations accurately reflect and present the issues that emerged from the research and stakeholder engagement process, and require further consideration and discussion in New Jersey.

The Alliance recognizes that important climate change adaptation and preparedness efforts are already underway in New Jersey. The intent of these recommendations is to support and advance ongoing activities as well as to foster a statewide dialogue regarding consistent and long-term public policy action to enhance preparedness for a changing climate in New Jersey. Examples of some ongoing and important climate change adaptation and preparedness efforts already undertaken in New Jersey are noted in the Introduction of this report.

The approach followed to develop these recommendations was guided by the Alliance Advisory Committee and involved several tasks, including research on climate change impacts in New Jersey, analysis of leading policy practices and extensive stakeholder engagement. The Alliance focused on key sectors and cross-cutting issues: agriculture; built infrastructure (transportation, energy, and telecommunications); coastal communities; emergency management; environmental justice; natural resources; public health; social services; and water resources. Stakeholder engagement partners were commissioned to gather the views of sectoral experts through various methods (surveys, workshops, listening sessions, one-on-one interviews). In addition, information was synthesized from a statewide survey on public perception of climate change, a May 2013 Alliance sponsored conference on climate adaptation leading practices, and specific research reports on climate adaptation from the perspective of the media, the state’s environmental community, policies related to building resilient structures, vulnerable

Floods in Sparta after days of heavy rains in August 2000 buckled roads and damaged bridges (Chris Hondros, iStock).
populations, and climate change adaptation funding and financing mechanisms. The outcomes of these efforts serve as basis and background to these recommendations and are available in a set of reports (also identified in the Introduction) that can be found on the Alliance's website. A companion document to these recommendations which provides an overview of actions that New Yorkers can take now, at the individual, family, neighborhood and community level, to prepare themselves and their communities for a changing climate, can be found here: https://www.sas.rutgers.edu/cms/njadapt/component/docman/doc_download/117-what-you-can-do?Itemid=.

In December 2013, the Alliance issued the report, Resilience: Preparing New Jersey for Climate Change: A Gap Analysis from the New Jersey Climate Adaptation Alliance, which outlined gaps in public policy that had been identified via extensive stakeholder engagement as well as informed by the research that had been completed to date. The December 2013 report identified six general areas of policy gaps:

- Research, needs assessment and data development;
- Enhanced implementation of existing data, tools, and methods;
- Regulation, policy and governance support;
- Coordination of adaptation planning and preparedness actions;
- Ensure suitable funding;
- Education and outreach efforts.

This report builds upon the December 2013 report by identifying recommendations that correspond to the six major categories in the gap analysis. These recommendations incorporate iterative consideration by the Alliance Advisory Committee in consultation with stakeholder engagement partners and technical experts. The table below provides a brief summary of the recommendations organized by the six gap categories. For each recommendation, the sectors affected by the recommendation are identified and those recommendations that can be considered initial steps are also identified.
Table 1: Climate change policy recommendations

1.0 - Strengthen climate change preparedness and adaptation in New Jersey through the establishment of a statewide climate adaptation policy that is designed to significantly reduce New Jersey’s vulnerabilities to a changing climate through actions that direct integration of science-based standards into state policies, programs and regulations and that direct actions consistent with the statewide policy be taken by State agencies, regional and local planning authorities and commissions, municipal and county government.

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<tr>
<td>1.1 Establish a statewide Climate Change Working Group through legislative or executive action to foster statewide preparedness planning, coordinate scientific and technical assessment of potential climate change impacts to the citizens and environs of New Jersey and to frame adaptation policy.</td>
<td>![Icon Key](ICON KEY)</td>
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<td>1.2 Form a Science and Technical Advisory Panel (STAP) within the Climate Change Working Group to rapidly develop a climate impact assessment.</td>
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<td>1.3 Use the climate impact assessment to inform consistent development and adoption of statewide climate adaption policy.</td>
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<td>1.4 Incorporate consideration of a changing climate into long-term planning that governs regulations, program operations, and funding allocation decisions with discrete outcomes, necessary resources, staff development and schedules for implementation.</td>
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<td>1.5 Incorporate climate change policy into capital planning and decision making of state agencies, regional and local planning authorities and commissions, municipal and county governments.</td>
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<td>1.6 Conduct a comprehensive evaluation of policies and regulations governing New Jersey’s coastal zone in light of identified risks to a changing climate.</td>
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<td>1.7 Convene a working group of experts to consider the outcomes of the statewide climate impact assessment on certain geographic areas of the state, including urban communities and the Delaware Bayshore, as well as on certain populations that are particularly vulnerable to a changing climate.</td>
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<td>1.8 Revise the Municipal Land Use Law to require a master plan element that addresses natural hazards such as climate change.</td>
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2.0 - Implement standards, regulations and policies that apply a risk management approach to identify people, places and assets (including natural capital) most at risk to climate stressors and direct investment to risk reduction efforts as well as uses that are compatible with a changing climate.

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<tr>
<td>2.1 Develop and enhance tools to restrict or discourage future development and redevelopment in areas at high risk to the impacts of current and future storms, flooding and sea level rise.</td>
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<td>2.2</td>
<td>Assess the vulnerability of New Jersey’s agricultural lands to a changing climate, including activities on land as well as aquaculture in coastal waters.</td>
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<td>2.3</td>
<td>Assess the vulnerability of natural areas (i.e. tidal wetlands, forests, and other natural areas) and the value of these areas for reducing and/or adapting to climate change.</td>
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<td>2.4</td>
<td>Require that all public water supply and public wastewater utilities develop, implement and periodically update plans for the identification and mitigation of natural and other risks to facility operations in light of the statewide climate change impact assessment and as part of current compliance requirements.</td>
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<td>2.5</td>
<td>Assess the vulnerability of transportation infrastructure using the climate change impact assessment.</td>
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3.0 - Rely on existing governance structures and programs, to the greatest extent possible, and build partnerships with community-based organizations, as a means to integrate climate change adaptation and preparedness rather than create new programs.

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<td>3.1</td>
<td>Assess the existing health and environmental burdens experienced by certain communities that may be exacerbated by a changing climate and enhance programmatic attention including climate change adaptation policy in these communities.</td>
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<td>3.2</td>
<td>Develop and sustain meaningful incentives at a statewide scale to encourage counties and municipalities to advance targeted and comprehensive buy-out programs for flood and storm prone areas.</td>
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<td>3.3</td>
<td>Encourage greater participation by a broader set of state and local agencies in state and local emergency management and hazard mitigation planning.</td>
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<td>3.4</td>
<td>Analyze and determine how to effectively plan for debris management during disasters and storms events.</td>
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<td>3.5</td>
<td>Enhance compliance inspections and pollution prevention assistance to facilities using petroleum or hazardous materials that exist in flood prone areas.</td>
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<td>3.6</td>
<td>Assess farmland preservation strategies and coordinated agricultural, floodplain and wetland easement purchases for agricultural locations that may be vulnerable to sea level rise or flooding from climate change to facilitate climate change adaptation preparedness.</td>
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<td>3.7</td>
<td>Examine regulation of agricultural conservation practices under federal and state authorities to best minimize barriers for farmers to apply conservation strategies that are beneficial for climate adaptation and consider health and sustainability of other ecosystems.</td>
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<tr>
<td>3.8</td>
<td>Develop long-term resiliency plans for the electric distribution system and investigate the feasibility of alternative configurations including micro-grids or implementation of smart-grid technology to mitigate risk related to power outages.</td>
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<td>3.9</td>
<td>Develop and adopt a comprehensive climate adaptation public health strategy as guided by the federal Centers for Disease Control Building Resilience Against Climate Effects (BRACE) framework.</td>
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<td>3.10</td>
<td>Set a goal of 80% municipal participation in the FEMA Community Rating System program.</td>
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<td>3.11</td>
<td>Convene a team of experts to recommend climate resilient design and construction guidelines along with commensurate amendments to regulations, codes and standards to meet the new guidelines.</td>
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<td>3.12</td>
<td>Modify regulatory standards regarding stormwater runoff, stream flow and water quality based effluent limits in NJPDES permits and water allocations to incorporate implications of climate change.</td>
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<td>3.13</td>
<td>Require proposed shore erosion control projects to consist of nonstructural shoreline stabilization measures, such as living shorelines, as a default design standard.</td>
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<td>3.14</td>
<td>Consider the need for mold standards to protect worker health and safety.</td>
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<td>3.15</td>
<td>Enhance environmental surveillance during and after storms in communities that already experience other environmental burdens such as contaminated sites or industrial facilities with hazardous materials.</td>
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<td>3.16</td>
<td>Encourage efforts to foster collaborative partnerships between local neighborhood organizations and various governmental levels of emergency management.</td>
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4.0 - Explore and implement creative strategies to generate stable funding for climate change adaptation and preparedness activities, favoring strategies that also result in reductions of emissions that cause climate change.

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<td>4.1</td>
<td>Convene a Blue Ribbon Panel to examine approaches to establish dedicated funds to support climate change preparedness in New Jersey and prepare a report to the Legislature with recommendations.</td>
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<td>4.2</td>
<td>Reflect the integration of the statewide climate change adaptation policy in the annual budget process of state agencies and authorities by including capital programming and operating and maintenance funds for enhancing resiliency and climate adaptation.</td>
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### RECOMMENDATIONS

| 4.3 | The State should pursue opportunities to participate in regional multi-state regulatory and non-regulatory initiatives that not only result in significant reductions in emissions through creation of markets for low-carbon energy, transportation and other sources of greenhouse gas emissions, but that also generate revenue which can be invested in strategies to address the impacts that result from these emissions by enhancing climate change preparedness and adaptation in New Jersey. |
| 4.4 | Maximize efforts to secure federal funds for climate adaptation and preparedness efforts. |
| 4.5 | Encourage the NJ Congressional Delegation to champion increased funding for existing flood mitigation programs managed by the Federal Emergency Management Agency. |

#### 5.0 - Promote education, training, outreach and innovative partnerships to better inform the public, decision makers and practitioners about climate change impacts and adaptation strategies to foster adaptation and preparedness capacity.

| 5.1 | Engage the New Jersey Climate Adaptation Alliance to lead a public education effort that effectively communicates climate change impacts and risks to New Jersey. |
| 5.2 | Authorize enhanced state training and resources for local officials regarding climate adaptation and resiliency planning. |
| 5.3 | Develop innovative approaches to implementing agricultural-sector climate change adaptation through public-private partnerships. |
| 5.4 | Develop a long-term, sustained education and outreach curriculum for the agricultural community, farmers, commercial fishermen and shellfishermen on climate change impacts and recommended management practices. |
| 5.5 | Develop a systematic and sustained training curriculum to teach transportation facility managers, infrastructure engineers and operators the basics of risk analysis and climate science. |
| 5.6 | Educate health care providers and practitioners on climate change impacts; start an organized campaign to educate vulnerable populations about self-reliance in the case of extreme weather events, including high temperatures. |
| 5.7 | Improve statewide and local emergency response communication protocols to ensure timely community communication about potential hazardous risks during extreme weather events. |
6.0 - Undertake analyses and research to inform climate adaptation and preparedness practices in New Jersey.

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<tr>
<td>6.1 Foster collaboration between state agencies, academic, federal and local governments as well as the NGO community with the goal of undertaking research and analyses on key issues to support climate change preparedness in New Jersey.</td>
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<td>6.2 Analyze New Jersey’s current utility regulatory structure to determine the degree to which it provides disincentives for proactive climate adaptation implementation</td>
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<td>6.3 Analyze the extent to which all-hazards planning within healthcare organizations is incorporating consideration of climate change impacts.</td>
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<td>6.4 Foster collaboration between public, private and non-profit sectors to develop and propagate strategies that improve personal resiliency among New Jersey residents.</td>
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<td>6.5 Evaluate needs for creating a statewide system that could allow private health care practitioners and other health care providers to establish links in the event of emergency events to share and maintain refrigeration for critical medical needs.</td>
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<td>6.6 Enhance existing agricultural extension programs to better address climate change impacts to New Jersey agriculture.</td>
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<td>6.7 Analyze NJ’s regulatory structure and policies for public investment to identify approaches to remove barriers to and provide incentives for use of green infrastructure, innovative design, and compatible uses that cost effectively promote climate adaptation while delivering additional ecosystem service or other benefits.</td>
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Appendix B: NJCAA Emergency Preparedness Recommendations
Resilience
Preparing New Jersey for Climate Change
Policy Considerations from the New Jersey Climate Adaptation Alliance

June 2014
Throughout the climate preparedness policy development process, the New Jersey Climate Adaptation Alliance received much feedback regarding emergency response activities. With recent storm events, such as Hurricane Sandy and Tropical Storm Irene fresh in their minds, stakeholders and experts provided many ideas and recommendations about strategies that may be needed to improve effectiveness of response efforts in the event of disasters and extreme weather events. The Alliance also heard that emergency response is a reactive activity that operates regardless of the cause (e.g. climate change impacts versus homeland security). Thus, rather than providing a series of emergency response policy recommendations that could be applicable to multiple hazards, the Alliance is “reporting out” on the recommendations and insights we received regarding emergency response separate from overall recommendations that are specific to adapting to a changing climate.

Key areas of improvement that stakeholders identified centered on communications, operations and management of shelters, addressing acute medical needs, fuel accessibility, better coordination with local community groups, and addressing mental health needs. Some of the specific suggestions that the Alliance heard during the stakeholder process include the following:

1. There is a need to enhance efforts that determine the most technologically sound means of emergency communications, strengthen the resilience of those systems, establish protocols for their use and make them accessible to utilities, county and local governments.

2. Improved communication among state, county and local agencies is critical. There should be a unified emergency plan that is used by state, federal and county agencies that clearly sets forth communications protocols.

3. A statewide list of electronic medical prescriptions and a coordinated pharmacy plan is needed to ensure individuals can receive critical prescription medicines if sheltered.

4. An electronic and web-based registration system is needed within the shelter system to track citizens’ movements within the shelter system while protecting their privacy.

5. An additional layer of staffing is needed within shelters to provide proactive resident advocacy, crisis counseling and effective communication among shelter staff and residents.

6. There is a need to set expectations and protocols for emergency preparedness and response planning and communications for utilities, cable and telecommunications companies in overlapping service territories and between BPU-regulated entities and the county and municipal governments in those territories.

7. New Jersey needs a strategic reserve for fuels for utility fleets and backup generators and needs to design an emergency distribution/access system.

8. Consideration should be given to providing the Governor with authority to direct state, county and municipal employees in the event of an emergency to staff shelters, etc.

9. New Jersey should develop a more comprehensive plan to address stockpile needs to ensure adequate supplies of food, water, medication, fuel and other supplies are available during emergencies.

10. There may be a need for New Jersey to offer a service to municipalities that would establish a statewide registry for voluntary municipal entry of records so that local officials have access to key sets of data in the event of a disaster.

11. New Jersey needs to place a greater emphasis on sheltering in place and sheltering in place needs to be identified as a priority for emergency management planning.

12. New Jersey should develop a partnership of social service agencies, academia, non-profits, local and state agencies to design a reform plan to address social service issues in shelters (violence, medications, psychiatric disorders, sexual predators, etc.).

13. Improved communication and coordination between first responders and those managing shelters, including national, state and local non-profit organizations and volunteers, is needed to provide effective sheltering. A set of best practices for local government communication with the public in extreme weather events would be very helpful. Improved systems to allow people living in shelters to communicate with family members are needed which could have the added benefit of reducing their shelter stay.

14. There should be an expansion of mental health and substance abuse services immediately after a climate-related event, along with proactive outreach and crisis counseling services to those in shelters and the most highly impacted communities. These services are most critical to those with chronic mental health and active substance abusers who rely on medication for their treatment.

15. A coordinated pharmacy plan is needed so that vulnerable populations are able get critical medicines in the event of disaster and in the days immediately after a disaster; many vulnerable populations may have evacuated without medications, prescriptions, identification or money to pay co-pays.

16. Especially in urban communities, disbursement of relief funds to residents in the event of emergency events should be done in partnership with urban community-based organizations (including faith based organizations) because those organizations know more about their communities and can help to address vulnerable populations and special needs of Low English Proficiency (LEP) populations.

17. More training is needed for emergency responders and shelter staff in terms of effectively dealing with vulnerable and special needs populations including the elderly and people with low English proficiency.

18. There is a need to reconsider sheltering-in-place locations.
Most municipalities provide shelters during disasters to those impacted directly by the disruptive event, which are typically located in municipal buildings or schools. While a necessary policy provision for any jurisdiction, these municipal structures are often not the best choices for shelter-in-place locations; many more resilient and less vulnerable structures are likely to exist beyond the municipally-owned building stock. Thus, jurisdictions should re-think disaster plans to better account for vulnerabilities in the shelter-in-place buildings they provide to residents; this may require new partnerships with private sector real estate developers and owners.