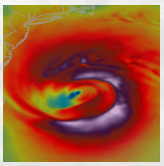

Resilience

Preparing New Jersey for Climate Change

A Gap Analysis from the New Jersey Climate Adaptation Alliance

December 2013

RUTGERS

New Jersey Climate Adaptation Alliance

The New Jersey Climate Adaptation Alliance ("the Alliance") is a network of policymakers, public and private sector practitioners, academics, and nongovernmental and business leaders organized to build climate change preparedness capacity in New Jersey. The mission of the Alliance is to identify, demonstrate, recommend, and communicate policies and cost-effective activities that can prepare New Jersey's vulnerable sectors to better meet the anticipated impacts of climate change. The Alliance is guided by an advisory committee and is facilitated by Rutgers University.

Right: Seaside Heights a day after Hurricane Sandy (Master Sgt. Mark C. Olsen, USAF).

ACKNOWLEDGMENTS

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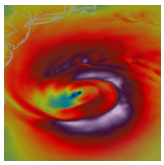


Resilience

Preparing New Jersey for Climate Change

A Gap Analysis from the New Jersey Climate Adaptation Alliance

Introduction

The New Jersey Climate Adaptation Alliance is a coalition of private- and public-sector leaders formed in 2011 to help New Jersey prepare for the impacts of climate change. This is a report on the Alliance's stakeholder outreach process to date.

Who we are

The New Jersey Climate Adaptation Alliance is a network of policymakers, public and private sector practitioners, academics, and nongovernmental organization (NGO) and business leaders who are committed to preparing New Jersey for the impacts of climate change. The Alliance is facilitated by Rutgers University, which provides science and technical support, maintains the Alliance's operations, and advances its recommendations.

The Alliance was formed in response to a consensus recommendation by participants in the November 2011 conference "Preparing NJ for Climate Change." Our mission is to partner with public and private organizations and leaders to identify, demonstrate, recommend, and communicate policies and cost-effective activities that will prepare New Jersey for the anticipated impacts of climate change. We advance our mission by:

1. Developing recommendations for state and local actions

2. Enhancing preparedness capacity, including development of tools and training

3. Facilitating demonstration and pilot projects with the private sector, local governments, and NGOs

4. Creating a clearinghouse of climate preparedness information and ongoing efforts in New Jersey

5. Conducting outreach to and education of the general public, decision makers, and stakeholders

6. Identifying needs for science, analysis, and data to support state and local action

For more information or to join our mailing list, go to the Alliance website (njadapt.rutgers.edu).

The Goldman Sachs Tower rises above the Hudson River in Jersey City; the historic Central Railroad of New Jersey Terminal stands in the foreground. Jersey City experienced severe flooding during Hurricane Sandy and Tropical Storm Irene, as did Hoboken, Weehawken, and other cities on the Hudson River waterfront. (Bigstock).

In this report

This report is an essential step toward the goal of developing policy recommendations to enhance climate change preparedness. To that end, we summarize key gaps identified to date through a thorough and ongoing stakeholder outreach process that will inform thoughtful evolution of policy recommendations. However, we first provide context regarding New Jersey's changing climate and vulnerabilities.

It is virtually impossible to discuss climate change in New Jersey without addressing the devastation wrought by Hurricane Sandy. Every aspect of our work since Sandy is colored by an awareness of the personal losses suffered by communities throughout the state. Nevertheless, it is essential to understand this report as a holistic response to global and regional trends that began long before Sandy reached our shores and are expected to continue for many decades after.

First, we examine the science of climate change – specifically, what New Jersey in the 21st century can expect in regard to

Above: Aerial view of the Jersey shore in the wake of Hurricane Sandy (Master Sgt. Mark Olsen, U.S. Air Force).

Far left: Beach restoration, Seaside Heights (Shawn Perez, Creative Commons).

Near left: Marines and sailors repair a pier in Hoboken a few days after Sandy (Cpl. Bryan Nygaard, U.S. Marine Corps).

precipitation, temperature, sea level rise, and extreme weather. Next is an assessment of public opinion in New Jersey about climate change and the willingness of residents to fund adaptation policy. An analysis of population vulnerability to climate change impacts follows.

Next, findings of a seven-month stakeholder outreach process designed to gather the views of lay people and professionals in a wide range of specialized fields are presented. The outreach process included surveys, listening sessions, a statewide poll, and a conference. The chief purpose of the ongoing outreach process is to identify New Jersey's most pressing needs in regard to climate change adaptation. Outreach was also conducted for issues that permeate multiple sectors: emergency management and vulnerable populations.

The outreach process was primarily organized into six sectors:

- Agriculture
- Built infrastructure
- Coastal communities
- Natural resources
- Public health
- Water resources

A summary of the needs identified to date via the stakeholder process that cross multiple sectors is presented first, followed by a detailed review of gaps for each sector. In the next few months, the Alliance will conduct a series of workshops for decision makers and technical experts who will review and add to the identified gaps in this report and then draft policy recommendations to address the gaps. The Alliance will issue a final set of consensus policy recommendations based on these workshops.

Climate Trends and Projections

New Jersey in the 21st century can expect higher temperatures, a greater frequency of heavy precipitation events, and rising sea levels.

> “ Sea levels along the New Jersey shore have risen faster than the global average … [T]he implications for coastal flooding will be substantial.

Climate change trends and projections in New Jersey generally follow global observations. Focusing particularly on trends and projections related to temperature, precipitation, sea level rise, and extreme weather events provides an important context for consideration of policy needs in New Jersey. This excerpt is taken from the “State of the Climate Report” issued by the Rutgers Climate Institute on October 14, 2013. The full report can be found at the Rutgers Climate Institute website (climatechange.rutgers.edu).

Temperature

New Jersey’s average temperature in 2012 was the highest in 118 years of records. Nine of the 10 warmest calendar years on record have occurred in New Jersey since 1990, and the five warmest years have occurred since 1998, consistent with the long-term upward trend of 2.2°F per century (Figure 1). Abnormal warmth was common through much of the year, with only one month (November) recording temperatures below the 1981–2010 average. Unusual summertime warmth has been noteworthy in recent years, with 6 of the 10 warmest summers on record occurring since 2005.

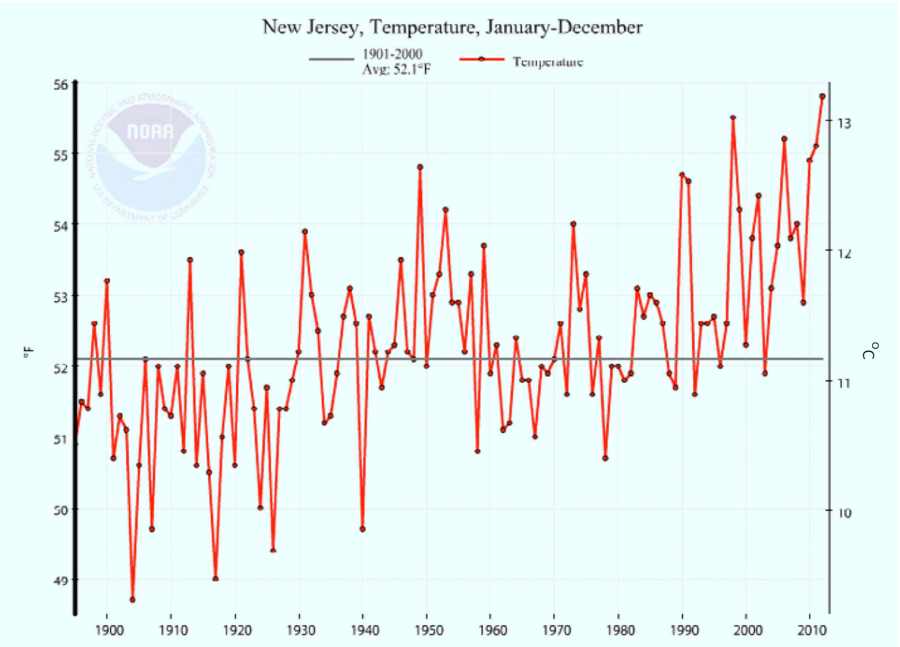


Figure 1: New Jersey statewide annual average temperature (NOAA National Climatic Data Center).

The past 25 years have been characterized by many more unusually warm months in New Jersey than unusually cold months. (Unusually warm and cold months are defined as the five warmest and coldest, respectively, for each calendar month). The period from 1988 to 2012 included 32 unusually warm months and only five unusually cold months. The disparity has been even greater since 2000, as unusually warm months have outnumbered unusually cold months by 25 to 2.

The trend toward higher temperatures is expected to continue in the decades to come as greenhouse gas concentrations continue to increase. Rising temperatures are expected to occur in all seasons, but the trend is likely to be more noticeable in summer. One study has projected that, by the middle of the 21st century, approximately 70% of summers in this region will be warmer than what would now qualify as the warmest summer on record and that the frequency of summers warmer than the warmest on record will rise to 90% by the end of the century (Battisti and Naylor, 2009).

Precipitation

After the wettest year on record in 2011, precipitation during 2012 was slightly below normal. However, 2012 was only the 47th driest for the entire 118-year period of record, demonstrating how much wetter New Jersey has been in recent decades than earlier in the 20th century. In 2013 to date, New Jersey experienced its wettest June on record and its second wettest summer.

Over the longer term, there has been an upward trend in annual precipitation in New Jersey. Since 1895, annual precipitation has increased at a rate of 4.1 inches (or about 9%) per century. 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. The last decade has been unusually wet in New Jersey. The heaviest precipitation amount for 6 of the 12 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. An index of this quantity is depicted in Figure 2. Heavy precipitation events have increased dramatically in the past two decades in the northeastern United States, occurring more than twice as often in recent years than during the past century (Figure 2). There is reason to expect that this trend may continue, and the Intergovernmental Panel on Climate Change (IPCC) projects that "(e)xtreme 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 and coauthors, 2013).

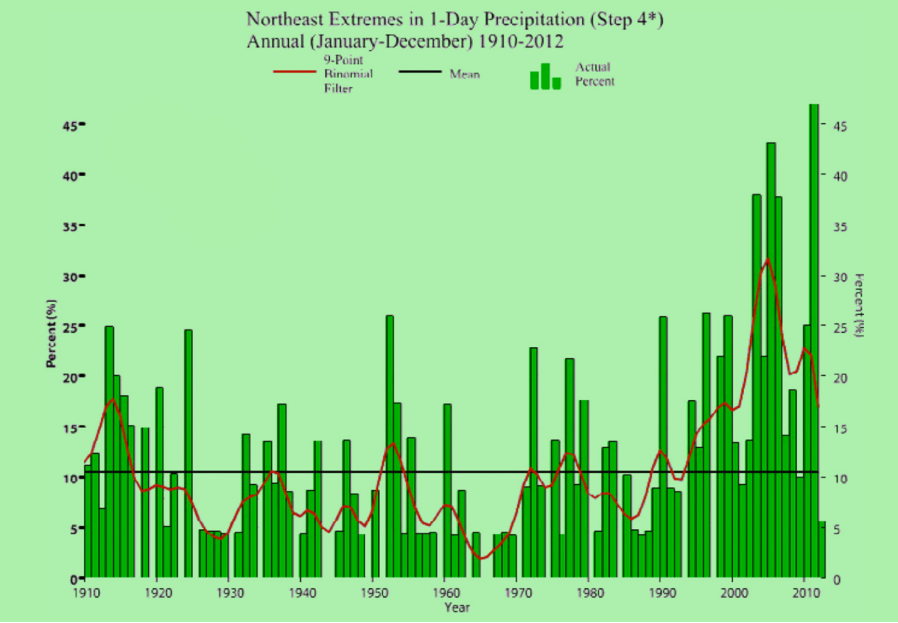
Sea level rise

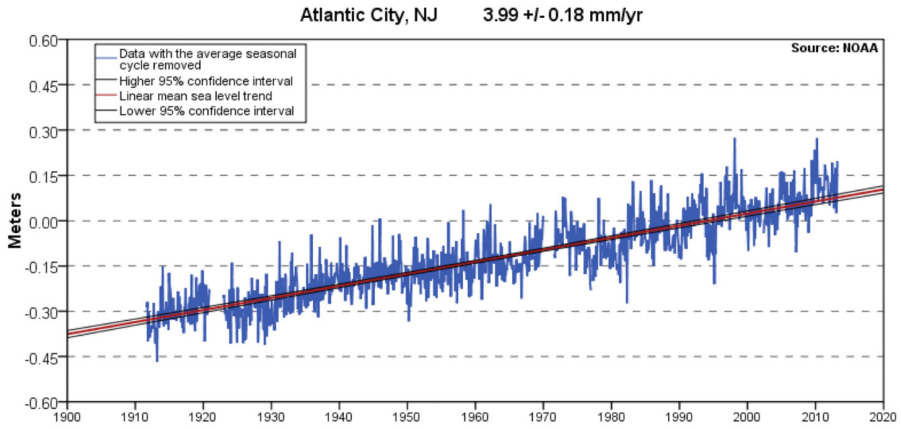
Global sea level rose at an average rate of 0.6 inches per decade during the 20th century, driven primarily by two processes: the thermal expansion of a warming ocean, which makes the same amount of water take up more space, and melting glaciers and ice sheets, which add water to the ocean. The rate of global sea level rise has increased in recent decades, with an average rate of 1.2 inches per decade since the early 1990s (Alexander and coauthors, 2013).

Rates of sea level rise vary globally and sea levels along the New Jersey shore have risen faster than the global average due to land subsidence at the same time water levels are rising. At Atlantic City, where records extend back to 1912, sea level has risen by an average rate of 1.5 inches per decade (Figure 3). A recent study led by Rutgers scientists has projected future rates of sea level rise (Miller et al., 2013). The projections are expressed as a best estimate and a range to account for uncertainties in future rates of global ocean warming and melting rates for the large ice sheets covering Greenland and Antarctica. According to these most recent projections, sea level is projected to rise by 7 to 16 inches by 2030, with a best estimate of 10 inches. In 2050, the range is 13 to 28 inches with a best estimate of 18 inches, and by 2100 the range is 30 to 71 inches with a best estimate of 42 inches. Even if the most conservative of these projections materialize, the implications for coastal flooding will be substantial.

Hurricane Sandy

An important question for coastal planners and residents is whether climate change will increase the likelihood of weather events such as Hurricane Sandy, which hit New Jersey on October 29, 2012. Recent studies find little evidence of an increase in the number of hurricanes and tropical storms in the North





Atlantic during the past century, but there is evidence of an increase in the frequency and intensity of powerful tropical cyclones during the period since 1970. Recent studies suggest that the global frequency of tropical cyclones will either decrease or change little as a consequence of global warming. However, the intensity of such tropical cyclones is likely to increase in terms of both maximum wind speed and rainfall, and the frequency of the most intense storms is expected to increase (IPCC, 2012).

Despite the uncertainties in future changes of tropical cyclone activity, there is high confidence that the impacts of future storms are likely to be more severe because of rising sea levels. Sea level rise will raise the baseline for flooding events, making severe coastal flooding events more frequent in the future. A recent NOAA study projects that the return period for coastal inundation equivalent to that from Sandy would decrease to less than 20 years by the end of the century if sea level rise in New Jersey is at the high end of the expected range (Sweet et al., 2013).

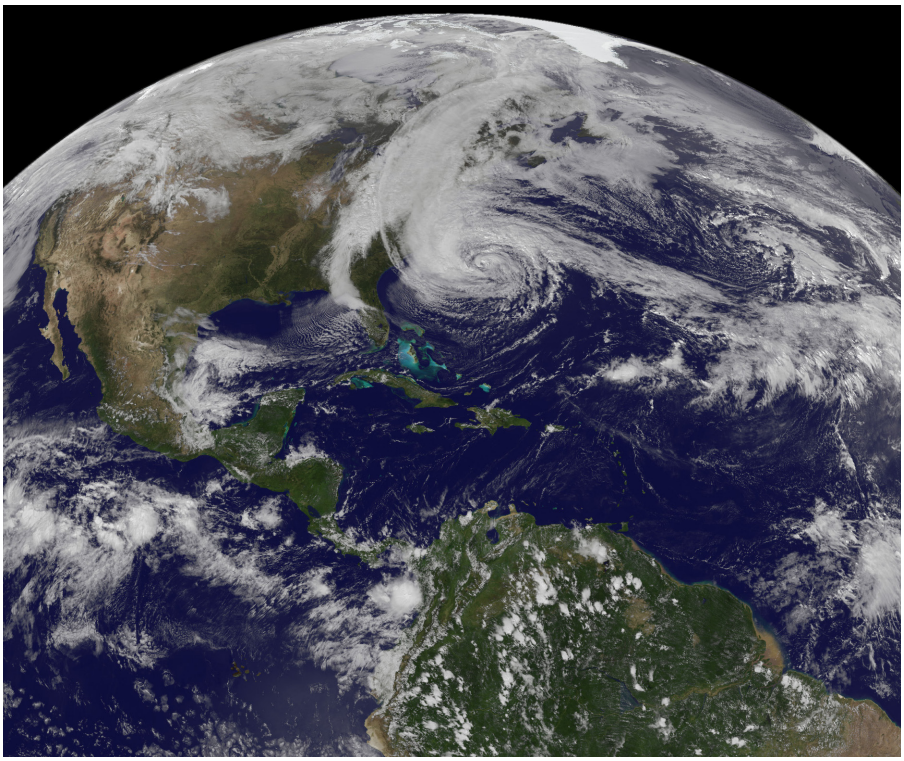
Figure 2 (top): Frequency of heavy precipitation events in the northeastern United States (NOAA National Climatic Data Center).

Figure 3 (bottom): Sea level at Atlantic City (NOAA National Ocean Service).

Public Support

Despite robust support for more stringent land-use regulations, there is only moderate trust in government to implement such policies and even less appetite for raising revenues to pay for them.

Hurricane Sandy travels north along the East Coast, October 28, 2012 (Robert Simmon, NASA Earth Observatory).



THE GENERAL PUBLIC

Hurricane Sandy is often described as a game changer in raising awareness about climate change risks, but did the storm truly resonate with New Jersey residents? If so, will they support policies to enhance the state's resilience to future climate challenges?

In a survey conducted four months after Hurricane Sandy and 19 months after Tropical Storm Irene, Rutgers University researchers gauged public support of land-use and building policies to reduce risk in flood-prone areas (Greenberg, 2013; M.R. Greenberg, personal communication, December, 2013). The survey asked 1,750 respondents to indicate their level of agreement with seven policies designed to restrict land use in flood zones, require housing to be built to resist storm water, and provide financial incentives to reduce storm-related vulnerability. The survey also looked at attitudes most strongly associated with support of these policies, notably concerns about global climate change, trust of public officials and scientists, and willingness to pay for such programs.

Survey results

With respect to risk-reducing options, the survey team posed the following question:

> Some people are talking about efforts to try to reduce New Jersey's vulnerability to hurricanes. Here are some proposals that could be used in redeveloping the New Jersey shore. Please let me know whether you agree strongly, agree somewhat, are neutral, disagree somewhat, or disagree strongly.

The responses to the seven options, which were randomized in presentation, are presented in Figure 4. Over half of respondents strongly agreed with allowing local governments to require housing in some areas to be built in ways highly resistant to natural disasters, have the federal and state governments identify the areas to remain undeveloped as they provide natural buffers in the event of storms, and relocate water and other infrastructure away from the most flood-prone areas. Forty-nine percent (49%) favored allowing the government to provide financial incentives to rebuild in ways that reduce future risk. Forty-two percent (42%) favored allowing local governments to prohibit housing in some areas, while 38% strongly favored limiting the number of times homeowners in high-risk areas may receive federal disaster relief. Only 35% favored having the federal and state governments purchase property in vulnerable areas for open space. Overall, 49% strongly favored four or more of the seven policy options.

Climate change concerns, trust in government, and support for public revenues

In regard to personal attitudes, respondents indicated broad concerns about the impacts of climate change but a lack of trust in government to address the issue (Figure 5). While 70% of respondents expressed concern about climate change impacts on New Jersey, and 64% agreed that "global climate change is a risk to me, my family and friends," only 41% felt "state and local officials understand the implications of global change for my region."

Willingness to pay for programs to reduce

Figure 4: Proportion of respondents who supported land use, design, and financial policy changes

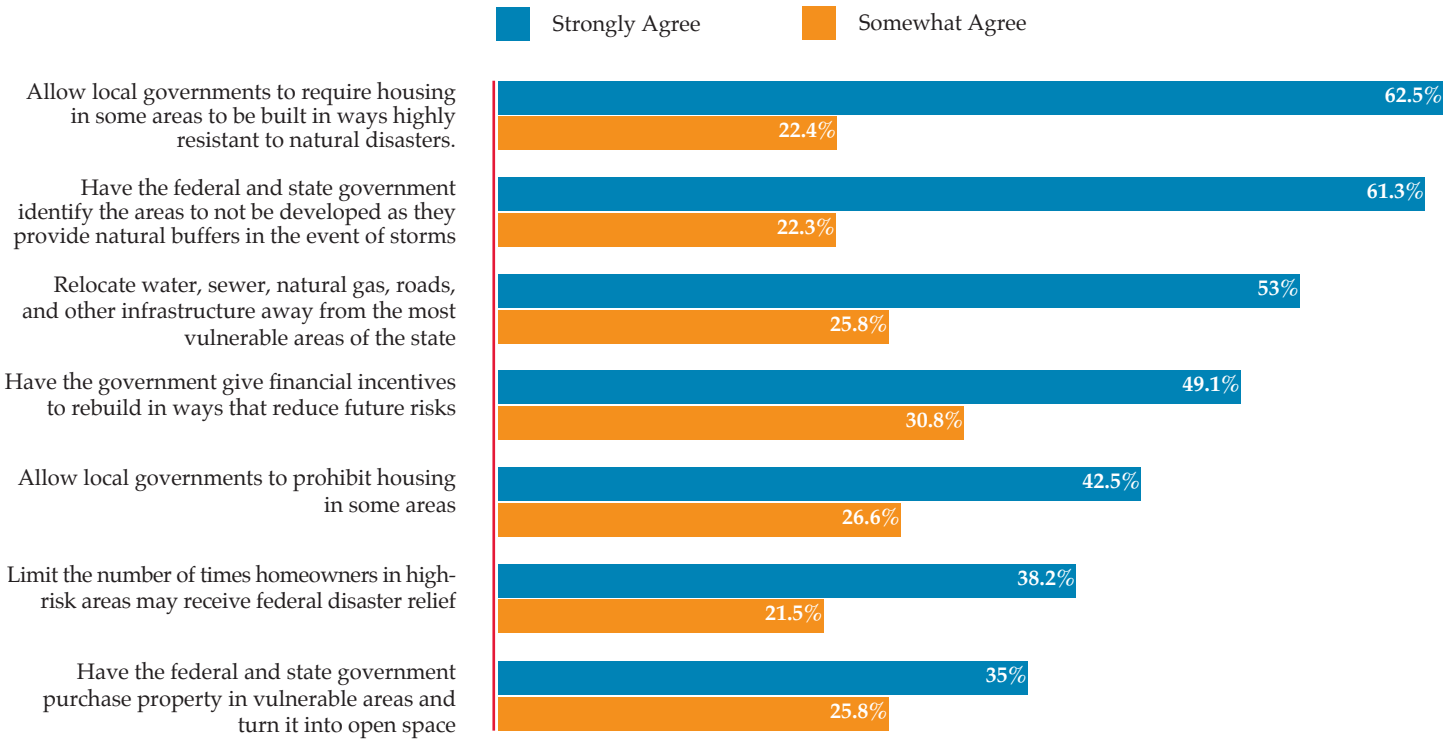
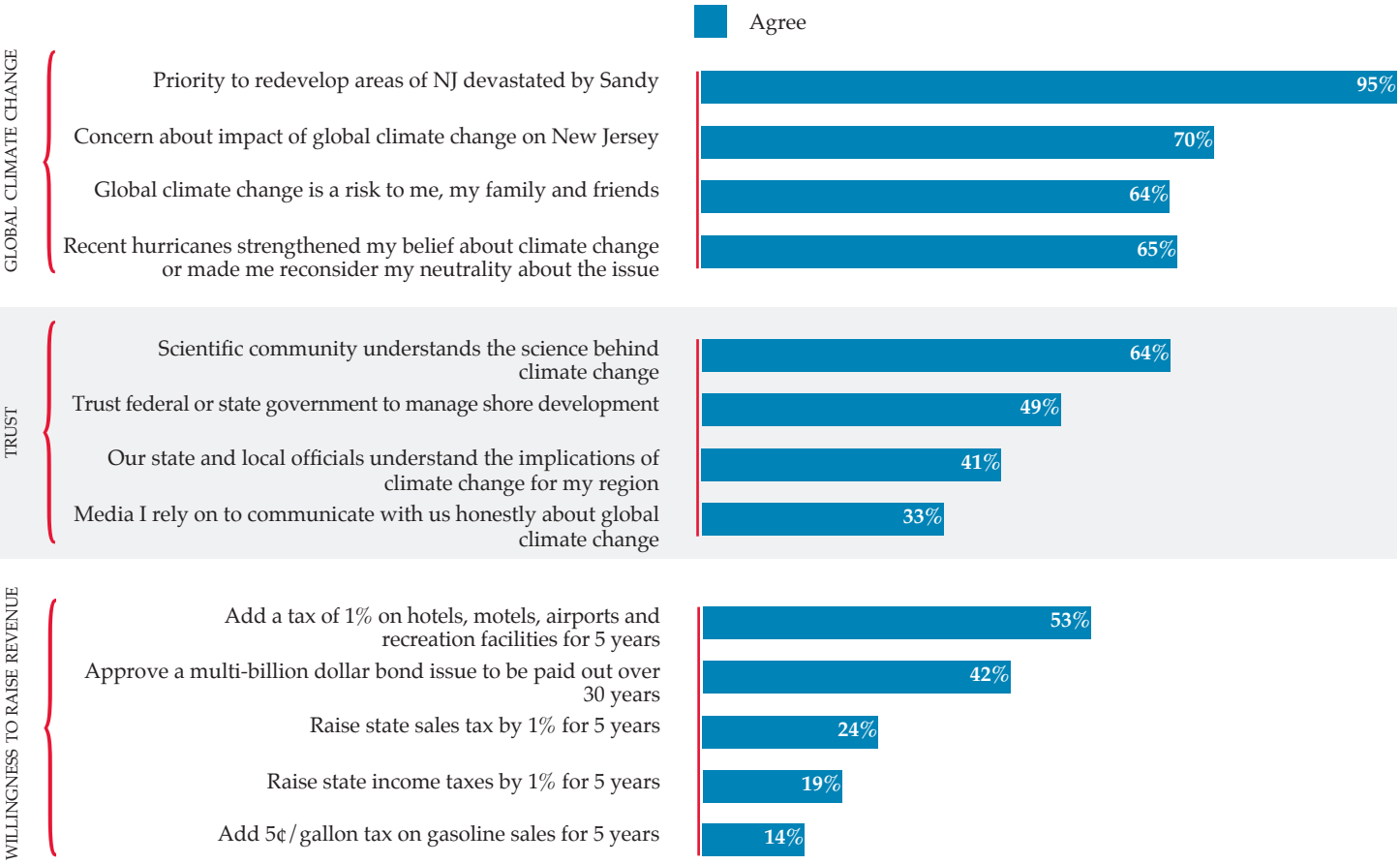


Figure 5: Concerns about climate change, trust of authorities, and willingness to raise revenue



95%
of the public agree that redeveloping areas devastated by Sandy is a priority.

41%
trust that state and local officials understand the implications of climate change.

24%
are willing to raise state sales tax by 1% for 5 years to raise revenues for repairs.

New Jersey's vulnerability to hurricanes was also low among respondents. Although 95% of respondents agreed that redeveloping areas devastated by Sandy is a priority, less than a quarter were willing to raise income, sales, or gasoline taxes. There was greater support for raising revenue by shifting the costs to future generations or visitors: 42% of respondents approved of a 30-year bond issue; 53% approved of an extra tax on lodging, airports, and recreational facilities.

Scientists were held in fairly high regard; the media were not. Sixty-four percent (64%) of respondents agreed that the scientific community understands climate change science. Only 33% of respondents agreed that the media communicate honestly about climate change.

Conclusion

The survey results point to a critical cross-current in the public's attitude about climate change adaptation. While there is support to accept more stringent land-use regulations to enhance resilience, there is less willingness to pay for these policies and only moderate confidence in government to implement them.

STAKEHOLDER SURVEYS

The Alliance also surveyed members of several stakeholder and practice-specific groups. As of this writing, a total of 607 informal online surveys have been completed by stakeholders representing nine sectors (Table 1). The surveys were distributed primarily via e-mail links to membership or mailing lists by sector liaisons on behalf of the Alliance. While most of the survey questions were about perceptions of the importance of climate change-related impacts and adaptation policies specific to each stakeholder group, each of the questionnaires contained an identical set of eight questions about the respondent's personal perceptions and beliefs about climate change. These questions were identical to those asked in the survey of the general public.

All of the stakeholder groups had higher levels of agreement that climate change is occurring than the public sample (70%), with planners, land conservationists, and natural resource managers highest at 89% or above (Table 2). Almost all of the stakeholder groups also agreed in higher proportions that climate change is human caused, with only public health officers (50%) and emergency managers (60%) agreeing in lower numbers than the general public sample (64%). Land conservationists and natural resource managers, joined by planners and the social service sector, had the highest levels of agreement about human causes.

On the question of whether global climate change is a risk to New Jersey, the sector respondents all agreed in higher proportions than the general public (70%), with rates of agreement ranging from 82% to 100%. Likewise, all stakeholder groups agreed at a higher rate than the general public (64%) that climate change is a risk to self, family, and

Table 1: Stakeholder-specific surveys.

STAKEHOLDER GROUP	ADMINISTERED VIA	NUMBER OF RESPONDENTS
Agriculture	NJ Farm Bureau, NJ Dept of Agriculture, Northeast Organic Farming Association NJ chapter, Rutgers NJ Agricultural Experiment Station, USDA NRCS	55
Coastal Communities	Constant Contacts list of the Jacques Cousteau National Estuarine Research Reserve including municipal officials, engineers, and consultants	119
Emergency Managers	NJ Emergency Management Association	51
Land Conservation	Attendees of NJ Land Conservation Rally	35
Municipalities	NJ League of Municipalities in partnership with Sustainable Jersey	In progress
Natural Resources	State, federal, regional commissions or agencies; nonprofit environmental groups	28
Planners	American Planning Association NJ chapter	138
Public Health Officers	NJ Association of City and County Health Officials	22
Social Services	Rutgers School of Social Work contact list containing 800 social service agencies, hospitals, state programs, schools, and government agencies	74
Water Resources	American Water Works Association NJ chapter; Association of Environmental Authorities; NJ Water Environment Association	85

Tropical Storm Irene caused flooding in locations throughout New Jersey, including Lawrenceville (far left, Master Sgt. Mark Olsen, U.S. Air Force) and Wallkill River National Wildlife Refuge in Sussex County (near left, Meagan Racey, USFWS).

friends; agreement among stakeholders ranged from 67% to 92%. The agricultural community agreed with both of these statements at the lowest percentage, and natural resource managers agreed at the highest percentage within the stakeholder groups.

Many stakeholder group respondents had similar levels of agreement regarding the scientific community's understanding of climate change science. However, land conservationists, planners, and natural resources stakeholders had notably higher levels of agreement than the public that scientists understand climate change issues. The same three stakeholder groups also had greater than 76% agreement that scientists communicate honestly about the climate change issue, more than 20% higher than the general public.

All nine stakeholder groups had lower levels of agreement than the general public that state and local officials understand the implications of climate change, but there was relatively high variation in the level of agreement, with the agriculture (7%) and natural resource (4%) respondents having much lower rates of agreement than emergency managers (38%). This variation might indicate a gap in state and local officials' comprehension of longer-term climate change impacts in certain sectors as opposed to the tangible and acute impacts from extreme events.

Regarding whether respondents trust the media to honestly communicate about climate change, most of the stakeholder group respondents were in the same general range as the public (33%), with agriculture having the lowest level of agreement (22%) and land conservationists (46%) having the highest level of agreement.

Table 2: Attitudes regarding climate change.

	STAKEHOLDER GROUP (NUMBER OF RESPONDENTS)									
STATEMENTS	Public (1,750)	Agriculture (55)	Coastal (119)	Emergency Managers (51)	Land Conservation (25)	Natural Resources (28)	Planners (138)	Public Health (22)	Social Services (74)	Water Resources (85)
A. Global climate change is not occurring (percent disagreeing with this statement).	70%	78%	84%	73%	89%	96%	89%	68%	83%	75%
B. Global climate change is mostly caused by human activity.	64%	64%	67%	60%	89%	78%	79%	50%	81%	52%
C. Global climate change is a risk to New Jersey.	70%	82%	96%	91%	94%	100%	95%	91%	94%	87%
D. Global climate change is a risk to me, my family, and my friends.	64%	67%	83%	82%	91%	92%	86%	77%	90%	69%
E. The international scientific community understands the science of global climate change.	64%	55%	64%	58%	80%	78%	77%	64%	64%	50%
F. I trust the scientific community to truthfully report their findings related to climate change.	54%	56%	68%	64%	86%	85%	76%	68%	66%	56%
G. Our state and local officials understand the implications of global climate change for my region.	41%	7%	15%	38%	11%	4%	23%	10%	23%	11%
H. The media I rely on communicate honestly with us about global climate change.	33%	22%	31%	29%	46%	44%	42%	29%	33%	27%

Vulnerable Populations

Stakeholder experiences and an analysis of social vulnerability help identify areas where climate change is likely to cause the most distress.

In the aftermath of Hurricane Sandy, the New Jersey National Guard provided assistance to displaced residents at emergency shelters throughout the state such as this one in Jersey City (Staff Sgt. Armando Vasquez, U.S. Air Force).

Minority and environmental justice communities, the poor, undocumented immigrants, the elderly, and people with physical and mental disabilities may be disproportionately vulnerable to climate change and environmental hazards. The experiences and concerns of representatives and leaders of vulnerable populations in New Jersey were solicited throughout the stakeholder engagement process to inform the Alliance's policy deliberations.

Stakeholder experience with vulnerable populations

Stakeholder engagement included listening sessions with social service providers and an online survey of the social services community that had 71 respondents. In addition, 75 representatives of environmental justice organizations and communities attended the New Jersey Sandy Climate Justice Roundtable, a workshop with breakout sessions held in October 2013. Though the Roundtable focused on Sandy, the discussion encompassed climate change broadly.

Lack of communication during and after Hurricane Sandy emerged as a common theme from stakeholder engagement activities centered on vulnerable populations. Residents and local organizations did not know where to go to evacuate, where to find information, or how to get assistance with immediate needs such as food, water, and fuel, and with long-term rebuilding needs such as FEMA grants. Stakeholders emphasized the importance of community involvement in emergency response planning; training residents how to prepare for and respond to extreme weather events in advance of disasters; ensuring that individuals and organizations are in a constant state of readiness; and improving coordination between government agencies and local community organizations.

Other impacts from storm events included isolation of elderly people on high floors; crime during power outages; the inability of people to go to work or get basic supplies due to their dependency on shut-down public transportation systems; a lack of FEMA workers who speak Spanish; difficulty tracking dislocated populations; and lack of planning in shelters, which led to safety issues and difficulty getting individuals necessary medicines.

Social services survey respondents are extremely concerned about the long-term health impacts of prolonged mold exposure, toxic contaminants from flooding, and consumption of unsafe water. Social services representatives highlighted the lack of focus on mental health issues and the acute need for surveillance of mental health conditions. Other climate impacts of concern among vulnerable populations include poor air quality, rising food prices and a lack of secure food supplies, and the vulnerability of the electrical grid. Many respondents suggested microgrids, renewable energy sources, local food sources, and greening of communities via tree planting as initiatives that would make their communities more climate resilient and reduce existing pollution. High heat days are also a concern as many low-income residents cannot afford to run air conditioners.

Survey respondents noted that climate change exacerbates challenges for an already overburdened, underserved population for whom climate change is not a priority considering their other pressing needs, but many emphasized the importance of educating vulnerable populations about the health impacts of climate change (e.g., poorer air quality, increased asthma, heat stress) and preventive practices. Educating youth so that they can educate their parents was viewed as a key strategy. Finally, stakeholders emphasized the need to form a coalition of supporters with shared interests, including environmental groups, mental health and medical practitioners, social service providers, educators, the agricultural sector, the private sector, unions, the environmental justice community, faith-based organizations, and community and nonprofit groups to promote mutually beneficial policies.

Social vulnerability

Recent literature suggests that characteristics of groups of people with heightened social vulnerability can include a lack of access to resources and information, social isolation,

and mental or physical dependence. Specific attributes influencing vulnerability include low socioeconomic status, racial and ethnic categories, linguistic isolation, low educational attainment, gender, age, compromised health, cognitive constraints, housing tenure, occupation, and family structure (Newcomb College Center for Research on Women, 2008; Balbus & Malina, 2009; Gamble et al., 2013; The Heinz Center, 2000; Cutter et al., 2003).

A study to identify the characteristics and geographic concentrations of populations that are particularly vulnerable to climate change in New Jersey was conducted in the fall of 2013 (Bickers, 2013). The study identified characteristics of socially vulnerable groups using the Social Vulnerability Index (SoVI) method (Cutter, SoVI 2006–10), modifying the model slightly for this analysis. The significant factors and unique vulnerability variables involved in the social vulnerability analysis have been categorized as 1) family structure, race, and socioeconomic status; 2) linguistic isolation, ethnicity, and population density; 3) age; 4) percentage of the population living in nursing and skilled-nursing facilities; and 5) percentage of mobile homes (Table 3).

Significant factors (see Table 3) indicate that certain unique vulnerability variables correlate with one another when analyzing social vulnerability. For example, family structure (i.e., families with large numbers of dependents and/or single-parent households) has been associated with a limited ability to obtain day care for children and elders, making it difficult to undertake activities needed to recover from an extreme weather event (Morrow, 1999). It is important to note that the statistical analysis performed correlates family structure characteristics with race and socioeconomic status as they relate to social vulnerability. However, this analysis is not designed to consider the interrelationships of those characteristics (for example, whether limited access to a car versus per capita income are more dominant factors in influencing family capability to obtain day care). Local leaders with a better understanding of community composition, likely at a finer level than what can be seen through census tract statistics, can use this analysis to demonstrate need for more local assessments.

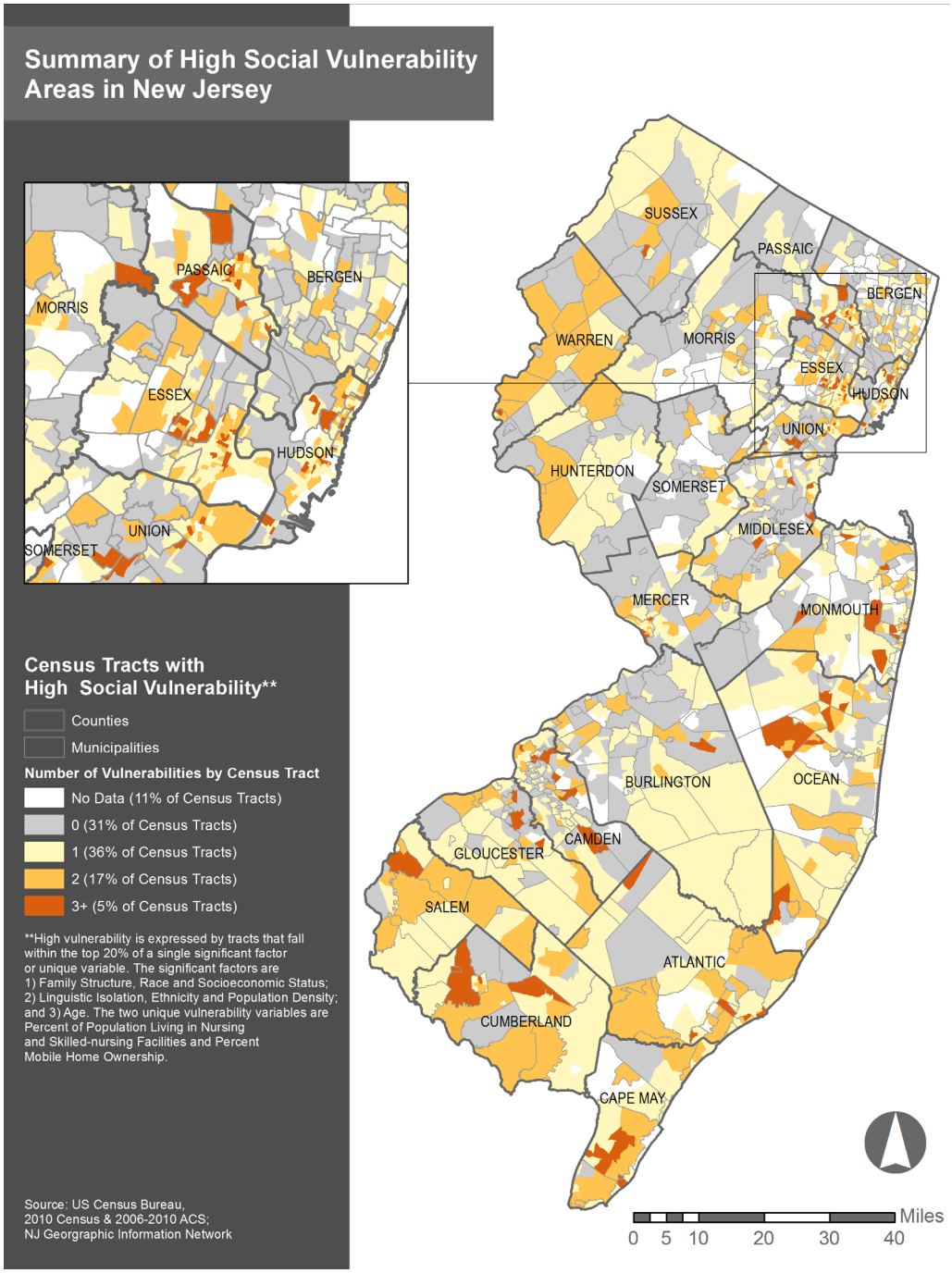


Figure 6: Social vulnerability to climate change impacts (map by Kelly M. Bickers).

Twenty-two percent (22%) of New Jersey census tracts exhibit two or more factors and unique vulnerability variables, which researchers classified as areas of high social vulnerability (Figure 6, Table 4). Areas with the greatest concentration of social vulnerability lie within the state's older industrial urban areas, portions of the rural south, and coastal areas (Figure 6, Table 5). Many of the areas researchers identified as highly socially vulnerable correlate with areas that experience frequent damage from storm events.

Table 3: Social vulnerability factors.
The table below summarizes the factors and related variables influencing social vulnerability.

Factors and unique vulnerability variables	Variables	
1. Family structure (single working mothers), race (black), socioeconomic status (low)	• Percent children living in single parent households • Percent female headed households • Percent black • Percent civilian unemployment • Percent poverty • Percent employment in service industry • Percent housing units with no car • Percent population with less than 12th-grade education	• Percent renters • Percent female participation in labor force • Percent Native American • Median gross rent • Median house value • Per capita income • Percent children living in married couple families
2. Linguistic isolation, ethnicity (Hispanic), population density (high)	• Percent speaking English as a second language with limited English proficiency • Percent Hispanic • Population per square mile • Percent renters	• Percent housing units with no car • Percent Native American • Percent poverty • Percent female participation in labor force
3. Age (seniors)	• Percent population under 5 years or 65 and over • Percent households receiving Social Security	• Median age • Percent female population • Population per square mile
4. Nursing home population	• Percent nursing home population	
5. Mobile home ownership	• Percent mobile homes	

Tables 4 and 5 on the facing page describe the nature and spatial distribution of social vulnerability in New Jersey.

Table 4 displays the range of factors and unique vulnerability variables that could be attributed to each tract, from no data to three or more vulnerability factors and unique vulnerability variables. Table 4 summarizes the number of tracts in the state that fall within each category. For example, starting in the first column, we can see zero vulnerability factors are expressed in 625 (31%) census tracts within the state. The last column in Table 4 provides the cumulative number of census tracts that fall within each category and all categories that precede it.

Table 5 displays the concentration of social vulnerability within the state. Table 5 summarizes the number of census tracts that display two or more factors or unique vulnerability variables by county and provides the percentage that these tracts represent within each county. For example, Essex County has 60 census tracts that display two or more factors or unique vulnerability variables, which represent 29% of all the census tracts within Essex County. Finally, Table 5 provides the total number of census tracts within the state that display two or more factors or unique vulnerability variables (444) and the percentage that these tracts represent within all tracts in the state (22%).

Table 4: Census tracts with high social vulnerability

Number of factors and unique vulnerability variables	No. census tracts	% census tracts	Cumulative no. census tracts
No data*	215	11%	215
0	625	31%	840
1	726	36%	1566
2	340	17%	1906
3+	104	5%	2010

**If a census tract had no data available for one variable, the entire tract was excluded from the analysis.*

Table 5: County summary of high social vulnerability**

Counties	Census tracts with 2 or more vulnerabilities	Total census tracts in county	Percent highly vulnerable census tracts
Atlantic	25	70	36%
Bergen	24	179	13%
Burlington	13	114	11%
Camden	29	127	23%
Cape May	13	33	39%
Cumberland	16	35	46%
Essex	60	210	29%
Gloucester	12	63	19%
Hudson	46	166	28%
Hunterdon	3	26	12%
Mercer	19	77	25%
Middlesex	20	175	11%
Monmouth	23	144	16%
Morris	14	100	14%
Ocean	32	126	25%
Passaic	30	100	30%
Salem	12	25	48%
Somerset	7	68	10%
Sussex	4	41	10%
Union	32	108	30%
Warren	10	23	43%
Total Census Tracts in NJ	444	2010	22%

***High vulnerability is expressed by tracts that fall within the top 20% of a single significant factor or unique vulnerability variable. The significant factors and unique vulnerability variables are 1) family structure, race, and socioeconomic status; 2) linguistic isolation, ethnicity, and population density; 3) age; 4) percentage of population living in nursing and skilled-nursing facilities; and 5) percentage of mobile home ownership.*

The New Jersey coast took the brunt of Hurricane Sandy's destructive force. Clockwise from top: a FEMA Community Relations team member talks with an evacuee at a Red Cross shelter at Pleasantville High School (Liz Roll, FEMA); portions of Tuckerton on Little Egg Harbor were completely inundated (U.S. Coast Guard); damage in some shore neighborhoods was nearly total, as in this now iconic image from Union Beach on Raritan Bay (Blackwater Images, iStock).

Cross-cutting Gaps

The members of our stakeholder groups identified critical needs that cut across multiple sectors and pertain to a wide variety of fields, ranging from science and education to political leadership, planning, and funding.

Stakeholder surveys, interviews, and focus groups reveal a need for New Jersey to devise coordinated and longer-term strategies to prepare for impacts of a changing climate. Stakeholders recognize that New Jersey's exposure to coastal storms, aging infrastructure, dense population, and historic land-use patterns make the state highly vulnerable to a wide range of climate impacts.

Cross-cutting gaps identified by stakeholders in multiple sectors are provided below. Later sections of this report outline individual sector-based policy needs and gaps expressed by stakeholders.

Consistent application of data and methods

Stakeholders across all sectors indicated a need for climate science and risk assessment methods that can be applied consistently to support adaptation planning, monitoring, and preparedness decision making. Risk management is the practice of characterizing, assessing, and prioritizing risks so that appropriate resources can be identified to minimize, monitor, and control risks. The Alliance's stakeholder process established a need for science that can consistently be applied by practitioners to identify risks from a changing climate in order to determine how to address those risks. Recommendations included the need for readily accessible data about climate trends, projections, frequency, and impacts as well as strategies to reduce, mitigate, and/or monitor risks. Stakeholders identified these data as the foundation for improved communication about a changing climate as well as the basis for decision making to justify planning and investment in climate adaptation.

Authoritative state guidance to support planning and decision processes

Multiple stakeholder sectors identified extraordinary value that would result from direct and authoritative state government guidance on climate change adaptation and preparedness. A state endorsement of scientifically informed and supported climate change parameters, such as adopting a standard for addressing sea level rise, will foster equivalent practices at all levels of government and encourage consistent application in public and private sectors. Stakeholders identified that authoritative state guidance on climate change parameters needs to be complemented by action that incorporates those parameters into state decision making. Stakeholders articulated a need to incorporate such key parameters (e.g., projected sea level rise) into local, regional, and statewide planning (e.g., State Development and Redevelopment Plan, statewide hazard mitigation planning, state Wildlife Action Plan, long-range state Transportation Plan, etc.) as well as into state-level investment and funding decisions (e.g., infrastructure investment).

Coordinated government planning and preparedness actions

Stakeholders requested more coordination among different levels of government and between agencies. Planning, funding, and implementing climate change adaptation will be more efficient if all levels of government are aligned and can best be initiated and facilitated by statewide direction and guidance. Reducing redundancy and inconsistency is cost-effective, as is integrating short-term projects with long-

"A state endorsement of scientifically informed and supported climate change parameters … will foster equivalent practices at all levels of government and encourage consistent application in public and private sectors.

Hurricane Sandy left behind a path of destruction along parts of the Jersey Shore; many houses were knocked off their foundations (Sgt. 1st Class Jim Greenhill, Army National Guard).

Above: A U.S. Customs officer oversees a shipment of portable generators in preparation for Tropical Storm Irene (Donna Burton, USCBP).

Right: A note of gratitude on Long Beach Island in the aftermath of Hurricane Sandy (Tech. Sgt. Matt Hecht, NJ Air National Guard).

term strategies. Coordinating the efforts of local governments across municipal boundaries can provide for holistic planning. Stakeholders identified efforts that could help to incorporate climate change considerations into planning at the local level, including public education programs, voluntary municipal actions, and development of local zoning and ordinances. Yet, stakeholders also indicated that activities to advance climate change adaptation and preparedness at the local level would certainly benefit from state guidance and interagency coordination to advance application of leading practices. In that regard, both governmental and nongovernmental stakeholders would like to increase involvement and capacity for stakeholders to participate in the development of guidance.

Improved planning and preparedness for vulnerable populations

Stakeholders pointed out that certain subsets of the state's population may be especially vulnerable to climate change impacts. These increased vulnerabilities are driven by a variety of factors discussed elsewhere in this report, including socioeconomic, demographic, and geographic factors as well as public health issues that reduce mobility, increase risk from heat stress, or otherwise create a lack of physical capability to adapt to a changing climate. In addition, an analysis of social vulnerability in New Jersey indicates that many of the areas identified as highly socially vulnerable lie within the state's older industrial urban areas, portions of the rural south, and coastal areas (Figure 6, Table 5). Recognizing inherent vulnerabilities now will allow for identification of specific strategies to ensure that climate change adaptation and preparedness activities are inclusive and focused on populations that are most in need of particular assistance. In many cases, strategies to mitigate vulnerabilities may best be developed in partnership with organizations that already work with targeted populations, including community development corporations, faith-based organizations, nonprofit community-based groups, health and mental health providers, and other service providers.

Ensuring sustainable and accessible funding

Stakeholders identified funding gaps ranging from small community initiatives to large-scale infrastructure projects. In general, stakeholders felt investment in preparedness and adaptation now would help deter larger costs later. They noted that investment priorities are a topic of intense debate and that short-term, event-specific investments typically take precedence over long-term adaptation needs. This observation was coupled with the sentiment that while event-specific grant money was helpful, a more sustainable and regular source of funding is needed for maintaining preparedness. They indicated a need for coordinated state action to identify such funding sources.

Furthermore, they noted that there is not widespread awareness of existing sustainable and/or innovative funding mechanisms. Better promotion of those mechanisms is needed to ensure their application. Although infrastructure banks, insurance products designed to transfer risk to private markets, and other public-private finance tools are available as alternatives for investment, stakeholders felt uncertain about how to best apply these financial alternatives and where to begin pursuing these strategies.

In a more immediate sense, stakeholders pointed to the lack of capacity, particularly at the local level (e.g., staffing levels and/or expertise), to apply for available funding, particularly grant funding. As a result, some stakeholders cited missed opportunities to apply for available programs from governmental and nongovernmental institutions after disasters.

Target education efforts

Stakeholders identified two distinct educational needs: 1) a shortage of sector-based professionals with the technical or scientific skills necessary to do the work of climate change adaptation, and 2) education of the general public about climate change impacts. Sector stakeholders also expressed a need for direction on actions that can and should be taken by practitioners in individual sectors; this is an initiative already under way within the Alliance through the development of a series of guides on what local entities (e.g., watershed managers, public health officers, local planners, etc.) can do to prepare for a changing climate. Outreach should range from schoolchildren to executive decision makers and should communicate projected climate trends, anticipated impacts, and short- and long-term actions that are needed at various levels (e.g., government, residents, business, community, etc.) to prepare for a changing climate.

New models for partnerships

Stakeholders felt that some gaps in coordination, collaboration, and planning could be addressed through nontraditional partnerships. They support the concept behind the Alliance and affirm the need to build partnerships among government, the business community, academic institutions, and NGOs. Such partnerships can explore innovative funding strategies and advocate for planning and regulatory initiatives. They also expressed openness to partnerships for innovative funding strategies and for enacting regulatory and planning actions that reduce risk by keeping people out of harm's way and that provide investors with certainty as to reduced risks. Examples of partnerships identified by stakeholders include involving local businesses, faith-based and community organizations along with government in development of community-level plans akin to civil defense plans of decades ago. Stakeholders also saw opportunities to form public-private partnerships with the insurance industry as well as providers at all levels of the supply chain to address and anticipate climate-related disruptions.

Stakeholders were eager to explore opportunities that apply market forces to create incentives for climate adaptation. Additionally, there was an interest among some stakeholders to document potential economic benefits of efforts to adapt to a changing climate. For example, an estimated 1.45 to 3.16 multiplier effect from investment in stormwater management best practices has been reported in three urban communities in Maryland and Virginia, along with a 3.9 to 4.8 cents per dollar multiplier on state and local fiscal impacts (Nees & Bunch, 2013).

FUNDING OPTIONS

Governments in the U.S. and abroad are using a variety of innovative ways to finance climate change preparedness:

Public-private partnerships (P3s) are intended to deliver goods or services traditionally provided by the public sector by expanding the pool of financing available to governments and transferring some financial risk from the public sector to private sector participants. Well- structured P3s can speed up project delivery and create cost and operational efficiencies, but are challenged by public and political opposition to losing control over public facilities and rates and a lack of experience that can cause contracting and legal issues (GAO, 2013). One example of a P3 is the West Coast Infrastructure Exchange (WCX), a regional infrastructure partnership formed by the States of California, Oregon and Washington and Province of British Columbia, Canada, in 2012 to reduce the costs of infrastructure investment throughout the region by pooling resources and bundling similar projects. **Infrastructure banks** can combine public and private funding and reside within an existing government agency or as a separate public corporation. Innovative examples include Chicago's Infrastructure Trust, Connecticut's "Green Bank" through its Clean Energy Finance and Investment Authority, and New York's state infrastructure bank through the NY Works program.

Risk transfer to capital markets through catastrophe bonds or related mechanisms can reduce the financial burden of natural disasters to the public by financing excessive risks and recovery efforts prior to their occurrence. These solutions are purported to speed up the delivery of resources and serve as an alternative to establishing a catastrophe reserve fund within the public budget. Risk pooling by governments facing common catastrophe risks can reduce the costs of disaster insurance to individual governments. Innovative examples include Mexico's MultiCat bonds, the New York MTA's storm surge bonds, and the Caribbean Catastrophe Risk Insurance Facility risk pooling solution.

Other **innovative revenue sources** include carbon taxes and markets. Revenues from these instruments support energy efficiency, renewable energy, transit projects, and air pollution reduction at national and regional levels around the world.

Clockwise from top left: Sunflower field, Duke Farms, Hillsborough (Anthony Quintano, Creative Commons); Pulaski Skyway, Kearny (Kai Schreiber, Creative Commons); eastern goldfinch (Nutley Signs, Bigstock); Tillman Ravine Natural Area, Stokes State Forest, Sussex County (Nicholas A. Tonelli, Creative Commons); the National Guard provides emergency services to flood victims in Hoboken (Spc. Joseph Davis, U.S. Army); Barnegat Lighthouse, Long Beach Island (Bigstock).

Sectors Introduction

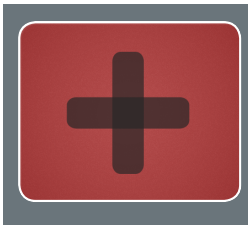
The Alliance focused on six sectors. Each sector consists of public and private entities that make up a stakeholder group. Stakeholders can be part of more than one sector. For example, emergency planning professionals are involved in all sectors, as are government officials. The scope of each sector is described below.

Agriculture
The agricultural community in New Jersey includes farmers, service providers, regulators, and other organizations responsible for growing crops, livestock, and nursery plantings. In addition, the agricultural community considered here includes those entities involved in aquaculture (e.g., shellfish growing and harvesting) and commercial fishing. Other agencies supporting agriculture in the state include those responsible for the optimal use and preservation of farmland.

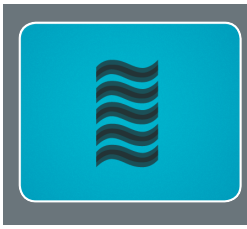
Built Infrastructure
Built infrastructure includes the physical structures and organizations that govern and provide transportation, energy, and telecommunications. Transportation infrastructure includes the roads, rails, waterways, bridges, and tunnels over which people and goods travel and the federal, state, local, and private entities responsible for developing and maintaining the infrastructure. Utility infrastructure encompasses physical generation and distribution of electricity and natural gas, in addition to telecommunications infrastructure.

Coastal Communities
The NJ Department of Environmental Protection (NJDEP) defines "coastal" for purposes of the public trust doctrine as any land adjacent to a tidally influenced waterway. This includes communities along the Atlantic Ocean, Raritan Bay, and Delaware Bay, as well as those along the tidal portion of the Hudson River and inland of the Atlantic coast barrier islands. This analysis seeks to understand impacts on coastal residents and organizations responsible for governance, such as municipal government, regional planning entities, and other professionals.

Natural Resources
The natural resources sector encompasses government agencies, quasi-governmental organizations, nongovernmental organizations, and resource users invested in the state's ecosystems, flora, and fauna. These resources include forests, wildlife, estuaries, and other natural features managed by a variety of state and federal agencies, quasi-governmental commissions, and private organizations, such as the NJDEP, U.S. Fish and Wildlife Service (USFWS), Highlands Council, Nature Conservancy, and others.



Public Health
The public health sector in New Jersey is inclusive of facilities, organizations, and stakeholders that are concerned with environmental, physical, mental, and acute and chronic impacts on health stemming from a changing climate. Stakeholders include hospitals, nursing homes, and community health centers in addition to the public and private organizations that encompass primary care physicians, emergency medical technicians, social workers, and administrative agencies.



Water Resources
The water resources sector includes organizations and infrastructure responsible for the provision and management of freshwater, wastewater, and storm water. This specifically includes infrastructure and organizations related to the availability and delivery of water for consumption and the management of waste and runoff. Stakeholders in this sector include the New Jersey Clean Water Council, water utilities, the Delaware River Basin Commission, and others.

Sector Profile

- 730,000 acres of productive farmland.
- Producer of more than 100 kinds of fruits and vegetables.
- 10,300 farms with cash receipts of $1.1 billion in 2012.
- Nursery, greenhouse, and sod industries led all commodities with cash receipts of $453.6 million in 2012.
- $211.7 million in cash receipts for fish and seafood.
- One of the top 10 national producers of blueberries, cranberries, peaches, tomatoes, bell peppers, cucumbers, snap beans, spinach, and squash.

(Source: NJDA, 2013)

Agriculture

STATE VULNERABILITY

Climate change is expected to have complex impacts on New Jersey agriculture because of the varied nature of the industry, which encompasses crops and livestock as well as aquaculture and fisheries. For example, fluctuations in precipitation such as excessive early-season rain can lead to development of shallow root systems. This puts crops at risk of disease and pest pressure if uneven rainfall later in the growing season results in the need for increased fertilizer, pesticides, and irrigation. While some aspects of climate change such as extreme weather events and drought will be negative, warming temperatures and increased levels of carbon dioxide may have some positive or neutral effects (Table 6). Taking advantage of opportunities and mitigating risk will be essential for the industry's long-term viability.

Rising temperatures

While an extended frost-free period may benefit crops such as peaches, melons, and peppers that require a long growing season, warmer temperatures and potential for greater drought frequency will increase irrigation and operational costs. Economically important crops such as blueberries and cranberries may be adversely affected by rising temperatures throughout the Northeast (USCGRP, 2009). Research is under way to mitigate the risks of rising temperatures, including the development of heat-tolerant cranberry cultivars and, more generally, a better understanding of how plants respond to heat stress in order to guide crop management decisions (Xu et. al, 2012).

Stakeholders identified access to water of great concern to the farm community, particularly from increasing temperatures and during times of drought which impact both water supply and quality. Stakeholders also identified the warming of tidal waters and oceans and increases in salinity as having detrimental impacts on fisheries and shellfisheries populations; such will impact life cycles of various fish and shellfish species, including those in coastal estuaries, by impacting zooplankton populations (their food sources) as well as impacting pelagic species distributions. Commercial fishermen and researchers have already observed shifting distributions of fish and invertebrates as ocean temperatures change (Pinsky et al., 2013). These shifts require fishermen to travel farther, which has financial and safety implications and can create management challenges as they cross jurisdictional boundaries.

Scientists and stakeholders expect that higher summer temperatures and heat stress will depress yields of crops adapted to cooler conditions (e.g., spinach, lettuce). They also expect rising winter temperatures to drive the continued northward expansion of agricultural pests and weeds such as kudzu. This could impede crop production and potentially compel farmers to increase herbicide and pesticide use. Farmers of high value fruit and vegetable crops are ineligible for a price safety net that exists for commodity crops, and, therefore, these farmers face increased costs from insurance or installing expensive irrigation systems that would be needed for addressing impacts such as droughts.

Warmer temperatures may also have a negative impact on the dairy industry. Researchers predict that higher temperatures in certain months may cause milk production to decline 5% to 20% across much of the region. A 10% decrease in milk production represents an estimated $3.3 million loss in New Jersey (CIER, 2008).

Opposite: A farm in Franklin Township, Warren County (Nicholas A. Tonelli, Creative Commons).

Far left: Fresh produce at the Hunterdon Land Trust Farmers' Market at the Historic Dvoor Farm in Flemington (John Gattuso).

Near left: New Jersey is one of the nation's biggest cranberry producers (Bigstock).

Extreme weather events and flooding

Water quality from flooding, both inland and in coastal areas, was identified by stakeholders as a vital concern to farmers. Extreme weather events such as hurricanes and other strong storms will have significant impacts on terrestrial and marine habitats as well. During Hurricane Sandy, crops were flooded or blown down, and, in some cases, planting and harvesting schedules had to be altered. For many weeks after the storm, shellfish harvesting was prohibited throughout New Jersey due to elevated bacterial and viral levels in coastal waterways (NJDEP, 2012b).

Sea level rise

Sea level rise may also damage bivalve habitat as salt water reaches farther up estuaries and alters salinity levels – a problem compounded by the reduced flow of freshwater streams. Even more troubling is the intrusion of salt water into coastal aquifers, which may diminish the availability of freshwater at the same time that rising temperatures are generating a greater demand for irrigation and human consumption (Frumhoff, 2007). Stakeholders identified saltwater contamination of freshwater and saltwater inundation from storm surges as a growing concern to agricultural interests in coastal areas of New Jersey; this would include salinity that can dehydrate crops and increasing storm surges that contaminate on-farm water supplies. A particular concern is that with rising temperatures will come the need for more irrigation, yet farmers in coastal areas do not have the ability to conduct analyses necessary to determine if their withdrawals will or will not have an impact on saltwater intrusion.

Increasing atmospheric carbon dioxide concentrations

The effects of elevated carbon dioxide on plant growth vary depending on species and overall conditions. In some cases, crop yields may increase. In others, weeds will benefit more than crops and have greater resistance to herbicides.

The absorption of atmospheric carbon dioxide in seawater lowers the ocean's pH. Known as ocean acidification, the process damages oyster and mussel populations as well as the phytoplankton and zooplankton at the base of the marine food web, which, in turn, may have consequences for the fishery as a whole (Hoegh-Guldberg and Bruno, 2010). Shellfish managers during the stakeholder process expressed concern about the impact of ocean acidification on oyster and surf clam populations.

ADAPTATION AND PREPAREDNESS GAPS

The agricultural stakeholders we surveyed were concerned primarily with flooding, erosion, and crop and livestock adaptability. Scientific research and risk assessment were the preferred methods of managing climate change impacts. Their suggestions for mitigating impacts included ideas such as replacing current crop varieties with those better suited for warmer temperatures; managing pests and invasive species; and addressing potential productivity reductions across agricultural sectors.

Stakeholders emphasized a need for enhanced vector and disease surveillance and other

Table 6: State vulnerability, agriculture.

Climate Impacts	New Jersey Risks
Rising temperatures	• Unsuitable conditions for some current crops such as blueberries and cranberries • Higher operational costs due to irrigation and pest management • Decreased milk production • Shift in distribution of commercial fish stocks
Extreme weather events and sea level rise	• Farmland and habitat destruction • Decrease in crop quality
Increasing atmospheric carbon dioxide concentrations	• Damages to shellfish and estuarine environments from ocean acidification
Potential drought	• Decline in water availability requiring alterations to irrigation practices

monitoring programs critical to the agricultural industry. In their view, such monitoring programs will yield a better understanding of climate change and strengthen their response to negative trends.

Stakeholders also noted that the ability to adapt to climate change may be limited by the nature of the agricultural industry. Because farming is a seasonal business, farmers are unaccustomed to planning ahead 10 or 20 years and may have some difficulty relating long-term impacts to near-term business decisions. Moreover, as small-business owners, farmers may not have the financial ability to experiment with new technologies or make necessary capital investments.

Similarly, stakeholders reported having trouble discerning the relevance of scientific research findings to their own agricultural practices. They encouraged scientists to partner more closely with the agricultural community in order to enhance the practical applications of their research.

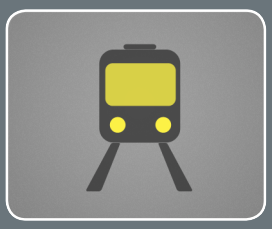
Table 7 presents a list of gaps identified in our stakeholder interviews as of October 31, 2013.

Table 7: Gap analysis for agriculture sector

Sector Gap Categories	Sector-specific Gaps	
Research, needs assessment, and data development	• Scientific evaluation of strategies for agriculture to reduce carbon emissions • Improved certainty on impacts to agriculture from climate change • Data from research sector/universities regarding climate resilient crops (field, nursery ornamentals, turf, etc.) that can be disseminated to farmers; such could include crops that can tolerate saline-intruded water • Needs assessment and leading practices for agricultural workers in terms of health and safety from increased temperatures and other climate change impacts • Property and resource vulnerability assessments • Research on alternative methods for cover crop establishment to seed the crop while primary crop still standing • Assessment of appropriate forest successional species	• Research and development of adaptive plant/agricultural species and varieties, including those adapted to reduced water quality from salinity • Research on the vulnerability of and impacts on recreationally and commercially important saltwater fisheries • Research on genetic development of shellfish adaptable to climate change over time • Research on innovative and cost-effective strategies for improved water systems management and design • Commissioning statewide study and assessment of vulnerability of economically important agriculture species • Development of low-cost weed/vector control approaches
Enhanced implementation of existing data, tools, and methods	• Drilling of new wells and/or seeking alternative water sources • Protecting connective corridors • Surveillance for diseases • Employing green infrastructure such as riparian buffers, living shorelines, wetland restoration • Designing and adopting livestock protection structures with low-tech evaporative cooling techniques • Vector and disease surveillance improvements	• Renewed emphasis on farm pond technical engineering and design from NRCS to address drought as well as protection of soil and water quality and community property from damage • Review and update of engineering design standards for conservation practices such as erosion control of grassed waterways now being impacted by increased storm intensity • Agricultural pest and invasive species management • Enhanced Best Management Practices to reduce stormwater runoff

Table 7: Gap analysis for agriculture sector (continued)

Sector Gap Categories	Sector-specific Gaps	
Regulation, policy, and governance support	• Water Supply Master Plan that incorporates climate change considerations for New Jersey agriculture • Enhanced water supply planning and conservation programs • Flexibility in federal and state fishery management plans to ensure they are adaptive and take shifting populations into account (e.g., allow for landing of harvest in different states) • Protecting farmland in low-lying areas (i.e., improvement to existing dikes)	• Assessment of farmland most suitable to increase climate resiliency and focus farmland easement purchase programs on areas less vulnerable to sea level rise • Easing permit restrictions for conservation practices in flood hazard areas and wetlands where those projects address erosion and water quality impacts from farms if they meet certain federal or state standards through a permit-by-rule • Developing incentives or markets for farmers who provide municipal pretreatment benefits for stormwater filtration or temperature mitigation in streams through soil holding capacity and carbon sequestration activities
Coordination of adaptation planning and preparedness actions (includes across and among public, private, and NGO sectors)	• Addressing loss of roads and infrastructure to access farm fields or getting goods to market from flooding events • Improved coordination on outreach, education and training between regional, federal, and state resource agencies and nongovernmental organizations	• Coordination of grant programs • Establishing public-private partnerships for seed mix guidance in cover crop standards; which seed mixes to plant at specific points in vegetable or specialty crop rotation
Ensuring suitable funding	• Incentive programs to preserve, increase, or improve climate-resilient agricultural land • Resources for research on viable adaptation practices, resilient crop species needed • Concern about property values in coastal areas if they are subject to sea level rise • Resources to develop educational materials/technical bulletins • Return of state cost-share for soil and water projects on preserved farmland	• Increased investment in tunnels and greenhouses to take variable weather out of the risk equation that could use passive energy, extend seasons • Increased investment in low pressure/low volume supplemental irrigation systems to ensure farmers are not missing irrigation needs at critical times during the growing season • Funding/capital to implement practices
Education and outreach efforts	• "How-to" on conducting a vulnerability assessment for farmers • More discernible information on what impacts to agriculture are most significant and what data are most accurate • Peer-to-peer demonstration projects to enhance adoption of practices by farmers, including benefits of conservation practices such as no-till agriculture to improve soil health and innovative ways to plant different families of cover crops earlier in the season	• Education of public, farmers, commercial fishermen/shellfishermen on impacts, management practices; this should be coupled with research on how to adjust to a changing climate and should be communicated via Farm Bureau, Cooperative Extension, technical bulletins, fact sheets • Integration of data from farmers who are innovating and experimenting with different techniques into guidelines and information for New Jersey farmers



Sector Profile

- 38,000 miles of roadway, 6,447 bridges.
- 1,001 miles of passenger rail lines, 742 rail bridges.
- 1,367 NJ Transit locomotives and railcars, 3,602 NJ Transit buses.
- 225 miles of navigable marine channels.
- Largest port on East Coast, processing 80 million metric tons of cargo annually, plus the South Jersey Port Complex on the Delaware River and Bay.
- Three commercial, 46 general aviation airports.
- Four electric distribution companies, four natural gas distribution companies.
- More than six telecommunications companies.

Built Infrastructure

STATE VULNERABILITY

Built infrastructure in New Jersey is varied and extensive. The infrastructure discussed in this section encompasses transportation, energy, and communications, and includes the following assets:

- **Roadways**
  Road-based transportation of people, goods, and materials, including highways, streets, bridges, tunnels, traffic control systems, and intelligent transportation systems as well as buses, bus terminals, and maintenance and storage facilities.

- **Rail**
  Rail-based transportation of people, goods, and materials, including rail tracks, track beds, overhead catenary, signal systems, bridges, tunnels, stations, and maintenance and storage facilities as well as rail cars and locomotives.

- **Maritime**
  Waterborne transport of people, goods, and materials, including navigable coastal and interior waterways, channels, piers, terminals, and ports as well as vessels.

- **Aviation**
  Airborne transportation of people, goods, and materials, including airports, heliports, landing strips, seaplane bases, and air traffic control systems.

- **Utilities**
  Investor-owned utility infrastructure that provides for the supply, transport, and delivery of natural gas and electric service across New Jersey.

- **Telecommunications**
  Infrastructure of cable television companies and telecommunications providers.

Climate change threats to New Jersey's built infrastructure include intense precipitation events and related flooding; wind, wave, and storm surge flooding impacts from more intense coastal storms; permanent inundation of currently upland areas due to rising sea levels; and temperature extremes, especially more frequent high heat days (Table 8).

Vulnerability and potential impacts vary across subsectors and regions of the state but are expected to be widespread and costly in both human and economic terms. Stakeholders recognize that infrastructure damage and related delays and disruptions will significantly affect almost every aspect of the state's economy in all regions.

Flooding, storm surge, sea level rise

Stakeholders perceive the greatest risk to transportation infrastructure to be flooding from more intense precipitation events, storm surge, and sea level rise. Inundation of properties is expected on a more frequent basis. Impacts are likely to include overtopping and washout of roads, bridges and rail lines; damage to drainage systems and low-lying electronic and mechanical equipment; and sand deposition and sedimentation in navigable channels. Electric and natural gas utility stakeholders are also concerned about flooding damage to distribution infrastructure, substations and subsurface transformers. Additionally, transportation stakeholders highlighted their dependency on electric utilities, citing power outages as a likely cause of damage and disruption of transportation operations and services for potentially extended periods.

Climate Impacts	New Jersey Risks	
Flooding, storm surge, and sea level rise	• Inundation of low-lying infrastructure, including substations, delivery lines, roads, bridges, tunnels, rail lines and terminals, land-side port facilities, ferry terminals, airports, and storage and maintenance facilities • Washout and overtopping of roads, bridges, and rail lines • Bridge abutment scour and undermining of road and rail beds • Damage to traffic and transit signaling systems and other Intelligent Transportation System (ITS) infrastructure	• Infrastructure closures resulting in travel delays and disruptions • Sand deposition and sedimentation in navigable channels • Risks to worker and public health and safety during weather events and restoration of service • Delays in service restoration from limited accessibility or interdependent system restoration
Severe wind and wave action from storms	• Travel and speed restrictions on bridges • Damage to bridge piers and abutments • Damage to overhead road signs and traffic signal infrastructure • Damage to overhead wires from falling tree limbs and downed trees	• Power outages due to damaged electrical transmission wires and substations • Changes in wave dynamics resulting from more intense coastal storms potentially affecting port operations and future development potential
Temperature extremes and high heat days	• Rail expansion and overhead wire sag resulting in operation restrictions and lost distribution efficiency • Pavement damage such as softening of asphalt and increased rutting	• Thermal expansion of pavement and bridge expansion joints • Greater demand for air conditioning on vehicles and at facilities • Heat buckling of runways

Table 8: State vulnerability, built infrastructure.

Opposite: U.S. Highway 22, Springfield.

Severe wind and wave action from storms

In addition to the flooding risks associated with extreme weather events, stakeholders identified severe wind and wave action associated with coastal storms as a significant threat. As with flooding, stakeholders recognized that storm-related power outages caused by damaged electrical transmission lines and substations are likely to cause damage and disruption of transportation operations and services. Severe winds can also endanger utility workers during infrastructure restoration.

Temperature extremes and high heat days

Finally, stakeholders perceive temperature extremes, especially an increase in high heat days, to be a significant climate change threat. This is especially true for the owners/operators of rail and road infrastructure. Extended periods of high heat days are anticipated to result in softening of pavement and increased rutting on heavily trafficked roads and highways, rail track damage, catenary wire sag, and excess tire wear on buses and other motor vehicles.

ADAPTATION AND PREPAREDNESS GAPS

Infrastructure assets in New Jersey are extensive and diverse. There are many public jurisdictions, agencies, authorities, and private owner/operators responsible for planning, constructing, operating, and maintaining the infrastructure and the range of available transportation and utility services. This complexity, combined with divergent opinions on potential climate change impacts among political leaders, makes preparedness planning and adaptation in New Jersey a significant challenge.

Stakeholders have become increasingly aware of climate-related risks and have gained

‘MIND THE RISK’

In a recent report entitled “Mind the Risk,” Swiss Re ranked the aggregate risk to the value of working days lost in the New York-Newark metropolitan area seventh out of 616 of the world’s largest urban areas. The risk score was based on five perils to the metropolitan area, including earthquakes, high winds, river flooding, storm surge, and tsunami, which can appear in combination as part of a severe storm. The New York-Newark area is also tenth in the world in the number of people (1.1 million) vulnerable to storm surge (Swiss Re, 2013).

Above: NJ Transit’s Summit Station (Dwight Hiscano).

Below: Newark Liberty International Airport (Bigstock).

a better understanding of infrastructure vulnerabilities. Given the size of the New York metropolitan area economy, a great deal of economic risk is related to the infrastructure that enables residents to work each day (Swiss Re, 2013). Climate adaptation efforts to date in New Jersey’s transportation sector fall primarily into four categories: 1) policy and planning, which includes research and vulnerability assessment; 2) emergency preparedness and operations; 3) infrastructure maintenance and asset management; and 4) hazard mitigation and infrastructure adaptation. Utility efforts fall primarily into improvements related to recent weather events, including Tropical Storm Irene and Hurricane Sandy. These events have prompted transit agencies, operators, and utilities to revisit infrastructure maintenance programs and asset management systems, to advance projects and programs designed to increase infrastructure resilience, and to review and update emergency management plans related to large-scale weather emergencies. A number of transportation agencies are enlisting front-line facility managers and operations staff in resiliency discussions in order to capture the vast knowledge these individuals possess regarding infrastructure performance.

Rather than a comprehensive approach to adaptation planning, recent weather events have provided an opportunity for climate adaptation discussions under the auspices of extreme weather preparedness and hazard mitigation. Although adaptation improvements are not generally being advanced under the auspices of climate change adaptation, resiliency improvements are more frequently being incorporated in project designs to enhance the infrastructure

reliability and performance in the context of more intense and extreme weather events. While progress has been made in a number of areas, stakeholders agree much more can and should be done to advance climate preparedness and enhance infrastructure resiliency in New Jersey's transportation and utilities sectors. However, stakeholders also face scrutiny from the public in justifying these investments through increases in fares, utility rates, and other cost increases.

Table 9 presents a list of gaps identified in our stakeholder interviews as of October 31, 2013.

Table 9: Gap analysis for built infrastructure sector.

Sector Gap Categories	Sector-specific Gaps	

Research, needs assessment, and data development	• Data needed to assess and monitor vulnerability across modes and subsectors
	• Design standards for:
	  • Drainage and culvert designs that incorporate extreme precipitation events
	  • Building and overhead sign standards that incorporate high winds
		• Pavement, bridge deck, rail, and overhead catenary wire standards that address thermal expansion and heat stress
		• Road bed, rail bed, and bridge design standards that address washout, erosion, scour, and wave action

Enhanced implementation of existing data, tools, and methods	• Uniform methods and guidance for conducting transportation infrastructure risk and vulnerability assessments • Demonstration projects to assess the effectiveness of adaptation strategies	• Cost-benefit analyses and capital planning processes that adequately account for value of long-term infrastructure resiliency
Regulation, policy, and governance support	• Incorporation of adaptation and resiliency in asset management strategy • Asset management approaches for transportation infrastructure managers at the county and municipal levels	• Standard practices for incorporating climate change in infrastructure design and asset management into state requirements for projects • Consistency in implementing leading adaptation practices across modes based on resources and agency priority
Coordination of adaptation planning and preparedness actions (includes across and among public, private, and NGO sectors)	• Coordinated planning for power restoration • Uniformity of climate risk assumptions regarding degree of frequency, magnitude, and time horizon to incorporate into capital planning and other investment and operating decisions	
Ensuring suitable funding	• Regional programs to accelerate asset replacement	• Incentives for hardening and resiliency to offset ratepayer concerns that would result from utility capital investment needs
Education and outreach efforts	• Training programs covering fundamentals of climate change science and impacts for sector employees • Guidance for incorporation of science into design standards	• Guidance for communicating long-term "bottom-line" benefits of resiliency improvements • Public education on costs of resilience and impacts on utility customer rates

Sector Profile

• 127 miles of Atlantic coastline and approximately 1,800 miles of tidal shoreline (NJ Sea Grant Consortium, 2010).

• More than 8 million residents in coastal watershed counties (NOAA, 2013).

• The tourism sector generated GDP of $34.7 billion – 7% of state economy (Tourism Economics, 2012).

• Atlantic, Cape May, and Ocean counties were the top three counties for tourism direct sales in 2012, accounting for $17 of $38 billion in state tourism spending (Tourism Economics, 2012).

Coastal Communities

STATE VULNERABILITY

New Jersey coastal communities are primarily situated in one of three regions, each with its own considerations and concerns regarding climate change:

- Delaware Bayshore
- Atlantic coast
- Urban coast

Atlantic coast communities are often perceived as the primary focus of adaptation and preparedness discussions, given recent experiences with Hurricane Sandy. Stakeholders from the Delaware Bayshore articulated that they lacked a strong political voice representing their adaptation and preparedness issues and felt that they have been disproportionately forced to consider retreat. Urban coast communities like Hoboken and Jersey City are likely to have unique concerns based on differences in population density, construction type, and other variables. Potential impacts to New Jersey coastal communities are summarized in Table 10.

Flooding, storm surge, sea level rise

As discussed in the overview of climate change in New Jersey, sea level along the New Jersey shore has risen faster than the global average due to land subsidence at the same time water levels are rising. At Atlantic City, sea level has risen by an average rate of 1.5 inches per decade (Rutgers Climate Institute, 2013). According to recent projections by Rutgers scientists, sea level is projected to rise by 7 to 16 inches by 2030, with a best estimate of 10 inches. In 2050, the range is 13 to 28 inches with a best estimate of 18 inches, and by 2100 the range is 30 to 71 inches with a best estimate of 42 inches. Even if the most conservative of these projections materialize, the implications for coastal flooding will be substantial (Miller et al., 2013).

Overwhelmingly, participants in the coastal community stakeholder listening sessions felt that flooding was the most pressing climate change impact. Concerns ranged from event-based coastal flooding and precipitation-derived inland flooding to flooding from storm surge and permanent inundation caused by sea level rise (Table 10). Conversations about flooding led to related issues such as compromised evacuation routes, an increased need for sheltering, coastal erosion, beach protection, concerns about community infrastructure (e.g., wastewater, storm water, utilities, and the occurrence of sinkholes and roadway collapses), and the need for home and roadway elevations.

Extreme events

Hurricane Sandy caused an estimated $36.9 billion in overall assessed damages to the state (ESA, 2013). According to the Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA), 48% of beach and dune systems on the Jersey coast have development within 100 meters (Lathrop, 2007). In addition, land and property values in Monmouth, Cape May, Atlantic, and Ocean counties alone total more than $100 billion (Cooper, Beevers, and Oppenheimer, 2005).

With sea level rise making more areas vulnerable to storm surge, these costs are likely to increase. Loss of beachfront with rising sea level is likely to result in a possible loss of recreational resources and tourism income. The decrease of the tax base is also especially acute given that community services such as

policing and public works were overstretched by Sandy and are still aiding in the recovery.

Other climate impacts mentioned by stakeholders include threats from forest fires, prolonged high heat events, increased drought and subsequent aquifer depletion, habitat conversions (in both marshes and forests) and associated fauna changes, and impacts to fisheries such as saltwater intrusion, changes in disease organisms, and reduced stocks of blue crabs, clams, and oysters.

ADAPTATION AND PREPAREDNESS GAPS

Federal, state, and local agencies are implementing programs to assess and mitigate climate change impacts in coastal areas. Many of the initiatives, such as the Getting to Resilience community planning and evaluation tool website and the NJ Floodmapper website, are tools designed to assist local professionals and residents to identify community vulnerability to coastal hazards and assess how well towns have incorporated adaptation and mitigation efforts into planning and preparedness processes and documents (JC NERR and BBP, 2013; CRSSA and JCNERR, 2013). There are also several funding initiatives under way based on post-Hurricane Sandy efforts. For example, the New Jersey Assembly appropriated $123 million to New Jersey's Blue Acres program after Hurricane Sandy to acquire vulnerable lands in coastal areas (Woods, 2012).

Implementation and utilization of these initiatives notwithstanding, stakeholders suggested that climate adaptation in New Jersey coastal communities presents a number of challenges:

- The slow pace of visible change
- Compliance with competing mandates
- A lack of political will at all levels of government to take immediate action

Coastal stakeholders reported a lack of time, staffing, and monetary resources to handle immediate priorities much less plan for the future. Many continue to work on recovery from Hurricane Sandy. Getting adjacent communities together is difficult due to a lack of time and an abundance of competing demands. Yet, stakeholders recognized that

Opposite: Holgate Unit of Forsythe National Wildlife Refuge at the southern tip of Long Beach Island (USFWS).

Above left: Mantoloking after Hurricane Sandy (Greg Thompson, USFWS).

Above: Kayakers in Belmar paddle streets flooded by Sandy (Tim Larsen, Governor's Office).

Table 10: State vulnerability, coastal communities.

Climate Impacts	New Jersey Risks
Sea level rise	• Loss of land due to inundation and erosion • Damage to public and private property as a result of inundation • Greater vulnerability to flooding due to higher storm surge base • Diminished tourism and tax revenues due to beach erosion
Extreme storm events	• Damage to public and private property from flooding, intense precipitation, or storm surge • Risk to human life and public health from extreme storm events and subsequent water contamination

Near right: Contractors construct a new beach clubhouse in Sea Bright as part of the rebuilding process after Sandy (Rosanna Arias/FEMA).

Far right: Ten months after Sandy, reconstruction continues at an apartment complex in Normandy Beach (Rosanna Arias/FEMA).

Below: Firefighters battle a blaze that tore through the Seaside Heights boardwalk less than a year after Sandy (Tim Larsen/ Governor's Office).

as professionals with a shared interest in protecting their communities they could have a powerful combined voice on coastal issues.

Coastal stakeholders saw government leadership and coordination as the primary gap preventing adaptation and preparedness measures in New Jersey. Stakeholders suggested that governments must coordinate better with one another and with business, nonprofit organizations, and citizens. They also recognized that time and funding are preconditions to allow governments to bolster their coordination and planning capacity.

Policy coordination was also top of mind for coastal stakeholders. Several stakeholders discussed the need to reduce red tape in planning and recovery. Many also suggested that incorporation of climate adaptation strategies into official planning processes can assist to develop consistent assumptions and allow for easier collaboration between neighboring municipalities and between federal, state, and local programs. In short, facilitating conversations across sectors is essential for reaching both short- and long-term planning objectives.

Table 11 presents a list of additional gaps identified in our stakeholder interviews as of October 31, 2013.

EMERGENCY MANAGEMENT

There are three jurisdictional levels of emergency management in New Jersey – state (NJOEM), county (21 offices of emergency management), and local (565 offices of emergency management). At the local level, emergency managers are commonly law enforcement or other emergency services personnel, political appointees, or volunteers.

As part of our stakeholder engagement effort, we specifically reached out to the emergency management community as a group that crosses many of our targeted sectors. We conducted a survey of local emergency managers as well as listening sessions to better understand their perspectives.

What we heard, generally, from the emergency management community is that their primary concern in regard to climate change is increased incidence and severity of flooding from changes in precipitation and extreme weather events. Some of the emergency management stakeholders have witnessed shoreline change in their lifetimes, including sea level rise and erosion, and are concerned about how those changes will affect their communities' ability to prepare for and respond to changes in precipitation and extreme weather events.

We heard from emergency management stakeholders that they view their role as being limited to event response rather than long-term planning for climate change. They generally pointed to a need for long-term planning that is best addressed through a broad, unified approach at the state level.

In terms of event response, the emergency management community emphasized protective strategies such as increased self-reliance during and after storm events (e.g., staying with family and friends rather than at shelters) and agreed there is a major need to both educate populations to be more prepared and self-reliant as well as to establish local systems that support sheltering in place. With respect to vulnerable populations, emergency managers cited the elderly as the population of greatest concern in regard to event response. Policy priorities among emergency managers include simplifying the process to apply for preparedness grants and enhancing grant-writing capacity, developing more resilient emergency communications infrastructure, and enhancing response capabilities with more personnel, equipment, and better coordination.

Table 11: Gap analysis for coastal communities sector.

Sector Gap Categories	Sector-specific Gaps	
Research, needs assessment, and data development	• Assessment of benefits of natural infrastructure such as tidal wetlands, dunes, marshes, and oyster reef breakwaters	• Comprehensive needs assessment associated with storm events (e.g., sheltering, backup generators, food, water, and logistical support)
Enhanced implementation of existing data, tools, and methods	• Evaluation of financial impacts on local tax and tourism revenue from storm events • Cost-benefit analysis of existing shoreline replenishment and coastal armoring programs	• Protection and restoration of natural shoreline buffers such as tidal wetlands and marshes, vegetated areas, dunes, and bay islands • Infrastructure vulnerability assessments • Use of social media for outreach

Regulation, policy, and governance support	• Incorporation of climate change projections, including sea level rise, in state and municipal plans, policies, and regulations
	• Framework for making decisions about protection, abandonment, and retreat or relocation
	• Guidance on public and private structure elevation
		• Review current regulations with a focus on climate adaptation, including:
		  • Floodplain definitions and regulations
		  • Permitting
		  • Design and construction standards
		  • Reduction in red tape/elimination of conflicting requirements for permits

Coordination of adaptation planning and preparedness actions (includes across and among public, private, and NGO sectors)	• Multijurisdictional hazard mitigation planning • Emphasis on cross-sector representation in the hazard mitigation planning process at the federal, state, and county levels • Streamlined grants process	• Improved coordination between volunteer support, Citizen Emergency Response Teams (CERTS), FEMA, and NGOs like the Red Cross • Mutual aid coordinated between municipalities
Ensuring suitable funding	• Technical, financial, and research assistance to build capacity of local governments to implement climate adaptation strategies • Programs for government continuity of operations after events (e.g., providing information technology capacity for municipal record backup)	• Cost-benefit analysis of existing shoreline replenishment and coastal armoring programs • Land acquisition, property buyout, and conservation easement programs • Incentive programs to relocate development away from vulnerable areas and protect natural areas
Education and outreach efforts	• Preparedness training to make general public more self-reliant in emergencies • Educate children on climate impacts • Increased need for sheltering	• Illustrative education to increase awareness of gradual climate change impacts among the general public • Rapid response systems/resilient emergency communications infrastructure

Sector Profile

- New Jersey is 42% forested (NJDEP, 2013a).
- NJDEP manages approximately 700,000 acres (NJDEP, 2013a).
- Nine National Park sites with about 4.9 million visitors in 2012 (National Park Service, 2013).
- More than 20 million people annually visit the state's Highlands region for recreational activities (NJDEP, 2013a).
- The Pine Barrens are more than a million acres (NJDEP, 2013a).
- Over 400 species of vertebrate wildlife, 134 freshwater fish, 336 marine finfish (NJDEP, 2013b).
- Significant coastal stopover for migratory birds (NJ Audubon, 2013).

Natural Resources

STATE VULNERABILITY

Climate change can have a serious impact on ecosystems, flora, and fauna, though it is sometimes difficult to assess direct effects on the overall health of an ecosystem. In regard to water, stakeholders are most concerned about an increased occurrence and severity of flooding, higher water temperatures, and more frequent and longer droughts. For land, stakeholders are most concerned about tidal wetland erosion/loss, beach/dune loss, soil erosion/loss, and reduced water filtration. For flora, fauna, and people, stakeholders are most concerned about critical species habitat loss, increased spread of invasive species, and increased occurrence or spread of pathogens, pests, and vector-borne diseases (Table 12).

Sea level rise

Swamps and marshes are among the wetland habitats most vulnerable to sea level rise in New Jersey. Stakeholders expressed concern about impacts from projected losses of critical coastal habitats and their effects on surrounding human communities. In addition, stakeholders want to understand more about how sea level rise will affect marsh habitat, the surrounding uplands, and coastal impoundments managed for waterfowl.

Sea level rise will also affect coastal fauna. The slightest amount of sea level rise and associated increase in salinity could negatively affect the tiger salamanders that inhabit vernal pools in Cape May County or the reproductive capabilities of bog turtle habitat in ephemeral wetlands. There is also concern about impacts on game species habitat, including trout streams. Impacts on fauna, particularly game species, could damage tourism.

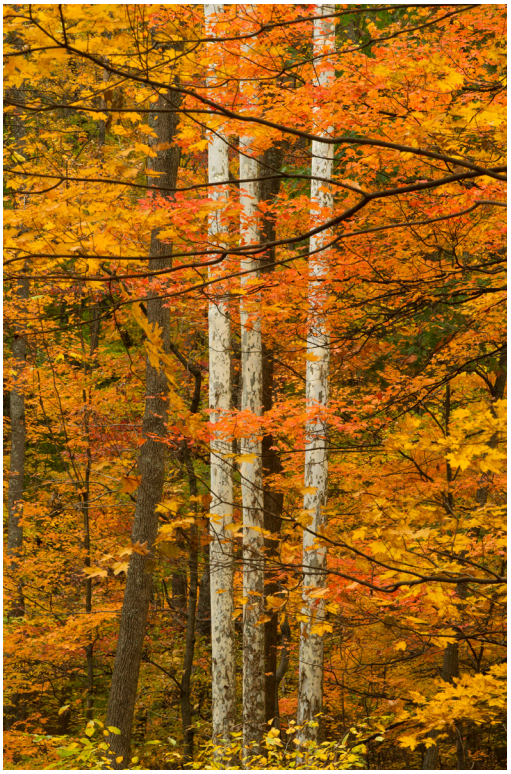
Extreme weather events

Severe storm events also pose a threat to wetland systems. As seen during Hurricane Sandy, storm-driven water removed vegetation, moved millions of tons of sand and silt, and exposed new open sand. The changed landscape likely eroded important habitat for many shorebirds and other important species like horseshoe crabs. In other areas, Sandy may have created new nesting habitat for birds like plovers and terns or stopover areas for migrant birds (Manomet Center for Conservation Sciences, 2012).

Storms can also cause an influx of excessive freshwater into saltwater systems, as happened during Tropical Storm Irene. The lower salinity affects habitats and species that rely on the presence of freshwater to guide their migratory patterns.

Rising temperatures

Rising temperatures may affect New Jersey forests in several ways. Climate change is not expected to reduce the size of Northeast forests, but it will alter the character of those forests. In northern New Jersey, scientists expect habitat for maple-beech-birch and



Clockwise from top left: Plains Brook, Pinelands (Dwight Hiscano); Lockatong Preserve, Delaware Township (Dwight Hiscano); students study saltmarsh sparrows, Forsythe National Wildlife Refuge (Chelsi Hornbaker, USFWS); northern pine snake (Bigstock).

spruce-fir forests to contract (Frumhoff et al., 2007). In terms of wildlife, temperature increases will especially affect cold-water species such as brook and lake trout (Trout Unlimited, 2007).

ADAPTATION AND PREPAREDNESS GAPS

Stakeholders in the natural resources sector generally agreed that we do not yet have the requisite baseline information on the health of natural resources in the state to fully understand how climate change will affect ecosystems, flora, and fauna. Stakeholders also shared a concern that addressing climate-related impacts will be focused on coastal areas instead of the uplands.

Stakeholders in the natural resources sector, including those within the New Jersey Department of Environmental Protection, are working to assess climate risks. Stakeholders articulated a desire for state guidance in developing common goals to ensure that their work can be coordinated and contribute toward common statewide goals for climate adaptation (Table 13). Many stakeholders felt that progress towards climate readiness will be sluggish and disorganized without strategic direction from state agencies and the state executive office.

Stakeholders also identified gaps in formal planning, including the State Strategic Plan and State Water Supply Plan. Many stakeholders have provided comments to the state regarding their concerns that government executives should consider incorporating climate adaptation strategies into such plans. In addition, stakeholders expressed a need for outreach to encourage partnerships across the state to leverage resources and capacity. They noted that the Alliance can play a key role to facilitate those partnerships, whether policy-, science-, or project-based.

Table 13 presents a more detailed list of gaps identified in our stakeholder interviews as of October 31, 2013.

Table 12: State vulnerability, natural resources.

Climate Impacts	New Jersey Risks
Sea level rise	• Beach and wetland habitat loss resulting from coastal inundation
Extreme weather events	• Beach and wetland habitat loss resulting from erosion or destruction • Decreased water quality from increased sedimentation
Rising temperatures	• Changes in character and composition of forest tree species • Increased forest pests • Increased and more severe wildfires • Salinity, circulation, and temperature changes affecting estuarine structure, species health and distribution, and migratory routes
Ocean acidification	• Food web at risk from impacts to shellfish and plankton

Table 13: Gap analysis for natural resources sector

Sector Gap Categories	Sector-specific Gaps	
Research, needs assessment, and data development	• Establishment of baselines and species monitoring for health, distribution • Identification of research and science priorities for upland and coastal ecosystems, flora, and fauna • Tools that allow regional and municipal governments and NGOs to respond to climate change impacts • Science-based "marsh futures" for coastal restoration efforts	• Assessment of impacts from new or expanding ranges of invasive species via: • Ballast water • Boat cleaning and transportation practices • Sale of invasive plants and animals • Increased monitoring and control of invasive marsh and coastal plants • Cleaning of machines to remove seed or root cuttings before moving to a new site
Enhanced implementation of existing data, tools, and methods	• Analysis of climate change impacts in upland and coastal areas • Improved climate modeling capacity for local-scale assessments	• Sea level rise cost-benefit analyses comparing no-action to strategic retreat • Sustained mechanism to monitor wetlands
Regulation, policy, and governance support	• Guiding state framework to enhance resiliency and survival of ecosystems, flora, and fauna • Incorporation of climate adaptation into policy (Energy and Water Supply Master Plans, State Development and Redevelopment Plan)	• Full implementation of the Global Warming Response Act • Flexible conservation regulations that take into account potential sea level rise and changing floodplains
Coordination of adaptation planning and preparedness actions (includes across and among public, private, and NGO sectors)	• Strategies for protection of buffer zones around vulnerable wetlands and vernal pools • Statewide monitoring of coastal restoration and living shoreline projects	• Regional conservation/restoration plans for at-risk coastal areas based on sea level rise • Sustainable forestry certification programs • Protection of habitat corridors
Ensuring suitable funding	• Ecosystem service markets such as carbon sequestration and biomass-based fuel production	• Incentives for improving health of watersheds and ecosystems • Sustainable funding for Green and Blue Acres programs
Education and outreach efforts	• Outreach and training for the conservation community and regional, state, and federal resources agencies on climate change adaptation strategies and methods for ecological resources	• Education for local governments on climate risk planning and conservation methods • Outreach campaign to educate the public about the impacts of climate change on human populations and natural resources, and encourage individual action

Van Campen Brook, Delaware Water Gap National Recreation Area (Dwight Hiscano).

Sector Profile

• Emergency management administered at three levels of government: state (NJOEM), county (21 offices), and municipal (565 offices).

• More than 100 hospitals.

• Other support services provided by state, county, and municipal health departments and state and county departments of human services.

• About 8% of adults and 10% of children in the state suffer from asthma (NJDHSS, n.d.).

• In 1999 and 2002, two of the hottest summers recorded in New Jersey, there were 30 and 18 cases of heat-related mortality, respectively (NJDHSS, n.d.).

Public Health

STATE VULNERABILITY

Public health impacts from a changing climate are wide ranging and include heat-related illnesses, changing air quality conditions, storm-related injuries and stresses, and infectious diseases. Surveys, interviews, and focus groups were conducted with public health officers, social service providers, and other representatives of the health care delivery system such as hospitals and nursing homes.

Many of the issues raised by these stakeholders were based on more recent experiences related to Hurricane Sandy and Tropical Storm Irene; however, these experiences are also instructive in many ways for events such as prolonged periods of high heat. Heat stress and heat stroke are also a concern, as is the spread of vector-, food-, and waterborne diseases. The public health officers who responded to our climate survey were most concerned about ensuring food safety during power outages and meeting an increased need for shelters during and after storms (Table 14). Also of concern were such storm-related impacts as increased exposure to mold and mildew, interrupted care for vulnerable populations, long-term economic impacts, stress and strain on responders, and injuries. Public health vulnerabilities from climate change also include increases in cases and severity of respiratory diseases as air quality is expected to deteriorate due to elevated particulate matter and ozone associated with increased temperatures.

Storm-related stress and injury

Acute issues cited by stakeholders included direct morbidity and mortality from drowning, downed trees, and carbon monoxide poisoning. As climate continues to change, there will be an increased need to enhance capacity of first responders in flood-prone coastal and river communities as well as exercise vigilance against food and water contamination in the wake of storm events. Stakeholders also thought that provisions should be made to address chronic issues, including the mental health impacts of repeated stressors and the health effects of mold exposure. In addition, combined sewer overflows, wastewater treatment plant failures, and other water infrastructure emergencies can create unsafe conditions.

Tropical Storm Irene and Hurricane Sandy illustrated the range of impacts extreme weather can have on public health. Lack of proper planning for shelters and an extreme lack of communication due to power outages were the most common complaints voiced by stakeholders. While many individual agencies had emergency plans, there was a lack of system-wide coordination between agencies. Power outages also caused significant issues for people requiring durable medical equipment such as ventilators and oxygen, and there was an inadequate supply of generators and a lack of knowledge about the proper use of generators.

With pharmacies closed, prescription drugs were unavailable – a particularly difficult situation for individuals on methadone and other psychoactive drugs. Volunteer physicians were willing to write prescriptions for general health problems, but they were reluctant to prescribe psychoactive drugs without consulting medical records. Shelters also presented public safety concerns, as individuals with mental health issues, registered sex offenders, and families with children were housed in the same facilities.

The long-term health impacts of primary concern were mold exposure and mental health. Stakeholders believed that residents were exposed to a great deal of mold while removing flood-damaged personal items or living in affected homes, with exposures exacerbated by delays in rebuilding. Social service providers emphasized that Hurricane Sandy further intensified routine shortages of mental health services. Finally, Sandy often separated caregivers and their clients (e.g., elderly people who moved in with relatives), and agencies had no way of tracking people they were supposed to serve.

Heat-related illness

Each year more than 1,200 people are treated in New Jersey hospital emergency departments for heat-related illness or sunburn; overexposure to summer heat causes between 45 and 170 hospitalizations in New Jersey annually. In 1999 and 2002, two of the hottest summers recorded in New Jersey, there were 30 and 18 cases of heat-related mortality, respectively (NJDHSS, n.d.). As heat waves increase in both frequency and duration, the incidence of heat stress and stroke will rise, with the elderly and poor suffering.

Air quality

Poor air quality, especially near heavily trafficked roadways, is already a major public health issue in New Jersey. About 8% of adults and 10% of children in the state suffer from asthma (NJDHSS, n.d.). Hospitalizations due to asthma are three times higher among blacks than whites, with the highest rate of hospitalizations in Essex, Hudson, Passaic, Mercer, Camden, Cumberland, and Atlantic counties (NJDHSS, n.d.). Increases in levels of ozone and particulate matter resulting from a changing climate are also expected to have an adverse impact on the incidence of cardiovascular disease (Portier et al., 2010).

Increases in the level of airborne pollen result in more asthma-related hospital admissions among children (Im & Schneider, 2005). A longer pollen season in New Jersey is already putting people at greater 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 (Bielory et al., 2012).

Infectious disease

As temperatures and humidity rise, certain vector-borne and zoonotic diseases will likely expand their ranges, including tick-borne illnesses such as Lyme disease and mosquito-borne diseases such as West Nile virus (CCSP 2008). New Jersey has a Communicable Disease Reporting and Surveillance System (CDRSS) that health care providers use to report communicable diseases to local health departments. Public health officers expressed a need for enhanced vector and disease surveillance programs and data during the stakeholder meetings.

Opposite: A National Guardsman assists at a shelter in Piscataway during Hurricane Sandy (Master Sgt. Mark C. Olsen, USAF).

Table 14: State vulnerability, public health.

Climate Impacts	New Jersey Risks
Heat-related illness	• Increase in mortality and hospitalization from heat stress • Exacerbation of existing chronic conditions such as cardiovascular and respiratory disease
Air quality conditions	• Increase in pulmonary and respiratory diseases and cardiovascular diseases due to higher levels of ground-level ozone and fine particulate matter associated with increased energy use during high temperature periods • Increase in asthma and allergenic diseases due to longer pollen season and greater potency of pollen
Storm-related injuries	• Morbidity and mortality due to falling trees, drowning, and carbon monoxide poisoning from generators • Increased mental health issues caused by repeated stressors • Consumption of contaminated food and water as a result of flooding, power outages, and displaced populations • Damage to low-lying health care facilities and infrastructure • Exposure to mold, mildew, and toxic contamination from flooding, including flooding of hazardous or contaminated sites • Lack of availability of medications and medical equipment as a result of power outages and business closures
Infectious disease	• Expanded ranges of vector-borne diseases such as Lyme disease and West Nile virus expected • Increase in food-borne pathogens such as salmonella and vibrio caused by rising temperatures • Flood-related increases in population of waterborne parasites such as Cryptosporidium and Giardia, which cause gastroenteritis

Additionally, extreme weather heightens the risk of contracting food- and waterborne diseases. Flooding makes exposure to contaminated water more likely, and power outages affect the safety of the food and water supply (USGCRP, 2009). Lack of communication during power outages can prevent residents from hearing boil water advisories.

ADAPTATION AND PREPAREDNESS GAPS

Stakeholders emphasized the need for better communication and coordination between health departments and state resources, various social services agencies, and public health officials and other sectors. Stakeholders also underscored the important role of resilient infrastructure in providing public health and social services.

According to our survey of public health officers, high priority actions at the state and regional level include better regional transportation options to assist in evacuations, a more resilient emergency communications infrastructure, and critical infrastructure assessments. Stakeholders consistently cited a lack of funding and staff as major barriers to implementing climate change adaptation, and they identified such additional needs as reliable emergency power sources, more precise weather forecasting, regional shelter planning, and stockpiling of supplies.

Table 15 presents a more detailed list of gaps identified in our stakeholder interviews as of October 31, 2013.

Below: Isles supports more than two dozen community gardens in Trenton (Vilseskogen, Creative Commons).

CLIMATE CHANGE AND CITIES: IMPACTS ON URBAN RESIDENTS

Climate change can disproportionately affect cities, with impacts on both infrastructure and residents (USCGRP, 2009). New Jersey, the most densely populated state, is witnessing the following impacts:

• Heat island effect

Decreased vegetation, waste heat from buildings and vehicles, and impervious surfaces such as concrete and asphalt create localized islands of hot climate in urban areas. According to a recent study, the average difference between urban and nonurban minimum temperatures was 3.0°C (5.4°F) for the Newark, N.J., area and 1.5°C (2.7°F) for Camden, N.J. (Rosenzweig et al., 2005). Warmer temperatures may impact community health (heat stress, air quality, and asthma triggers such as allergens, mold, and mildew) and energy usage (greater need for air-conditioning), among other impacts.

• Housing

Housing for low-income populations is typically less energy efficient than other homes, and residents lack the resources and incentives to add air-sealing and insulation measures, to upgrade to efficient appliances, or even install efficient air-conditioning (Pivo, 2012). Rising temperatures may exacerbate the energy cost burden for low-income households. In addition, heavy precipitation events and flooding could amplify increases in humidity, triggering mold in homes. A high percentage of affordable housing leaks, resulting in an increase in asthma triggers. Leaks can prevent programs from weatherizing homes through improvements such as attic insulation. Leaks also cause flaking and peeling paint, resulting in higher lead poisoning rates given the concentration of lead paint in older urban homes (RWJF, 2011; M. Johnson, personal communication, December, 2013).

• Toxins

Urban areas in New Jersey typically have higher concentrations of environmental toxins than other areas due to a legacy of industrial activity. When low-lying urban areas flood, toxic contaminants carried by floodwaters can contaminate homes, gardens, background soil, and water supplies (EPA, 2012; M. Johnson, personal communication, December, 2013).

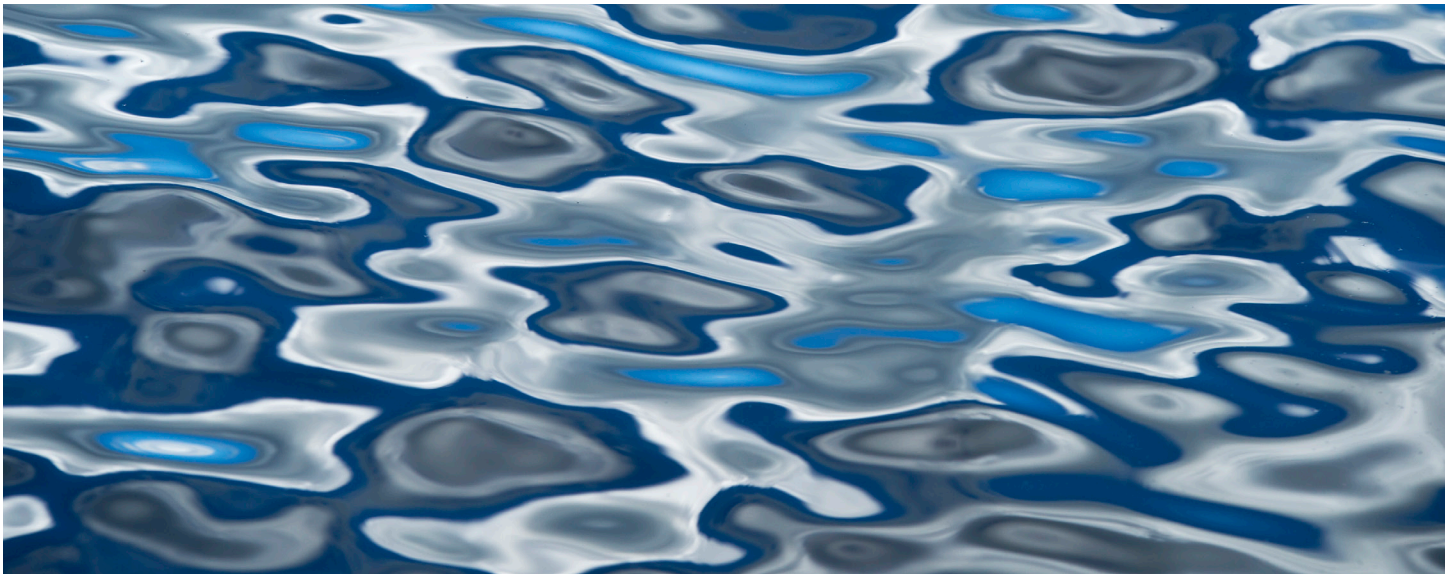
New Jersey Community-based Efforts

Isles Inc., a community development organization based in Trenton, has been testing effective ways to weatherize and renovate houses across older communities in central New Jersey in order to create cool, dry, and healthy homes. In addition, Isles works to improve the health of homes by reducing asthma, lead poisoning, and other threats. Isles also trains residents in green jobs and community planning (Isles, Inc., 2012).

The Ironbound Community Corporation (ICC) is a community-based nonprofit organization in Newark focused on environmental justice issues for many decades. As part of rebuilding efforts after Hurricane Sandy, ICC is initiating a community-driven climate resiliency planning effort that identifies the most critical vulnerabilities and resources residents need to prepare for future climate events. In addition to working directly with residents on the front lines of climate change, ICC has partnered with the City of Newark to identify and implement green street initiatives that include depaving sidewalks and medians, planting hundreds of street trees, increasing waterfront green space and parks, and planting new community gardens (ICC, 2013).

Table 15: Gap analysis for public health sector

Sector Gap Categories	Sector-specific Gaps	
Research, needs assessment, and data development	• Local health impact assessments and climate adaptation plans • Enhanced data collection and surveillance programs for vectors and disease • Quantified assessment method and risk maps for areas with high environmental burden	• Quantified risks to public health and health care service delivery infrastructure • Assessment of current process quality and capability to execute post-event mental health surveillance • Census of vulnerable subpopulations/ vulnerability assessments
Enhanced implementation of existing data, tools, and methods	• Technical capacity and performance standards to deal with mold exposure issues	• Additional regional shelters, charging stations, and cooling and warming centers
Regulation, policy, and governance support	• Updated shelter regulations (e.g., families with children, elderly, patients with mental health issues, access to Megan's Law registry) to increase health and safety of sheltering population	• Statewide policy for prescription drug distribution during power outages
Coordination of adaptation planning and preparedness actions (includes across and among public, private, and NGO sectors)	• Communications plans for tracking social service clients displaced by extreme weather • Assistance in stockpiling fuel, generators, food, water, and medical supplies • Regional transportation options for evacuations (e.g., public transit) • Resilient emergency communications infrastructure programs • Debris cleanup planning, in particular contaminated materials	• Coordination requirement for local health departments, businesses, utilities, governments, and community organizations in emergency response planning • Ongoing review process for existing emergency preparedness and response plans • Coordination improvements between health departments, medical providers, social services, and government • Coordination of health and safety needs with utilities during infrastructure planning
Ensuring suitable funding	• "Surge" resources for local health departments and social service providers during and after emergencies	
Education and outreach efforts	• Community organization engagement in planning for extreme weather events • Home energy assistance programs to subsidize heating and cooling for vulnerable populations	• Centralized data source on providers of health and social services • Climate-related training programs for health professionals, including bilingual staff to assist undocumented immigrants in locating resources



Sector Profile

• Five major drainage basins: Delaware River, Atlantic Coastal, Passaic/ Hackensack Rivers, Raritan River, Wallkill River.

• 80% of state's area within federally designated sole source aquifers, supplying at least 50% of drinking water in overlying areas (USDA NRCS, 2006).

• Estimate of total water use in 2005 was 1,930 million gallons per day statewide (USGS, 2013a).

• New Jersey loses 20% to 22% of its treated water annually from leaking pipes (Facing our Future, 2013).

Water Resources

STATE VULNERABILITY

Heat and drought

Stakeholders in the water-resources sector expressed concerns about the impact of climate change on both the quantity and quality of New Jersey's water supply and the integrity of its distribution infrastructure (Table 16). Principal among these concerns was the trend toward warmer temperatures and severe drought, which has the doubly negative effect of decreasing supply while increasing demand. They specifically cited reductions in surface water supplies and groundwater recharge, overall lower water levels in reservoirs, and greater variability in those water levels.

The stakeholders were especially concerned about reservoirs in the Delaware River Basin, which supply both New Jersey and New York City. They recalled the droughts of 2002, when these reservoirs were badly drained and state officials realized that greater interconnectivity should be developed between each of the available reservoir sources in order to get water to the places most in need (NJDEP, 2004).

Water quality degradation

Climate change also threatens water quality. Among the most problematic of these threats is saltwater intrusion, which occurs when the salinity of the water supply rises above drinking standards because of seawater migration. The southern portion of the state is susceptible to this problem, especially in the tidal regions supported by water utilities in the Delaware River Basin (Cooper et al., 2005). Water supply quality is further endangered by the vulnerability of wastewater infrastructure, which is at risk of flooding due to the typically low elevation of facilities. Erosion and contamination from runoff degrade water quality as well, leading to treatment challenges and deterioration of reservoir conditions. Degradation of water quality could lead to more stringent requirements for wastewater discharges, higher treatment costs, and the need for capital improvements for both the water utilities and their industrial customers (EPA, 2012).

Extreme weather and flooding

Extreme weather events can damage infrastructure such as treatment plants, intake facilities, and water conveyance and distribution systems, and cause widespread disruption of service. Environmental stakeholders are especially worried about combined sewer overflows caused by such events.

Opposite top: Monksville Reservoir, West Milford (Dwight Hiscano).

Opposite bottom: Merrill Creek Reservoir, Warren County (Bigstock).

Left: Workers replace a pump station valve damaged by Hurricane Sandy floodwaters at the Bayshore Regional Sewerage Authority in Union Beach (Rosanna Arias, FEMA).

Resource demand

In a recent study, a New Jersey based workgroup estimated that at least $36.6 billion and possibly as much as $40 billion was needed in 2008 to fund New Jersey's water systems infrastructure needs. Development patterns and a lack of investment may continue to strain water resources if conservation efforts are not implemented (Facing Our Future, 2013).

Changes in agricultural practices in response to climate change could also significantly reduce the ability of drinking water utilities to supply their ratepayers. A host of other environmental variables related to climate change can also harm source water, including algal blooms, increases in turbidity and pollution inputs, and altered or reduced vegetation cover in watersheds. Such vulnerabilities suggest the need not only to review the strategies of water utilities to meet customer demand but to manage the demands of other interdependent systems.

ADAPTATIONS AND PREPAREDNESS GAPS

The members of our stakeholder group identified adaptation needs in several areas, including governance, funding, science, and education. They emphasized that climate change as a concept is not formally recognized in state land-use or water-supply planning. They felt that incorporating climate change adaptation into planning and regulation would be an effective method of driving adaptation strategies into practice. The stakeholders also expressed a need for greater coordination between agencies at all levels of government for the purposes of emergency management, watershed protection and restoration, and climate change adaptation.

In regard to funding, the stakeholders indicated a need for economic incentives and financing programs for infrastructure upgrades and maintenance. Financial incentives for landowners to restore or protect wetlands and riparian areas were also considered valuable. They noted the success of land preservation efforts and underscored the need to establish

Table 16: State vulnerability, water resources.

Climate Impacts	New Jersey Risks
Heat and drought	• Infrastructure degradation and obsolescence • Decreases in surface water supply and groundwater recharge • Lower water levels in reservoirs • Greater water level variability
Water quality degradation	• Saltwater intrusion • Contamination from flooding, runoff, erosion, or failure of low-lying treatment infrastructure
Extreme weather events and flooding	• Infrastructure damage from intense precipitation events or storm surge • Infrastructure failure from overload or power outage, resulting in contamination • Physical damages and losses to public and private property from flooding
Resource demand	• Limited capacity to meet demand for personal and commercial consumption • Failure of aging infrastructure

> “ [T]he stakeholders indicated … the need to establish a sustainable source of funding for watershed preservation through the Blue and Green Acres programs.

a sustainable source of funding for watershed preservation through the Blue and Green Acres programs.

The stakeholders also communicated a need for more refined and extensive data collection and analysis for the purpose of risk assessment. Quantifying risk will help water-resource managers better understand vulnerabilities in the water supply and delivery infrastructure, including vulnerability to saltwater intrusion, storm surge, and inland flooding.

There is also a desire for professional training in green infrastructure design and other new techniques as well as an update on how these new approaches align with existing regulations. It makes little sense, for example, to educate civil engineers in new techniques and tools without first understanding the regulatory standing of those techniques in federal, state, and local design standards. Additionally, water utility staff will need to become more technically competent in addressing the many issues climate change poses, from alterations in water chemistry to the design, operation, and maintenance of infrastructure under changing conditions.

Public education is needed, too. Informing consumers about climate change and water conservation is essential for the successful implementation of climate change adaptation strategies. The more consumers know about water-use issues, the better able they will be to make informed investment decisions about water quality and infrastructure upgrades.

Table 17 presents a list of gaps identified in our stakeholder interviews as of October 31, 2013.

Copperhead Pond, Sparta Mountains, Sussex County (Dwight Hiscano).

Table 17: Gap analysis for water resources sector

Sector Gap Categories	Sector-specific Gaps	
Research, needs assessment, and data development	• Water conservation, reuse, and purification technology alternatives to hard infrastructure • Landscape practices and plants to reduce water use	• Data collection and analysis capacity for risk assessment, planning, and performance management at all levels of the public sector
Enhanced implementation of existing data, tools, and methods	• Analysis of sector interdependencies to inform capital planning and asset management strategies • Storm water management through green infrastructure	• Quantification of system vulnerability to saltwater intrusion, storm surge, and inland flooding • Protocols for inspection and maintenance of existing systems to account for long-term climate impacts

Regulation, policy, and governance support	• Coordination and institutionalization of adaptation planning and regulation at municipal and state government levels
	• Recognition of climate change in state and local planning and regulation:
	  • NJ Statewide Water Supply Plan
	  • NJ State Development and Redevelopment Plan
	  • Hazard Mitigation Plan
		•Updated regulations on:
		  • Floodplain definitions
		  • Permitting of water treatment and/or wastewater treatment facilities
		  • Design and construction standards for infrastructure development
		• Agricultural water restrictions

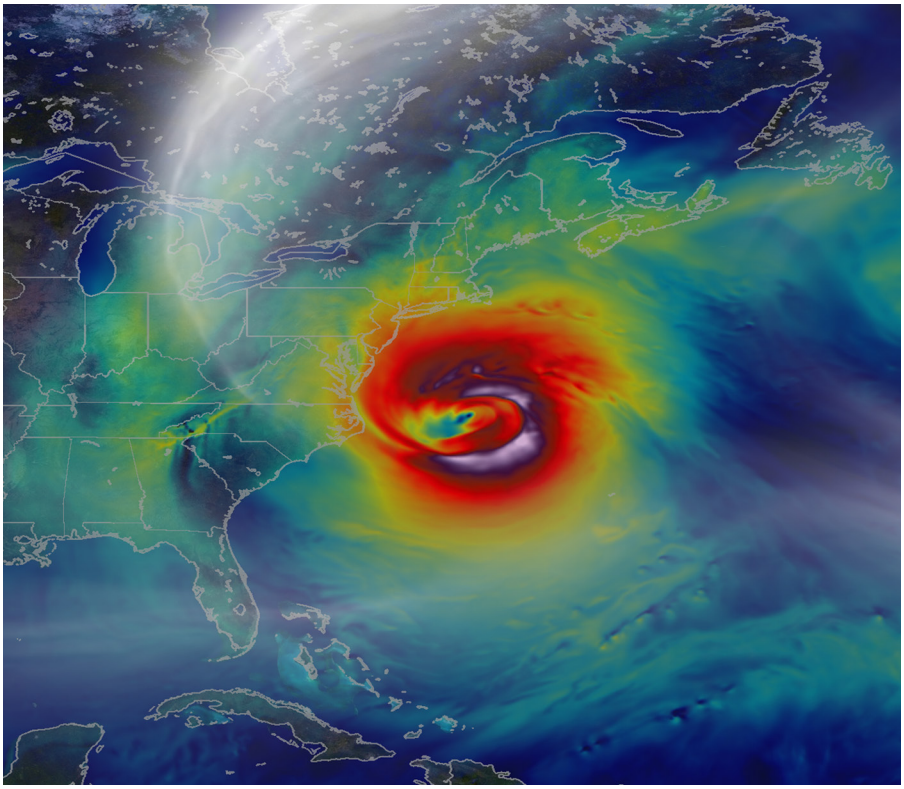
Coordination of adaptation planning and preparedness actions (includes across and among public, private, and NGO sectors)	• Partnerships with businesses to understand mutual aid and promote resilience of critical facilities • Coherent and coordinated policy vision of climate scenarios	• Emergency management plans that incorporate climate change and coordinate parties • Stakeholder group to organize and coordinate state-level adaptation planning and implementation
Ensuring suitable funding	• Incentives and financing programs for infrastructure improvements and maintenance • Funding for Blue and Green Acres programs beyond current allocation	• Planning for sustained funding of utility system maintenance and upgrades
Education and outreach efforts	• Water conservation practices and technologies available to the general public • Effective risk communication on cumulative impacts of climate change • Hazard awareness and education about combined sewer overflow discharge and failure of wastewater treatment plants	• Training and tools for engineering and design professionals • Effective communication on citizen action and behavior • Outreach to municipalities on alternatives to hard engineering approaches for water infrastructure

Next Steps

The Alliance will conduct a series of workshops to draft policy recommendations addressing the gaps identified in this report.

Opposite: Snowfall blankets the Northeast, October 30, 2011 (NASA Goddard MODIS Rapid Response Team).

Below: A visualization of Hurricane Sandy created by NASA's GEOS-5 global atmosphere model (NASA/GSFC/William Putman).



The Alliance was convened more than six months prior to Hurricane Sandy and continues to serve as a forum for people from a wide range of fields to find consensus on strategies to enhance climate change preparedness in New Jersey. The Alliance's ongoing effort to generate public policy recommendations involves a deliberative process informed by analysis of key issues and stakeholder engagement.

To date, the Alliance's public policy effort has involved the following:

- Identification of climate trends and projections
- Analysis of impacts and leading adaptation practices within targeted sectors
- Identification of vulnerable communities
- Examination of strategies to finance climate preparedness
- Articulation of New Jersey citizens' perspectives on climate change impacts and policy options to enhance the state's preparedness
- Engagement of stakeholders to better understand climate change preparedness perspectives and policy gaps

Next, the Alliance will conduct workshops for invited decision makers and technical experts representing their respective stakeholders. The purpose of these workshops will be to draft recommendations to address the gaps identified in this report. The Alliance Advisory Committee will issue a final set of consensus policy recommendations based on the workshops.

Hurricane Sandy was a pivotal event in New Jersey's history and remains a touchstone in the Alliance's deliberations. Our challenge now is to understand the lessons Sandy continues to teach and apply that knowledge to holistic climate preparedness. The Alliance members have listened carefully to consensus policy recommendations that address the full breadth of anticipated climate change in New Jersey.

In addition to developing key state and local policy recommendations, the Alliance will continue to:

- Conduct research and analysis
- Translate research and analysis findings into outreach and educational materials to fill needs identified by stakeholders
- Develop tools for climate preparedness planning
- Maintain the NJ Climate Adaptation Directory
- Pursue demonstration projects
- Connect practitioners with one another and with entities in need of assistance
- Work toward implementation of key recommendations once developed

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Front and back cover image: Hurricane Sandy shortly before landfall (Jeff Schmaltz, LANCE MODIS Rapid Response Team, NASA GSFC)