Mayor's Office of Energy & Sustainability
City of Albany, NY

Albany Climate Change

Vulnerability Assessment and Adaptation Plan

AUGUST 2013

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Flooding. July 10, 2013 - Albany, NY

prepared by VHB

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Flooding in Downtown Albany after Hurricane Irene.

Mayor's Office of Energy Sustainability
City of Albany, NY

EXECUTIVE SUMMARY

Evidence of climate change is increasingly documented around the globe. The greatest impacts are now being seen at the north and south pole, with arctic temperatures rising twice as fast as the rest of the world. Summer arctic sea ice has been reduced by 20 percent since 1979 (NRDC 2005). Thawing permafrost in Alaska is releasing large deposits of methane (a greenhouse gas that is 21 times more effective at preventing infrared radiation from escaping the planet) that were previously locked in a deep freeze (Gillis 2011). Melting glaciers and land-based ice sheets are contributing to global sea level rise. The north and south poles, with their large deposits of ice that help regulate our global climate, are melting at an increasing rate, causing impacts that could threaten many parts of the world (NRDC 2005). Understanding these impacts at the regional and local levels is imperative to ensure society is prepared for existing and projected future changes in weather and climate.

Hudson River flooding in the Corning Preserve.

Regions throughout New York are likely to be affected by climate change in different ways. Low-lying areas of Long Island and New York City could see much of their land inundated by rising seas and increasing storm surge, as evidenced by Superstorm Sandy, and Upstate New York and Vermont were devastated by Hurricane Irene in 2011.[1] The New York State Energy Research and Development Authority (NYSERDA) recently completed a report, *Responding to Climate Change in New York State*, referred to as **ClimAID,** which outlines the potential impacts of climate change across New York State and provides recommendations for adaptation strategies to address these impacts. Albany's Climate Change Vulnerability Assessment and Climate Adaptation Plan builds off of the ClimAID report by analyzing how climate change could affect Albany's people, infrastructure and natural resources and providing recommendations and strategies on how to improve the city's resilience and adaptive capacity.

In Albany, climate change will likely lead to: increases in temperature, including more frequent high-heat days and heat waves; increases in average annual precipitation; increases in the frequency and intensity of precipitation events; and sea level rise along the tidal Hudson River. There is also a possibility that Albany will experience more extreme weather events such as ice storms, thunderstorms (bringing hail and even tornadoes), and tropical storms including hurricanes and Nor'easters.

These changes could lead to an array of local and regional impacts. For example, the combination of rising water levels in the Hudson River and an increase in precipitation could overwhelm the stormwater system, leading to significant flooding.

1 For more information on the impacts of Superstorm Sandy, please review the following documents: http://www.nyc.gov/html/sirr/html/report/report.shtml

This would have implications on a range of infrastructure systems from sewer and water to transportation and energy. Extreme heat could significantly threaten local public health by decreasing local air quality and increasing the risk of heat related illnesses such as heat stroke. A warmer climate can also affect natural resources by putting additional stress on already sensitive ecosystems such as the Pine Bush Preserve. In addition, water quality can be significantly reduced with warming temperatures, making it less capable of supporting ecological functions and recreational opportunities. Many of these impacts and others are already affecting Albany, but climate change has the potential to make these impacts more frequent, severe, or of longer duration.

Climate change presents the City of Albany with both challenges and opportunities; understanding what these challenges and opportunities are is a crucial first step in preparing Albany for a changing climate

Corning Preserve

KEY TERMS AND DEFINITIONS

Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Changing Climate Condition: These are the direct climate-related consequences of global climate change. They include things like changes to annual average temperature, precipitation, and sea level rise.

Climate Effects: These are the result of climate impacts on social, natural and infrastructure systems. Climate effects include changes to air quality, property damage, service disruptions, length of the growing season, water quality, and habitat changes.

Climate Impact: The effects that result from changing climate conditions. Climate impacts include things such as flooding, drought, heat waves, wildfires, and landslides.

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Risk: The likelihood of an event happening and the consequence should that event take place.

Sectors: A sector is a component of an integrated system such as an economy or a society. Sectors examined in a vulnerability assessment vary but often include agriculture/food, air, biodiversity/ecosystems, cultural resources, emergency preparedness, energy, fish/fisheries, forestry, infrastructure/built environment, insurance, land management, national security/defense, public health, technology, tourism/recreation, transportation, urban development/land use, water resources, and wildlife. For the Albany Climate Change Vulnerability Assessment and Adaptation Plan, the following sectors were examined: public health, property, transportation, critical facilities, energy, water and sewer, air quality, natural habitat, and urban forest.

Sensitivity: Degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct or indirect.

System: A system is a combination of related parts organized into a complex whole. Urban environments are comprised of interconnected social, infrastructure, and natural systems that provide essential functions and services.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

INTRODUCTION

The City of Albany has been taking action to address climate change since 2005 when Mayor Gerald D. Jennings joined an inaugural group of mayors from around the country in signing the U.S. Mayors' Climate Protection Agreement. Since then, more than 1,000 mayors have signed the agreement, committing to reduce greenhouse gas (GHG) emissions in their communities. The city has moved forward steadily in its efforts to reduce GHG emissions, making progress toward becoming a more sustainable community.

The creation of the Mayor's Office of Energy and Sustainability in 2010 positioned the city to expedite the implementation of activities to reduce energy use and costs for both the government and the community at large. Since the creation of the Office, the city has completed a comprehensive greenhouse gas (GHG) emissions inventory, installed more than 100 Big Belly solar trash compactors and recycling bins around the city, developed a municipal energy conservation policy, and is working to become an electric vehicle ready community. The city also developed a climate action plan that has been integrated into the Albany 2030 Comprehensive Plan, which was adopted by the Albany Common Council in April 2012. The completion of this Climate Change Vulnerability Assessment and Adaptation Plan signifies another step towards securing a more sustainable future for Albany.

Understanding Vulnerability

Understanding vulnerability is a vital part of the climate change adaptation planning process. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC 2007). This report assesses Albany's exposure, sensitivity, and adaptive capacity to an array of changing climate conditions in order to understand how the city is vulnerable to the impacts of climate change.

Methodology

The goal of this Plan is to examine the impacts of climate change, assess how they will affect the city's systems and sectors, and provide recommendations and strategies on how to improve the city's resilience and adaptive capacity. In keeping with the concepts of Albany 2030, the city's comprehensive plan, this plan has been prepared to coordinate with other long range

planning efforts. It provides a baseline understanding of the impacts of climate change, enabling the city to incorporate these impacts into current and future planning endeavors. The approach used during this assessment process also represents a combination of best practices and lessons learned from climate adaptation and hazard mitigation efforts around the country.

The vulnerability assessment begins with a Climate Profile, summarizing Albany's current climate, observed historical trends, and future projections. A number of resources and tools were used to develop the climate profile:

- The Albany County All-Hazard Mitigation Plan
- Historical documents/records

- Federal Hazard Maps
- Federal Emergency Management Agency's (FEMA) National Flood Insurance Program's (NFIP) detailed flood maps and studies
- Geographic Information Systems (GIS)
- Modeling Software - FEMA HAZUS-MH (earthquakes, hurricanes, wind, and floods)

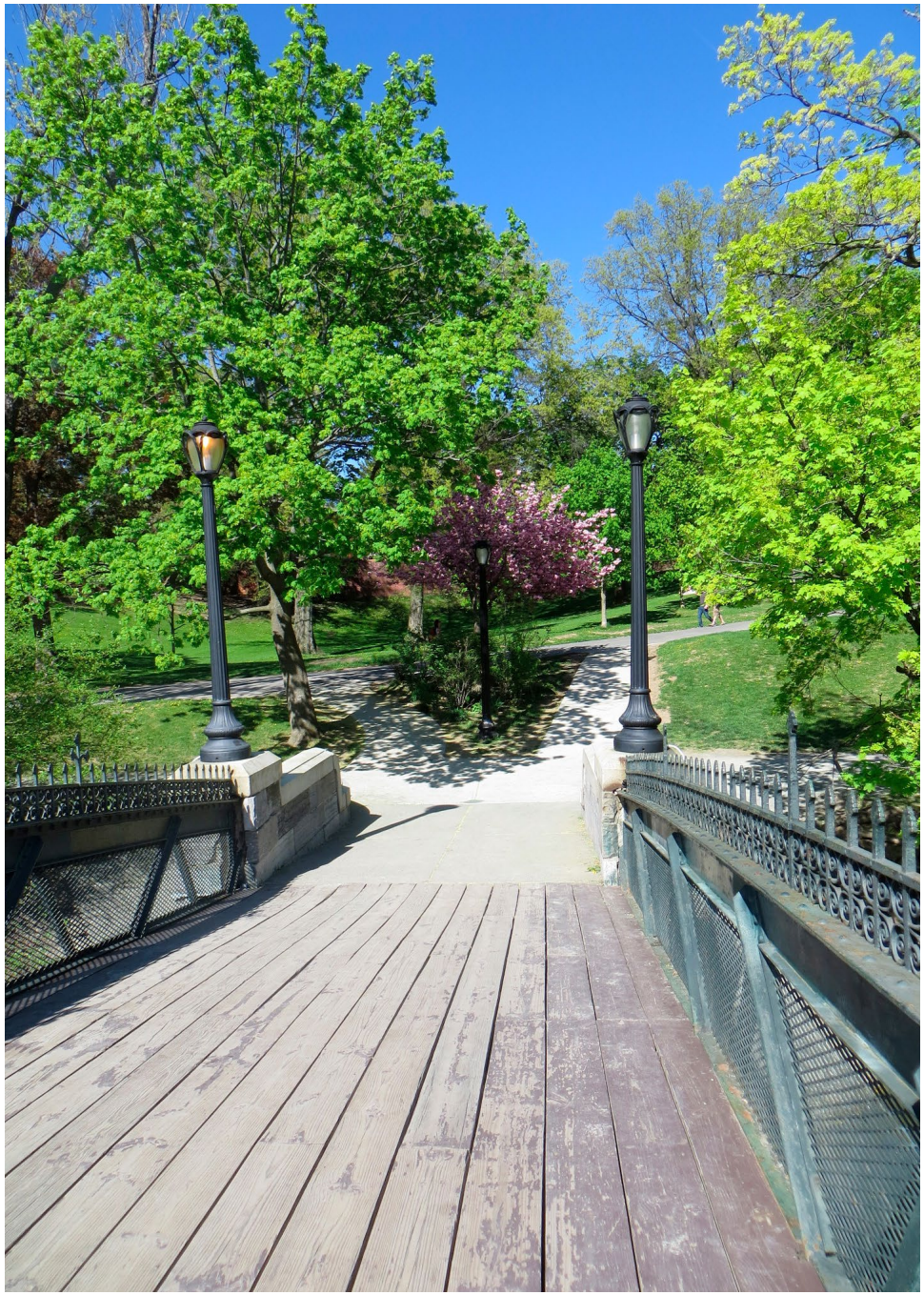
ClimAID gives a comprehensive description of the anticipated changes in climate for each region of New York State. ClimAID was instrumental to the development of this vulnerability assessment, providing regional data on changing climate conditions and examples of how such changes will impact equity and economics, water resources, ecosystems, agriculture, energy, transportation, telecommunications, and public health. These data were applied to the context of Albany in order to understand how Albany could be affected by projected changes in climate. Information for this report was also gathered from the Northeast Climate Impacts Assessment (2007) and the New York City Panel on Climate Change (NYPCC).

Mapping and modeling were used throughout the vulnerability assessment to better understand the spatial organization of the city and how it relates to the impacts of sea level rise and flooding. The 2030 floodplain scenarios were developed using United States Geological Survey's digital elevation model (USGS DEM) data in conjunction with ESRI ArcGIS 3D Analyst. Existing floodplain data supplied by the city were used as a base for the model along with the USGS DEM data. Sea level rise projections for 2030, extrapolated from ClimAID, projects the rapid-ice melt scenario will result in a four to nine inch sea level rise along the lower Hudson River during the 2020s. The rapid ice-melt scenario is based on an acceleration of recent rates of ice melt in the Greenland and west Antarctic ice sheets. Recent scientific studies have found that based on the rates the ice sheets are currently melting the rapid-melt scenario may be more likely than more conservative scenarios (NYSERDA 2011). For the vulnerability assessment for Albany, the upper end of the rapid ice melt scenario range, nine inches, was used for modeling to reflect the 2030 planning horizon of the comprehensive plan. Additional 2030 floodplains were modeled with a nine-inch rise in the base flood elevation to visualize what future flooding could look like in the city. This analysis does not include any increases in precipitation since there is some uncertainty about how precipitation may change over the next 20 years.

After completing the Climate Profile, the project team identified the systems and sectors to examine in the study. Three systems were selected: society, infrastructure and natural resources. The sectors within these systems include public health, property, transportation, critical facilities, energy, water and sewer, air quality, natural habitat, and urban forest.

The final step of the process was to prioritize the areas of vulnerability and make recommendations on adaptation actions. While dollar figures and other quantitative metrics were not available for the analysis, a qualitative risk assessment was conducted that combined the probability of a change happening with the degree of impact that would occur if that change took place. Systems or sectors facing a high probability-high impact event are generally those for which adaptation actions should be prioritized.

Using the results of the vulnerability assessment, the City of Albany has identified an initial set of strategies that will help increase the city's resilience to climate change and natural hazards in general. The city has already begun this process through the Comprehensive Plan, which lays out a blueprint for future development in Albany. This Climate Change Vulnerability Assessment and Adaptation Plan is another tool to help the city better plan for and ultimately build resilience to existing and future climatic changes.



Historic Washington Park's diverse tree inventory will be impacted by climate change.

University at Albany

Mayor's Office of Energy Sustainability
City of Albany, NY

CLIMATE PROFILE

This section provides an overview of the city's historic, current, and projected climate. In addition, projections of changing climate conditions for the region are provided. Information provided in this section serves as the baseline for understanding the impacts of climate change on the social, infrastructure, and natural systems within Albany.

Regional Climate

New York State has a humid continental climate that is characteristic of much of the northeastern United States. The local climate is strongly influenced by variations in latitude, topography, and proximity to large water bodies. Cold, dry air masses from the northern interior of North America, combined with warm, humid air masses from south and south-westerly prevailing winds, create the dominant continental climate of New York State in the winter and summer respectively. Air masses arriving from the North Atlantic Ocean can produce cool, cloudy, and damp conditions typical of a maritime climate, although this influence is secondary to the continental air masses passing through the state (New York State Climate Office n.d.).

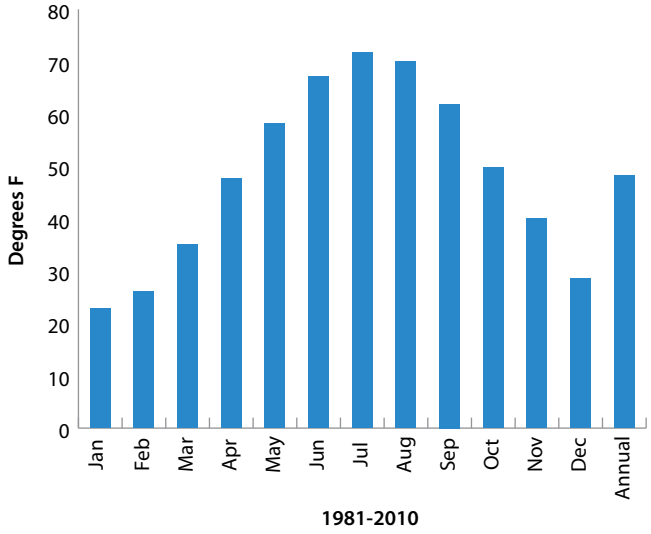
Almost all storm and frontal systems moving eastward across the United States pass through or near New York State. Storm systems moving northward along the Atlantic coast also influence the state's climate, with interior parts of the state experiencing the effects of these coastal storms. New York can also experience extended periods of unusually cold or warm weather when high-pressure systems move through the eastern part of the United States (New York State Climate Office n.d.).

Albany's Climate

Average Temperature

The City of Albany currently experiences an average annual temperature of near 50 degrees Fahrenheit (degrees F). July is the warmest month, with an average temperature of 72 degrees F and January is the coldest month with an average temperature of 23 degrees F (NOAA n.d.). Figure 1 shows the annual average temperature as well as each month's average temperature from 1981 to 2010.

Figure 1
Albany Annual Average Temperature. (NOAA n.d.)



Observed Trends

New York State has experienced a warming trend over the last century, with most of the warming occurring in recent decades and during winter months. **Table 1** shows the observed change in temperature in Albany over various time periods. The warming trend is highest when analyzed over the time period of 1970 to 2008. During this time, the annual temperature increased by more than half a degree Fahrenheit (F) and the average winter temperature increased by over one degree F.

Projected Climate Impact

The annual average temperature is projected to increase by one and a half to three degrees F by the 2020s, three to five and a half degrees F by the 2050s, and four to eight degrees F by the 2080s **(Table 2).** A four to eight degree increase would have a significant impact on the average summer heat index (a measure of how hot it actually feels based on temperature and humidity), as shown in **Figure 2.** The low greenhouse gas emissions scenario in Figure 2 assumes an average annual temperature increase similar to that shown in **Table 2.** The high emissions scenario in Figure 2 assumes a temperature increase of four to eight degrees F by mid-century, and eight to 14 degrees F by the end of the century.

Table 1: Observed Temperature Change in Albany, NY

TIME PERIOD	ANNUAL (˚F / decade)	SPRING (˚F / decade)	SUMMER (˚F / decade)	FALL (˚F / decade)	WINTER (˚F / decade)
1970-1999	0.58*	0.23	0.52	-0.02	1.64**
1970-2008	0.64**	0.23	0.69**	0.47	1.23**
1901-2000	0.18**	0.25**	0.13*	0.06	0.29**

*Significant at the 95% level. **Significant at the 99% level. Source: (NYSERDA 2011)

Table 2: Projected Temperature Changes in the Hudson and Mohawk River Valley (ClimAID Region 5)

	BASELINE	2020s	2050s	2080s
TEMPERATURE (F)	50	+ 1.5 to 3	+ 3 to 5.5	+ 4 to 8

Source: (NYSERDA 2011)

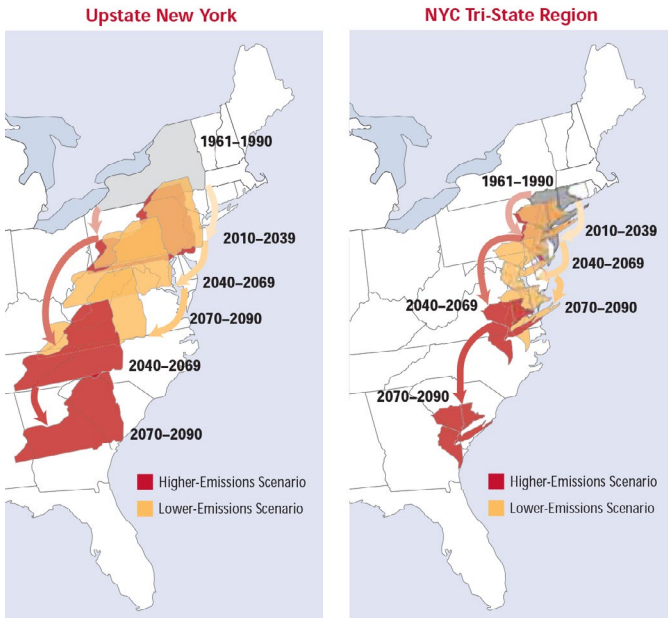


Figure 2
Projected Summer Heat Index in New York. (Frumhoff, et al. 2007)

Figure 3
Days per month in Albany with temperatures over 90° F. (NOAA n.d.)

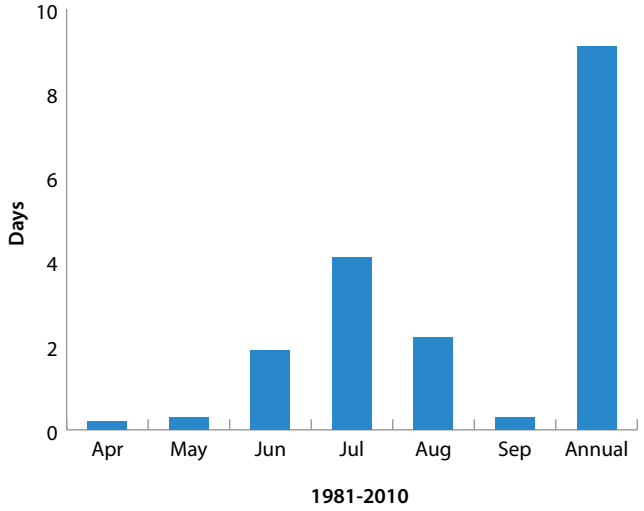
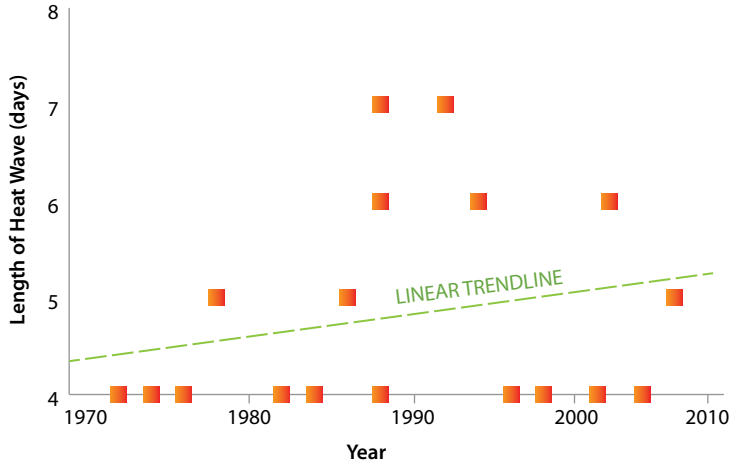


Figure 4
Albany Heat Waves 1970-2010 (NOAA n.d.)



Extreme Temperature

Between 1981 and 2010, Albany experienced an average of 9.1 days over 90 degrees **(Figure 3).** Albany rarely experiences days over 100 degrees, with the last 100-degree day occurring in 1953. The highest temperature on record is 104 degrees F, which occurred on July 4, 1911 (NOAA n.d.). The coldest temperature on record is minus 28 degrees F, recorded on January 19, 1971.

Observed Trends

Albany does experience heat waves (three or more consecutive days with maximum temperatures over 90 degrees F), although heat waves are not an annual occurrence. According to the National Weather Service Forecast Office, heat waves in Albany typically occur during July and August. However, the city has experienced heat waves as early as May (a four day heat wave was recorded on May 30, 1895) and as late as September (four day heat waves were recorded September 1929, 1961, and 1973) (NOAA n.d.). The longest heat wave recorded was a ten-day event in August 1953. More recent heat waves include:

- August 6-9, 2001 (four days)
- August 11-16, 2002 (six days)
- June 7-10, 2008 (four days) (NOAA n.d.)
- July 5-9, 2010 (five days)

Heat wave data supports a warming trend in the region over the last 30 years **(Figure 4).**

Projected Climate Impacts

Climate change is likely to increase average annual high heat days and heat waves in Albany. Projections of future high-heat days and heat waves show an increase from 18 to 75 annual days over 90 degrees F, with two to nine heat waves occurring annually by the end of the century (NYSERDA 2011). Additionally, Albany will likely experience fewer days below 32 degrees F. **Table 3** outlines the projected changes in extreme temperature throughout the 21st century.

Table 3: Changes in Extreme Heat and Cold Events for Saratoga Springs (ClimAID Region 5): minimum, central range*, maximum					
		BASELINE	2020s	2050s	2080s
HEAT WAVES AND COLD EVENTS	**Number of days per year with maximum temperature exceeding**				
	90 F	10	11 (14 to 20) 28	17 (20 to 35) 49	18 (26 to 60) 75
	95 F	1	1 (2 to 4) 7	3 (3 to 10) 18	3 (6 to 25) 42
	Number of heat waves per year**	2	2 (2 to 3) 4	3 (3 to 5) 7	3 (4 to 8) 9
	Average heat wave duration	4	4 (4 to 5) 5	4 (4 to 5) 6	4 (5 to 6) 9
	Number of days per year with min. temp. at or below 32 F	134	121 (128 to 139) 147	92 (111 to 127) 135	78 (90 to 120) 131

*The central range refers to the middle 67% range of values from model-based probabilities across the global climate models and greenhouse gas emissions scenarios.
**Heat waves are defined as three or more consecutive days with maximum temperatures over 90 degrees F.
Source: NYSERDA 2011

Table 4: Precipitation Patterns in Albany, NY 1971-2000		
SEASON	**TOTAL INCHES**	**AVERAGE NUMBER OF DAYS ABOVE 1 INCH**
Spring	10.09	3
Summer	10.92	3
Fall	9.85	3
Winter	7.74	0
Annual	**38.6**	**9**

Source: (New York State Climate Office n.d.)

Precipitation

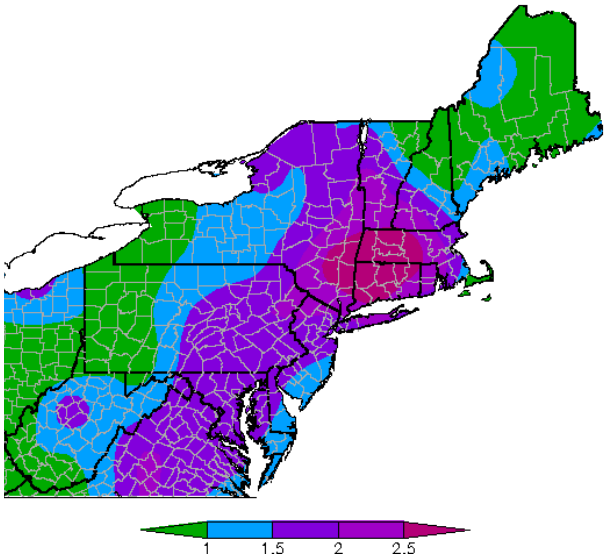
Average Precipitation

Albany currently experiences approximately 39 inches of precipitation each year, with the summer, spring, and fall seasons each contributing between 10 and 11 inches each (Table 4). Winter precipitation is the lowest, contributing 7.74 inches to the total average annual precipitation. Albany typically does not experience winter days with non-snow precipitation above one inch.

Observed Trends

A comparison of the two most recent thirty-year period averages indicates an overall increase in annual precipitation. Figure 5 shows the difference in normal precipitation between the periods of 1971 – 2000 and 1961 – 1990. This comparison shows that average annual precipitation has increased by approximately 2.5 inches in Albany (Northeast Regional Climate Center 2009). Precipitation measured in inches per decade also increased between 1900 and 2000 in Albany by 1.13 inches, a difference that is statistically significant at the 99 percent interval (NYSERDA 2011). However, when looking at the time period, 1970 to 2008, there is no statistically significant change in precipitation per decade.

Figure 5
Difference in normal precipitation between the two 30 year periods: 1971-2000 and 1961-1990 annually. (Northeast Regional Climate Center 2009)



According to ClimAID, "These results point to the dominant influence of natural variability at decade-to-decade timescales on precipitation, and suggest that average precipitation changes over the region's observed historical record cannot be attributed to climate change" (NYSERDA 2011, 22).

Projected Climate Impacts

Variations in the observed trends, as well as challenges with modeling, make future projections of precipitation highly uncertain. ClimAID does provide some rough projections. By the 2050s, Albany could experience up to a five percent increase in overall precipitation and between a five and ten percent increase by the 2080s **(Table 5).** Much of this increase is expected to occur during the winter months **(Table 6).**

Table 5: Projected Precipitation in the Hudson and Mohawk River Valley (ClimAID Region 5)

	BASELINE (1971-2000)	2020s	2050s	2080s
Precipitation	39 in*	+ 0 to 5%	+ 0 to 5%	+ 5 to 10%

Source: (NYSERDA 2011)
*The 39 inch baseline in annual precipitation is specific for Albany. The annual precipitation baseline came from the New York State Climate Office's Climate Summary for the City of Albany. (New York State Climate Office n.d.)

Table 6: Percent Changed Projected in Seasonal Precipitation in the Hudson and Mohawk River Valley by 2050s

WINTER	SPRING	SUMMER	FALL
+5 to +15	-5 to +10	-5 to +5	-5 to +10

Source: (NYSERDA 2011)

Snowfall may actually increase in the next few decades due to intensified lake-effect snow. Lake-effect snow is a result of weather systems moving over the Great Lakes and picking up moisture from these bodies of water. When the lakes are frozen, the systems do not pick up moisture. Seasonal ice cover has decreased on the Great Lakes by eight percent per decade over the past 35 years, enhancing the lake-effect snow in New York. However, according to ClimAID "by mid-century, lake-effect snow will generally decrease as temperatures below freezing become less frequent" (p. 36) (Kunkel et al., 2002 in NYSERDA 2011).

Extreme Precipitation

An extreme precipitation event is defined as a 24-hour period with over one inch of precipitation. Between 1981 and 2010, the average number of extreme precipitation days per year was 7.5 days (Northeast Regional Climate Center 2009).

Observed Trends in Extreme Precipitation

In regards to precipitation, it is not just the total annual amount that has been changing but also distribution and intensity. Recent work by DeGaetano (2009) assessed trends in extreme rainfall occurrence across the conterminous U.S. Approximately two-thirds of the trends in rainfall amounts for storms with 2- 5- and 10-year return periods were positive, and an even higher

Table 7: Projected Changes in Extreme Precipitation Events for Saratoga Springs (ClimAID Region 5): minimum, central range*, maximum					
	EXTREME EVENT	**BASELINE**	**2020s**	**2050s**	**2080s**
INTENSE PRECIPITATION	Number of days per year with rainfall exceeding:				
	1 inch	10	8 (8 to 11) 12	9 (10 to 11) 12	10 (10 to 12) 14
	2 inches	1	1 (1 to 2) 2	1 (1 to 2) 2	1 (1 to 2) 2

*The central range refers to the middle 67% range of values from model-based probabilities across the global climate models and greenhouse gas emissions scenarios.
Source: (NYSERDA 2011)

percentage were positive in the Northeast. A positive trend in the number of events greater than one inch (within 24 hours) from 1961-2000 in NYS is shown in **Figure 2** (red line). *(http://wri.eas.cornell.edu/climate_change.html)*

Trends in Extreme Precipitation Events in the Northeast from 1948-2007: *www.amwa.net/galleries/climate-change/2010_NortheastExtremePrecip.pdf*

Projected Changes

Although annual increases in precipitation are likely to be minimal and uncertain, larger increases are projected in the frequency, intensity, and duration of extreme precipitation events (NYSERDA 2011). **Table 7** shows the projected number of annual precipitation events with rainfall exceeding one and two inches from the 2020s through the 2080s. The number of precipitation events above one and two inches may or may not increase depending on the emissions forecast scenario.

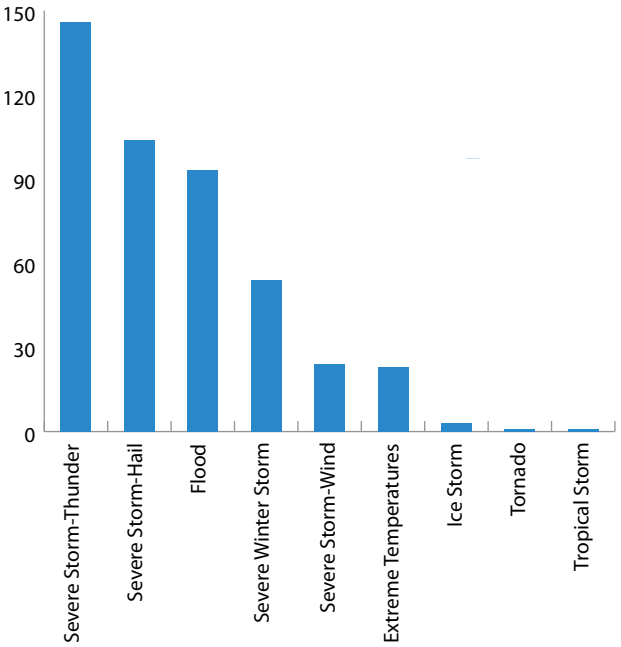
Severe Weather

The Albany County All Hazard Mitigation Plan (2007) evaluated, scored, and ranked 32 hazards applicable to Albany County. Severe storms, ice storms, landslides, severe winter storms, tornadoes and floods all scored in the "Moderately High Hazards" category. Moderately low natural hazards include wildfire, extreme temperatures, earthquake, hurricane, blight, epidemic, ice jam, drought and infestation.

Severe storms are the most frequent weather event that Albany has experienced **(Figure 6).** Severe storms include hail storms, windstorms, or severe thunderstorms. According to the National Weather Service, 20 to 25 thunderstorms occur in Albany County annually; each year a few of these storms are considered severe (Albany County 2007 and NOAA National Severe Storms Laboratory 2006).

Nor'easters frequently occur from September through April, bringing heavy precipitation in the form of ice, rain and/or snow as well as strong winds. Many of Albany's most severe flooding events have been the result of nor'easters.

Figure 6
Albany County Hazard Frequency 1991 – 2011 (NOAA n.d.)



Projected Changes

According to ClimAID, "some of the extreme events that have a large impact throughout the state cannot be quantitatively projected into the future at local scales due to the high degree of uncertainty" (NYSERDA 2011, 36). By the nature of being 'extreme,' such events are rare and difficult to predict and project with any sort of future frequency. This is in part due to the uncertainty as to how climate change is impacting extreme weather events. However, a recent study from the Proceedings of the National Academy of Sciences of the United States of America has found evidence connecting extreme weather to climate change. The article, which came out in March of 2012, reported that the recent warming trend (which is more than three standard deviations warmer than the climatology of the 1951 – 1980 base period) lends a "high degree of confidence that extreme anomalies such as those in Texas and Oklahoma in 2011 and Moscow in 2010 were a consequence of global warming because their likelihood in the absences of global warming was exceedingly small" (Hansen, Sato and Ruedy 2012, 1).

Nor'easters, Hurricanes, and Tropical Storms

NYSERDA provides climate projections for frozen precipitation, large-scale storms (tropical storms, hurricanes and nor'easters), and associated extreme wind. It states that, "intense mid-latitude, cold-season storms, including nor'easters are projected to become more frequent and take a more northerly track" (Kunkel et al., 2008 in NYSERDA p. 36 2011). The Northeast Climate Impact Assessment (NECIA) suggests that by the end of the century (under the high emissions scenario), between five and 15 percent more late-winter storms will move far enough north to affect the Northeast. This translates to about one additional late-winter storm per year. Little change is projected under the low emission scenario (Frumhoff, et al. 2007).

There is still significant scientific debate as to whether or not hurricanes will become more frequent or more intense as a result of climate change. It is hypothesized that warmer surface waters in the tropics may lead to the formation of more tropical depressions, many more of which may develop into stronger hurricanes. However, ClimAID points out that "other critical factors in the formation and intensity of these storms are not well known, including changes in wind shear, the vertical temperature gradient in the atmosphere, and patterns of variability such as the El Nino Southern Oscillation climate pattern and large-scale ocean circulation" (NYSERDA 2011, 36).

Thunderstorms

There is also debate as to whether or not thunderstorms will become more frequent as a result of climate change. A study conducted by Purdue University found that climate change could make conditions more favorable for thunderstorms in the eastern United States. Thunderstorms require three ingredients to form: moisture, rising unstable air, and a source of lift, which is often created by heat from the sun. The Purdue study concluded that some areas, including New York, could experience a future increase in the number of days with severe thunderstorm conditions (NDSEV) of 100 percent or more (Trapp et al. n.d.). However, the models used in this study are not adequate for local planning efforts.

Sea Level Rise and Flooding

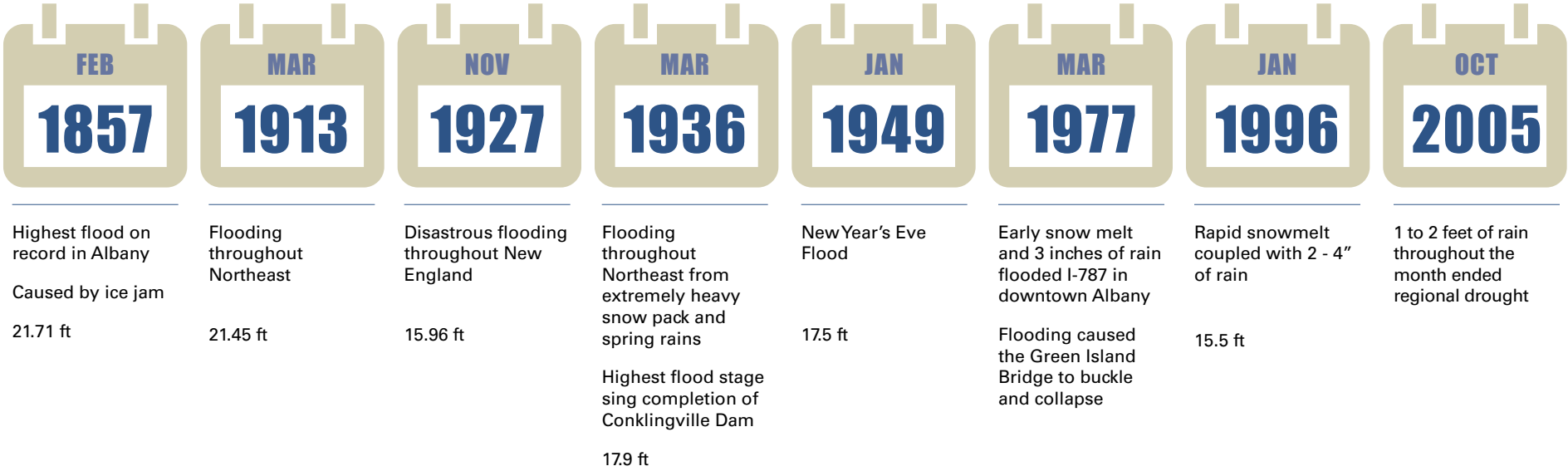
Even though Albany is not a coastal community, the city is located on the tidal Hudson River. The Hudson is affected by changes in sea level as far north as the dam in Troy, which is just north of Albany, leaving the city vulnerable to sea level rise. The level of the Hudson River is also important for flooding in the city. The base flood elevation, the level of floodwater expected to occur once in a hundred years, would be raised as changes in sea level causes the Hudson River to rise. A higher base flood level would increase the amount of land vulnerable to flooding. Currently, the city has 1,509

acres of land in the 100-year floodplain and 226 acres in the 500-year floodplain. This land includes much of the city's downtown. As of October 2011, Albany property owners had 160 policies with the National Flood Insurance Program. All properties located in the floodplain are insured for an aggregate of over $40 million dollars.

Observed Trends

Albany has a long history of flooding. In 1857, the highest flood ever recorded in Albany was a 21. 71-foot flood caused by an ice jam on the sandbars south of the city. The January 1996 flood is the most recent significant flooding event to affect the city. This flood was a result of a warm spell that brought two to four inches of rain and caused over 45 inches of snow to melt (NOAA n.d.). Most recently, in 2011, the remnants of Tropical Storm Irene caused significant flooding in downtown Albany. According to a hydrologist with the U.S. Geological Survey, Irene was just below the 100-year flood level in the city, measuring at 15.4 feet above the base elevation of the River (Coleman 2011). **Figure 7** describes some of Albany's other historical flooding events and **Map 1** shows Albany's current floodplain map.

Figure 7
Albany's historical flood events with flood stages in feet. (NOAA n.d.)



Map 1: Current 2030 Floodplains

Projected Changes

According to ClimAID, the Capital Region can expect a one to nine inch rise in the Hudson River by the 2020s, depending on the climate model scenario used **(Table 8).** By the 2080s, the city can expect an eight to 18 inch rise in the Hudson River, or a 37 to 50 inch rise under the rapid ice melt scenario. Such changes will exacerbate flooding throughout the city. This sea level rise, coupled with more frequent extreme precipitation events, could lead to more recurrent and severe flooding for Albany. **Map 2** shows what the floodplain might look like based on a nine-inch raise in the Hudson. According to this scenario, 1,764 acres of Albany would be at risk for flooding during a 100-year flood event and 289 acres would be at risk during a 500-year flood event.

Severe flooding occurred after Hurricane Irene

Table 8

MID-HUDSON & CAPITAL REGION	2020s	2050s	2080s
Sea Level Rise*	1 to 4 in	5 to 9 in	8 to 18 in
Sea level rise with rapid ice-melt scenario**	4 to 9 in	17 to 26 in	37 to 50 in

*Shown is the central range (middle 67%) of values from model-based probabilities (16 global climate models by 3 GHG emissions scenarios) rounded to the nearest inch

**The rapid ice-melt scenario is based on acceleration of recent rates of ice melt in the Greenland and west Antarctic ice sheets and paleoclimate studies

Source: (NYSERDA 2011)

Map 2: Future 2030 Floodplains

Indirect Impacts of Climate Change

While this report focuses on the direct impact of climate change to the infrastructure, people, and natural resources within the city, it is important to note that many of the regional and global impacts of climate change will also have implications for Albany. For example, the City of Albany relies on goods and services (water, energy, and food) from regions that may be severely impacted by climate change. Albany could also become a destination for populations displaced from other regions due to climate factors. The White House's Interagency Climate Change Adaptation Progress Report states, "local impacts from climate change, such as crop loss or severe flooding, often have consequences that extend beyond regional or even national borders—for example, changes in human migration and disruptions of food supply." (White House Council on Environmental Quality 2010, 7). This report does not explore the indirect impacts of climate change on the City of Albany but acknowledges that future work in this area may be needed.

Table 9. Climate Impacts and Vulnerable Populations in Albany (NYSERDA 2011)

CHANGING CLIMATE CONDITION	CLIMATE IMPACT	PLANNING AREA	VULNERABLE POPULATIONS
Increased temperature, more high-heat days and heat waves	Heat-related illness	Public Health	Outdoor workers, athletes, children, elderly, asthmatics, low-income, pre-existing illness
	More vector-borne diseases	Public Health	All populations
Increased Precipitation and Flood Events	Damage to property	Economic	Low income, small business owners, single parent households
	Respiratory illness from mold and toxic flood residue in homes	Public Health	Children, elderly, asthmatics, low-income, pre-existing illness
	Increased pollutants in water supply from run-off, could lead to gastrointestinal diseases	Public Health	Children, elderly, low-income, pre-existing illness
	Disrupted transportation service	Transportation	Low-income, elderly, individuals with pre-existing illness

Mayor's Office of Energy & Sustainability

SOCIAL SYSTEM PROFILE

The projected increases to Albany's climate in terms of temperature and precipitation, flooding and other extreme weather events will affect the various social systems within the city. While all individuals in Albany will be affected by changes in climate, some populations are more vulnerable than others. According to ClimAID, the following populations are most vulnerable to climate impacts in New York State: children and the elderly; asthmatics and individuals with pre-existing illnesses; low-income groups; small business owners; and outdoor workers and athletes. Additionally, those who do not speak English or those who are more socially isolated are likely to be more vulnerable to an array of climate impacts than those who understand English and are socially connected.

Economic Vulnerability

One of the frequent metrics used to assess vulnerability is household income. The reason for this is that, generally, low-income individuals and families have less flexibility in their financial resources, meaning they are less able to allocate resources to things like disaster recovery or preventative maintenance. Without financial resources or strong social networks that can assist during times of trouble, lower income families are less likely to rapidly and effectively rebound from extreme weather events. This vulnerability can be compounded with other stressors such as the loss of a job or family illness.

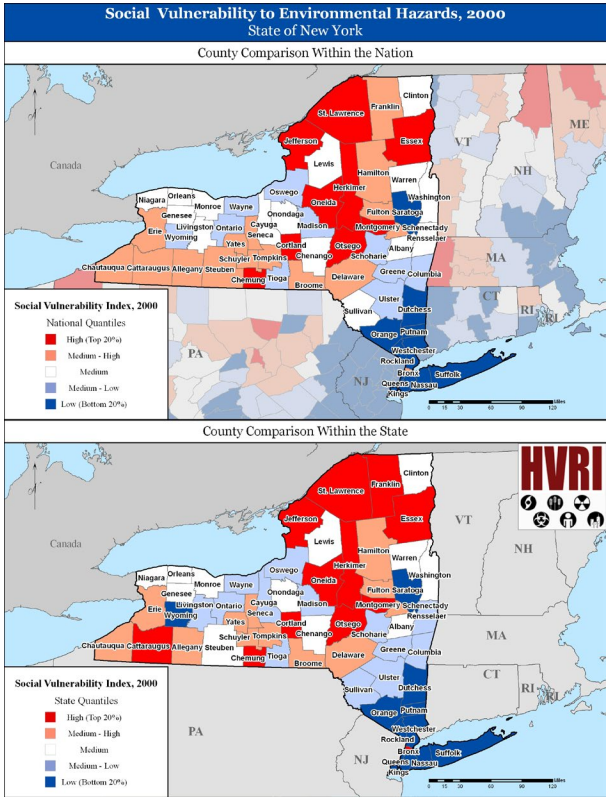
Currently, Albany has a median household income of $38,642, which is approximately $16,000 less than the median income for New York State **(Table 10).** Albany also has a much higher percentage of its population in poverty than the state average (25.4 percent compared to the statewide average of 13.8 percent). These factors combined indicate that the City of Albany has a disproportionately high percentage of economically vulnerable individuals and families.

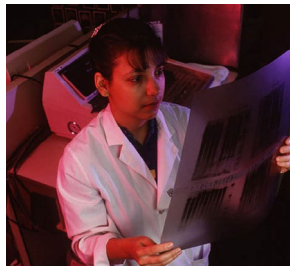
Table 10: Median Income and Poverty Data for Albany 2005-2009

INCOME INDICATOR	ALBANY	NY STATE
Median Household Income	$38,642	$55,233
People of all ages in poverty (%)	25.4%	13.8%

Source: U.S. Census Bureau. American Community Survey. 2005-2009. 10 January 2012

Figure 8
Social Vulnerability of Albany County Relative to New York State and Nationally (Hazards and Vulnerability Research Institute 2011)





Social Vulnerability

The Social Vulnerability Index (SoVI)[1] is a tool commonly used to map vulnerable populations relative to environmental hazards, such as severe storms and flooding. As shown in **Figure 8,** Albany County has a "medium" level of social vulnerability compared to New York State and the United States as a whole. **Map 3** further differentiates the location of vulnerable populations in the City of Albany, demonstrating that some of most vulnerable populations are located in the northern and western portions of the city. Some of these areas will likely be affected by a 2030 100-year flood event, including areas of elevated highway, industrial land, and public land.

The remainder of this section will focus on how the public health sector is likely to be impacted by changes in climate.

Public Health

Many of the impacts likely to affect the City of Albany fall under the umbrella of public health. High heat days and longer growing seasons reduce air quality, increase the risk of heat-related illnesses, and could result in longer breeding seasons and ranges for pests that carry diseases harmful to humans. Increased precipitation can lead to mold and increased risk of gastrointestinal (GI) diseases. Flooding and other extreme weather events result in service disruption, property damage and other complications that can delay emergency service providers or prevent people from reaching treatment.

Air Quality

Air quality is a concern with climate change because high-heat days result in elevated levels of ground-level ozone, a gas that is harmful to human health. According to the EPA, "sunlight and high temperatures, combined with other pollutants such as nitrogen oxides (which comes from vehicle exhaust and other combustion engines) and volatile organic compounds, can cause ground-level ozone to increase" (EPA 2011). Ground-level ozone can damage lung tissue and it is especially harmful for those with asthma and other chronic lung disease (EPA 2011). Higher temperatures and atmospheric carbon dioxide levels also lead to higher pollen counts, which affects individuals with allergies, asthma, and other respiratory ailments (NYSERDA 2011).

1 The Social Vulnerability Index (SoVI) was developed by the Hazards and Vulnerability Research Institute (HVRI). SoVI is a tool recommended by the National Oceanic and Atmospheric Administration (NOAA)'s for assessing social vulnerability as part of NOAA's Road Map for Adapting to Coastal Risk process. HVRI website: http://webra.cas.sc.edu/hvri/products/sovi_maps.aspx, NOAA: http://www.csc.noaa.gov/digitalcoast/training/roadmap/index.html

Map 3: Social Vulnerability

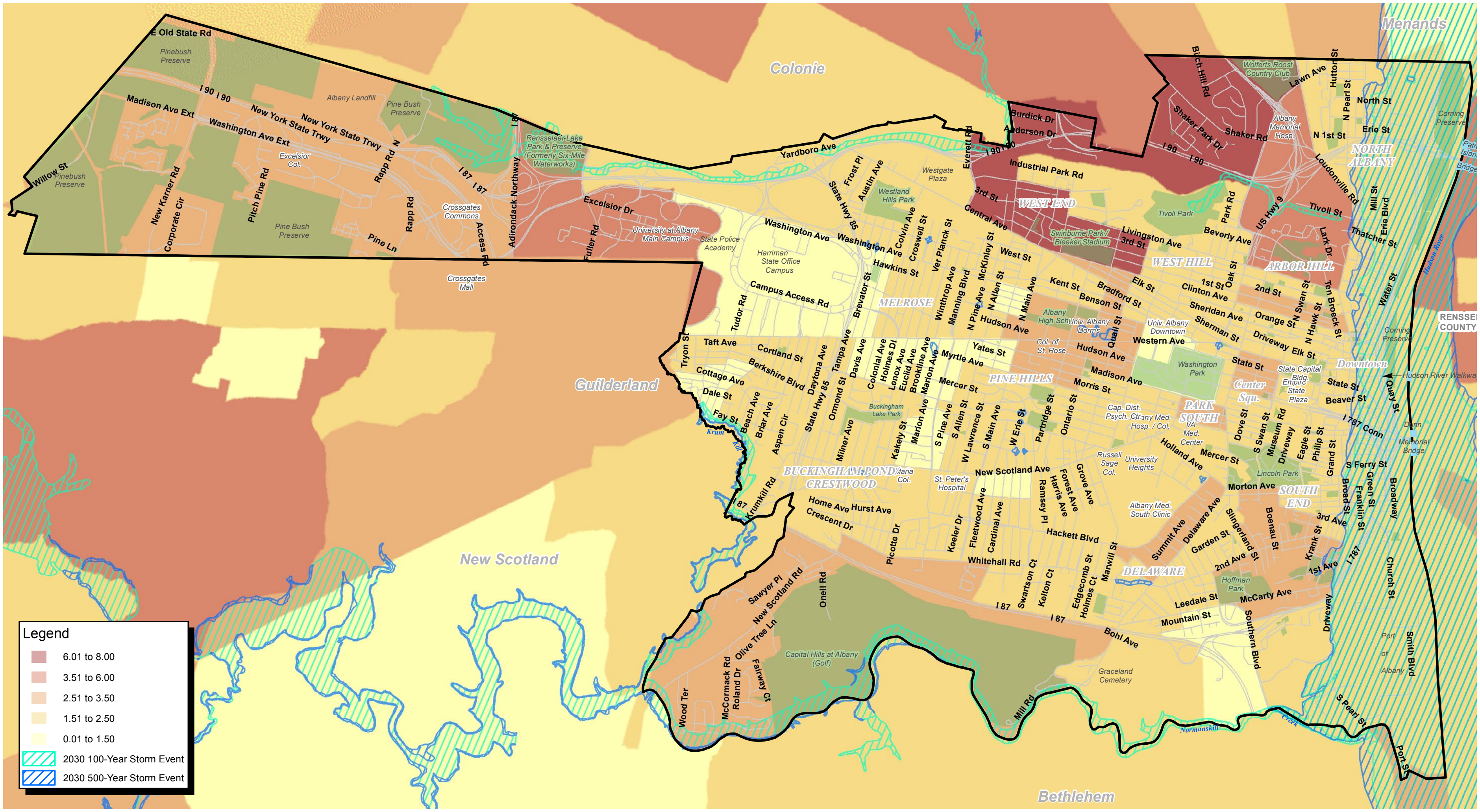


Figure 9

Annual number of days with an Ozone Air Quality Index (AQI) above 100 from 2000-2010.

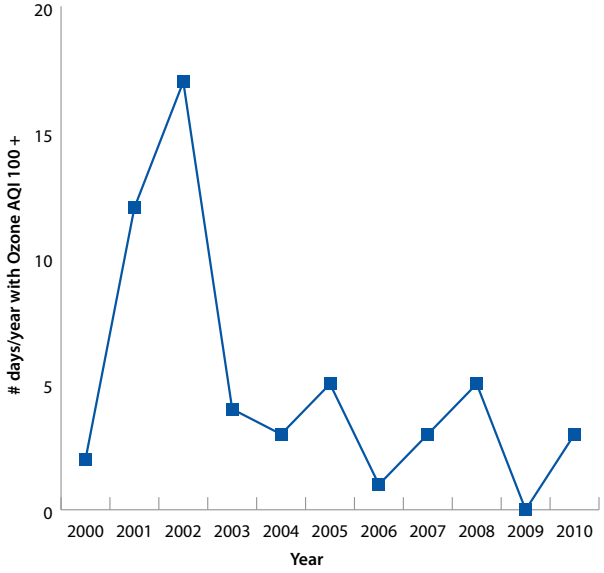
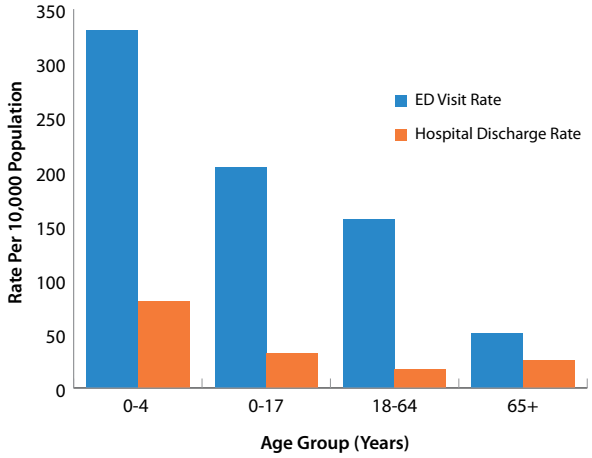


Figure 10

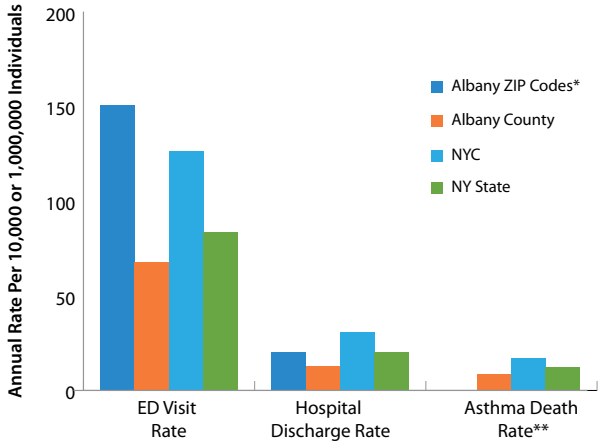
Emergency Department (ED) visit and hospital discharge rates for asthma in Albany (2007-2009)



Source: Statewide Planning and Research Cooperative System (SPARCS). *Information on Asthma in New York State,* September 2011. 10 January 2012.

Figure 11

New York Regional Asthma Emergency Department, Hospital Discharge, and Death Rates (2007-2009)



* Albany zip codes may include areas outside the geographic boundary of the City of Albany.

** Asthma death rate is per 1,000,000 individuals. All other rates are per 10,000 individuals. Data not available for Albany zip codes.

Source: Statewide Planning and Research Cooperative System (SPARCS). *Information on Asthma in New York State,* September 2011. 10 January 2012. www.health.ny.gov/statistics/ny_asthma/

Over the past ten years, Albany County had an average of five days per year where the ozone Air Quality Index (AQI) levels were above 100, the threshold at which air quality is considered unhealthy for sensitive individuals **(Figure 9).** The city will likely experience more high ozone days as the number of extreme heat days per year increases.

Asthma

Children are disproportionately affected by poor air quality because they have the highest asthma rates of all age groups. According to the 2009 New York State Asthma Surveillance Summary Report, children ages 5-9 years have the highest rates of existing cases of asthma and children aged 0-4 had the highest emergency department and hospitalization discharge rates **(Figure 10).**

The City of Albany has higher average asthma emergency department and hospital discharge rates than those of Albany County and New York State **(Figure 11).** The average emergency room visit rate for zip codes located within the City of Albany even surpassed the New York City region, which has the highest asthma rates in all of New York State.[2] Asthma related-hospital visits are more common in low-income individuals who do not have access to asthma control medications or regular doctor visits. This relatively high emergency room visit rate in the city suggests that many asthma cases occurred in individuals without

2 Note that individual zip codes within New York City may exceed the emergency room asthma rates of individual Zip Codes located within the City of Albany. However, when averaged together, zip codes in the City of Albany exceeded the average rate of New York City's five counties.

health insurance or regular access to medical care (NYSERDA 2011). Economically, the average cost of asthma hospitalizations increased by 91 percent between 1998 and 2007 (New York State Department of Health 2009). As the climate continues to change, it is very likely that asthma rates will continue to climb, leading to higher hospitalization rates and growing economic expenses.

Indoor Air Quality

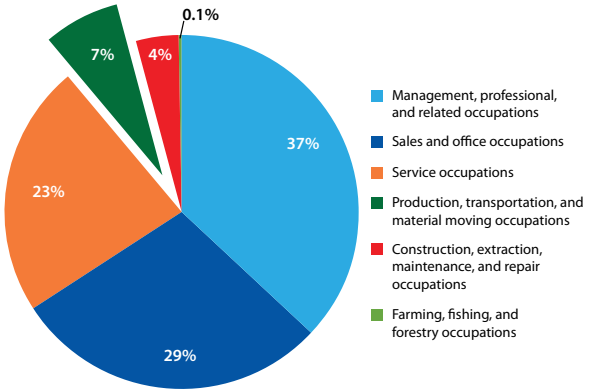
Indoor air quality could also be affected by climate change as more frequent and extreme precipitation and flooding leads to increased mold growth. Damp buildings are ideal habitats for molds, which can cause increased respiratory diseases and asthma (NYSERDA 2011). Mold can also result from an increased level of moisture in the air—something a warmer climate will likely bring. Low-income populations may be particularly vulnerable to mold as they may lack the financial resources for remediation. Renters may also be more vulnerable to mold if their rental properties are not properly maintained. Overall, older buildings are most likely to develop mold growth due to inadequately sealed building envelopes, poor heating ventilation, and air conditioning (HVAC) systems.

Heat Related Illness

High heat days can lead to heat-related illnesses such as heat stroke and heat exhaustion. The City of Albany currently has a "Code Blue" warning system to alert individuals of extreme cold spells and to move the homeless populations indoors however, no such warning system exists for high heat days. The city does provide cooling centers for individuals on hot days to avoid heat-related health problems. Data were not available to show current or past hospitalization discharge and emergency room visit rates for heat related illness in Albany or to indicate how many residents have air conditioners in their homes. However, national studies indicate that increased urban temperatures are directly contributing to higher hospitalization rates and increasing mortality (National Climate Assessment, 2013).

Young children, the elderly, and those with cardiovascular diseases face increased vulnerability during high heat days. People who are active and work in outdoor environments are also at higher risk of heat related health illnesses compared to inactive individuals and those who spend most of their time indoors (NYSERDA 2011). The majority of Albany's workforce is in an occupation that does not require outdoor work or physical labor. However, as shown in **Figure 12** approximately 11 percent of the population works in occupations that could put employees at risk on high heat days. Albany's college and young adult populations could be more susceptible to heat-related illness. These populations are often active in afternoon sports, taking place during peak daytime heat.

Figure 12
Albany Occupations by Type (2005-2009)



Source: U.S. Census Bureau. American Community Survey, 2005-2009. 10 January 2012. http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId

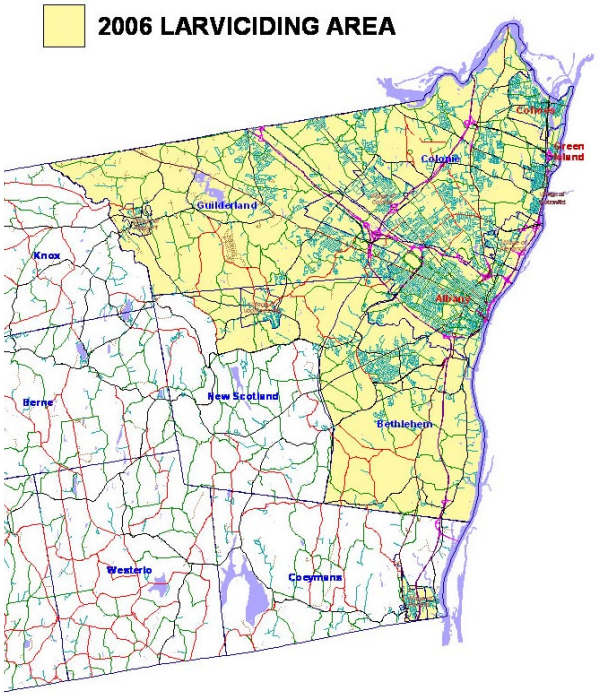
Vector-borne Diseases

Warmer weather resulting from climate change could lead to longer breeding seasons and expanded ranges for pests such as ticks and mosquitoes that carry diseases harmful to human health, such as Lyme disease and West Nile Virus.

Lyme Disease

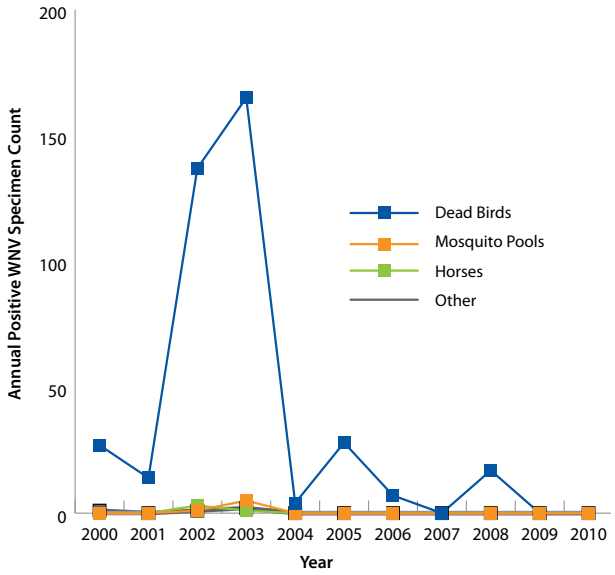
Lyme disease is a bacterium that is transmitted to humans through ticks infected with the disease. New York State has the highest number of reported cases of Lyme disease in the United States, with over 95,000 cases reported since 1986 (Wadsworth Center n.d. and New York State

Figure 13
2006 Larviciding map of Albany County.



Department of Health 2011). Because deer ticks are currently active from May through November, and can be active anytime the temperature is above freezing (New York State Department of Health 2011), Albany should be prepared for more cases of Lyme disease as summers grow longer and winters become shorter.

Figure 14
Number of positive West Nile Virus (WNV) specimens in Albany County (2000-2010)



West Nile Virus

West Nile Virus is an infection carried by mosquitoes that can cause encephalitis in humans (New York State Department of Health 2011). As shown in **Figure 13** positive test results for West Nile virus have been found in dead birds and other animals in Albany County since 2000. However, it was not until September 2011 after Tropical Storm Irene that the first human case of West Nile virus was reported in Albany County.

In a statement made by Albany County Health Commissioner.

> "This first human case of West Nile virus illness in Albany County appears to be a direct consequence of the unprecedented floods caused by the recent hurricane and tropical storm. It is important to note that West Nile virus illness can be prevented. Taking personal protective measures to reduce exposure to mosquito bites can considerably reduce the risk of getting West Nile virus illness."
>
> (Albany County Department of Health 2012)

Albany County has a West Nile Virus control plan that emphasizes education and non-pesticide methods for eliminating mosquito breeding sites, although the Albany County Health Department uses larvicides to reduce mosquito populations in urban areas such as the City of Albany **(Figure 14)** (Albany County Department of Health 2012). Despite management efforts, it is possible that the city will see more cases of West Nile Virus and other vector borne diseases as conditions become more conducive to their growth in the region.

INFRASTRUCTURE SYSTEM PROFILE

Increased high heat days, heat waves, and flooding present challenges to Albany's infrastructure. Transportation, water, and critical facilities are examples of infrastructure that provide vital services to the community. When this infrastructure becomes compromised, there are immediate and significant cascading impacts. For example areas may be cut off from emergency vehicular access, drinking water supplies could become contaminated or otherwise compromised, and businesses may have to shut down in the absence of transportation networks. Table 11 indicates some of Albany's vital infrastructure that is located in today's floodplain, as well as the projected future floodplain. Flooding is just one impact of climate change on infrastructure—extreme heat can also be highly damaging. This section describes how the impacts of climate change may affect Albany's transportation, water and sewer, critical facilities, and energy infrastructure.

Table 11. Infrastructure in the Floodplain

		PRESENT	2030
Transportation	Local Roads (miles)	21.25	30.3
	State Roads & Highways (miles)	11.78	16.94
	Private Roads (miles)	0.22	0.23
	Public Transit Routes (miles)	226.41	392.7
	Bus Terminals (miles)	135	277
	Rail Road (miles)	10.67	13.36
	Bikeways* (miles)	9.39	11.61
Water	Water Supply	n/a	n/a
	Pump Stations (number)	10	10
	Outfalls (number)	11	11
Critical Facilities	Fire Stations (number)	1	1
	Police Stations (number)	1	1
	Public Libraries (number)	0	1
	Schools (number)	0	2
	Health Services (number)	0	0

*Including Proposed

Transportation

Albany's transportation infrastructure is an interconnected network of a variety of overlapping and complementary systems. These systems include public transportation, state roads and highways, local roads, railroads, and aviation. All of these systems cannot function as intended without one other. Their redundancies and individual services are designed to provide the city with a resilient and efficient transportation network.

Public Transportation

The City of Albany is served by a regional bus system managed by the Capital District Transportation Authority (CDTA). Currently 226 miles of bus routes are within the floodplain. Based on future sea level rise, this number will likely almost double by 2030 to 393 miles. Bus stations and other CDTA facilities will also be at an increased risk to flooding. For example, the CDTA's administrative office and bus maintenance facility, located at 110 Watervliet Avenue will likely be in the 100-year floodplain by 2030 according to the model. The Greyhound Bus Terminal and the Broadway BusPlus station will be in the 100-year floodplain by 2030 according to the model. The South Pearl BusPlus station (also a main transfer hub) will likely be inundated during a 500-year flood event.

Extreme heat can also cause rider discomfort and worker safety issues. London has taken preventative measures by painting the roofs of its iconic red buses white in order to reflect heat (US Department of Transportation 2011).

State Roads and Highways

Interstate-90, -87 and -787 all serve the City of Albany. Currently there are 12 miles of state roads and highways in the floodplain; by 2030 this number could increase to 23 due to sea level rise. This includes the I-90/ I-787 and the I-787 and the S Mall Arterial exchanges. The elevated highways will be spared from flooding; however the exit and entrance ramps and the underpasses could be affected by the anticipated flooding. The remnants of Irene caused significant flooding in this area. **Figure 15** shows flooding from Irene at Broadway in Albany. As the climate changes, this type of flooding will likely occur more often and expand further inland.

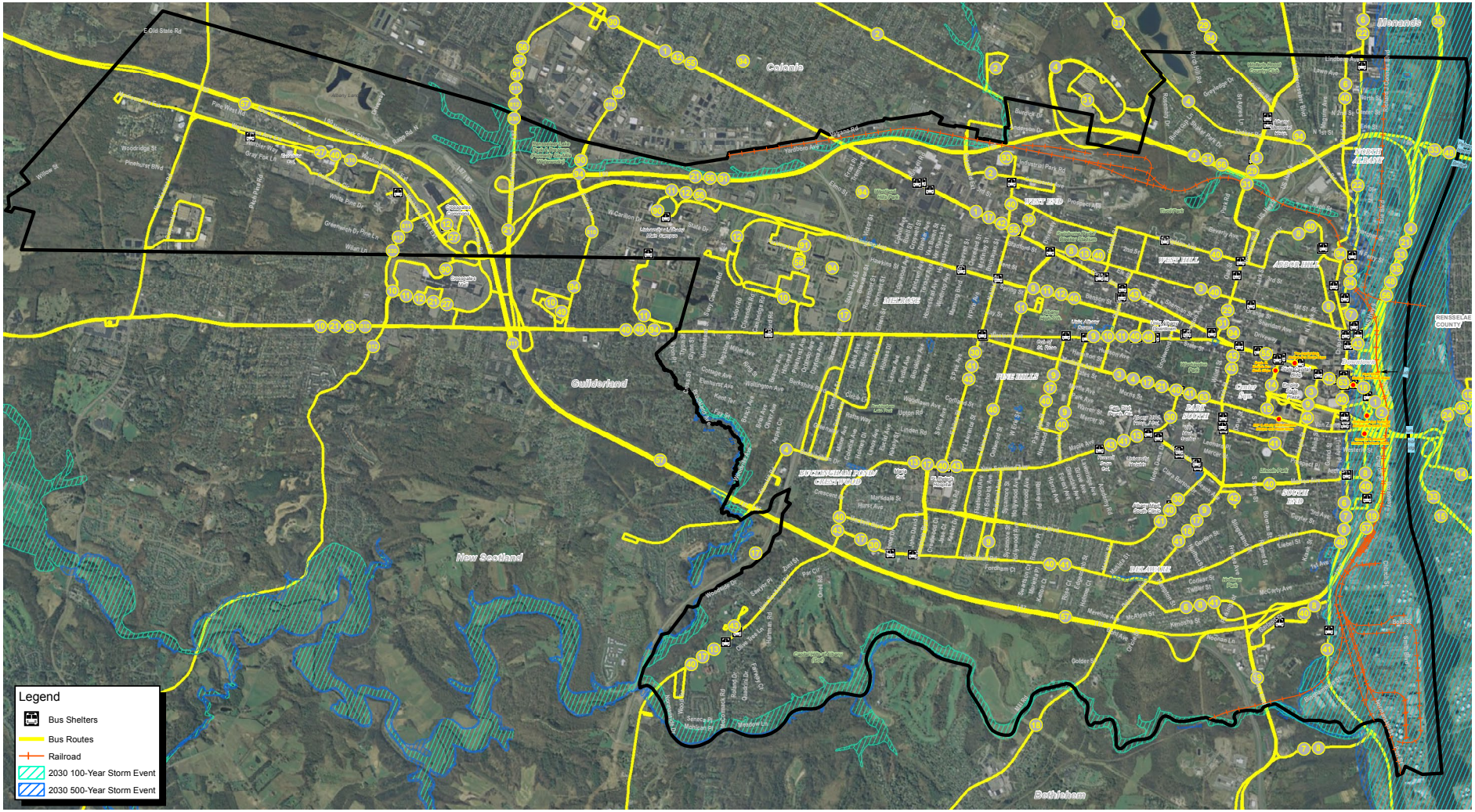
Local Roads

Many local roads along the Hudson River are also subject to increased flooding as the River rises with sea level rise. Urban flooding puts even more roads at risk than shown on **Map 4.** During intense precipitation events, the stormwater system can become overwhelmed and water that normally

Figure 15:
View of Hudson River flooding from Broadway in Albany, New York following Tropical Storm Irene, September 2011. Photo credit: Laura DeGaetano, Albany County Senior Natural Resource Planner.

collects in the streets and drains to the river will be unable to do so. Urban flooding can lead to traffic delays, public health issues and increased maintenance costs. For more information on Albany's stormwater management system, see the Stormwater Management and Sewage Treatment section on **page 50.**

Map 4: 2030 Transportation



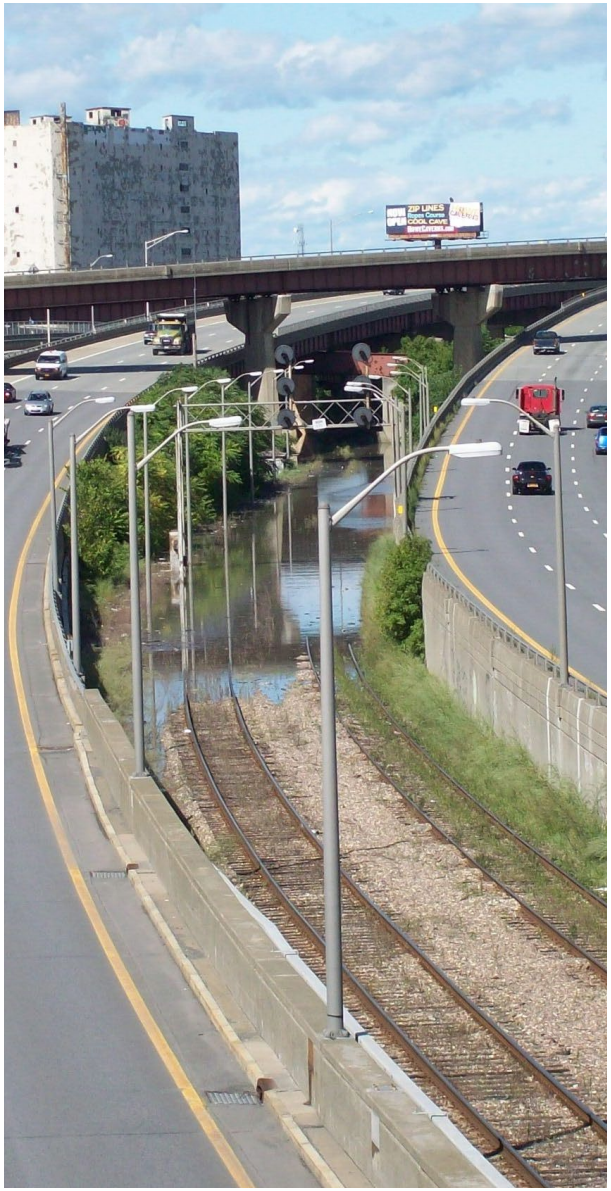


Figure 16:
View from Highway 787 of the flooded rail tracks after Hurricane Irene, September, 2011

Rail

The City of Albany has 19.5 miles of rail that connects it to the West (Syracuse, Buffalo, Toronto, Cleveland and Chicago), North (Vermont, Montreal, and the Adirondacks) and to the South (New York City). The rail is shared by Amtrak and CSX, a rail-based freight transportation company.

Flooding is likely to occur along much of the tracks located in the city. The miles of rail in Albany within the floodplain could jump from 10 miles to 13, according to the models. **Figure 16** shows flooding along rail tracks near Highway 787 after Irene in 2011 makes use of the tracks impossible.

In addition to flooding, extreme heat can cause delays as trains must reduce their speeds because hot rail tracks are not as strong. In extreme cases, tracks may actually buckle (US Department of Transportation 2011). High winds may also cause more delays from thunderstorm and other extreme weather events due to debris on the tracks.

Aviation

The City of Albany is home to Albany International, a commercial airport. This airport is not located in the floodplain; however extreme weather events and heat can impact the services and infrastructure of the airport.

Extreme weather events such as snow and ice storms, tropical storms, and severe thunderstorms cause flight cancellations and delay. Climate change could increase the frequency of some of these storms. This would result in more frequent delayed or canceled flights, cause the temporary shutdown of the airport, and/or result in flight detours to alternative airports. However, with more winter precipitation falling as rain rather than snow, winter disruptions may decrease (NYSERDA 2011).

Shifts in wind patterns and air temperatures will also impact the aviation sector. Flight takeoff and landing patterns are dependent on wind. High winds result in service disruptions. High air temperatures reduce the lift capacity of planes during takeoff and landing. This could mean that runways would have to either be lengthened, or passenger, freight, and/or fuel loads reduced (NYSERDA 2011). Runway surfaces will need new performance specifications to cope with extreme heat.

Water and Sewer

Most water and sewer systems are vulnerable to existing extreme weather events. As the climate changes, these systems are likely to be further overwhelmed, potentially leading to sewer overflows, declining water quality, and significant localized flooding.

Water Supply

Albany's water supply is a reservoir system that, according to ClimAID, is moderately sensitive to climate change and could supply the city for 912 days without any inflow **(Tables 12 and 13).** The larger the reservoir storage is relative to demand, the more resilient the supply will be. This ratio for Albany is 0.00137 or 1:729.73, making Albany's daily withdrawal approximately 1/730 of the total supply (NYSERDA 2011).

Reservoir systems such as Albany's could be stressed by two primary factors:

- Downward shift in their long-term average supply
- Large increase in demand

Based on ClimAID and other New York State projections, it is unlikely that a downward shift in the long-term reservoir supplies will occur (NYSERDA 2011). However, factors such as

Table 12:
Vulnerability of water supplies in New York State to climate change (NYSERDA 2011)

	Category	Sensitivity to Climate Change	Population Served
1	Withdrawal from large water bodies	Low	2,000,000
2	New York City system	Moderate	9,300,000
3	Other reservoir systems	Moderate	1,300,000
4	Run-of-the-river on small drainage	High	62,000
5	Long Island groundwater	Moderate	3,200,000
6	Other primary aquifers	Moderate	650,000
7	Homeowner well water	Moderate to high	1,900,000
8	Other small water supply systems (groundwater/surface water)	Moderate to High	600,000
	Total		19,012,000

Note: Water supply sensitivity is related to the length of drought that a water system could endure without being severely stressed, as estimated from system storage and demands. This analysis is only intended to provide a general assessment of vulnerability within broad categories. Ultimately, individual water supply systems would require system-specific analysis.

Table 13:
Average daily demand, total storage, and approximate days of supply for a sample of reservoir systems in New York State. This was calculated based on historical rates of demand, adjusted down by 20 percent to account for conservation (NYSERDA 2011)

Municipality	Demand (million gallons/day)	Storage (million gallons)	Secondary Source	Days of Supply w/ No Inflow
Ithaca	3.3	261	Yes	99
Oneonta	1.5	140	Yes	117
Beacon	2.3	218	Yes	118
Ilion	1.97	225	Yes	143
Rome	9.5	1,419	No	187
Colonie	10.4	1,797	Yes	216
Plattsburg	2.3	457	Yes	248
Guilderland/Watervliet	7.3	1,700	Yes	291
Fredonia	1.4	335	No	299
Albany	18.5	13,500	No	912
Troy	14.4	12,912	No	1121

Note: Storage volume information was taken from a USGS inventory of large dams in New York and from a New York State Department of Health (1974) repo

"All reservoir systems will be stressed if there is a downward shift in their long-term average supply (although this appears unlikely based on the ClimAID and other climate projections for New York) or a large increase in demand associated with population influx, increase irrigation, or growth of water-dependent industries." – NYSERDA, 2011

population influx, increased irrigation, and growth of water dependent industries could create a significant increase in demand. Climate change may affect all of these factors.

Increased Demand from Population Growth

Climatic changes across the United States could trigger large population shifts. Many low-lying coastal areas, including the densely populated New York City metropolitan area are threatened by sea level rise and storm surge. If sea level rises as projected, millions of people may be forced to relocate. Albany, being the state capital and having all of the associated jobs and infrastructure, may be an attractive place to live for many of these former coastal residents.

The ClimAID report sheds light on potential population migration from the Western United States to the Northeast. Severe water shortages are already occurring in the Southwest and they are likely to worsen with climate change. The Colorado River, which provides water to more than 27 million residents across Nevada, Arizona, California and Colorado, will likely experience a further decline in river flows. Even if demand from the Colorado River remains steady, there is a 58 percent chance of shortage by 2050 based on the minimum expected decrease in runoff. This could prompt a population shift to eastern states, including New York (NYSERDA 2011).

Increased Industry Demand

Water demand from industry could increase in the future due to expansion of the agriculture and resource extraction sectors (NYSERDA 2011). Although average annual precipitation is projected to increase, most of this increase will occur in the winter. During the summer there is a projected increase in the frequency of drought, especially in the late summer. This could increase the water demand from the agriculture sector during these periods of drought (NYSERDA 2011). Secondly, agricultural production may increase in the region if water rights conflict and depletion of groundwater supplies make production in other parts of the country less feasible. With projections signaling an increase in precipitation in the East, as well as a longer growing season, New York State may see some of its 1.5 million acres of idle or underused agricultural lands brought back into production and consuming large amounts of water. (NYSERDA 2011).

ClimAID identifies the drilling for natural gas as "an emerging consumptive water use in the region." Natural gas extraction in this region currently requires a hydraulic fracturing process (fracking) that involves pumping as much as 7 million gallons of water down each well at high pressure to open up fractures through which trapped natural gas can be extracted. The report points out that fracking will not be spread uniformly across Western and Upstate New York and "intensive withdrawals from smaller headwater streams may lead to localized low flows if not managed properly" (NYSERDA 2011, 94).

Figure 18:
Outfall at the Albany County Sewer District South Plant shortly after Tropical Storm Irene, September 2011.

Sewage Treatment and Stormwater Management

As intense precipitation events become more frequent, Albany's sewage and stormwater management system will become more stressed, leading to untreated stormwater and sewage being discharged into the Hudson River. Albany has a combined sewage and stormwater system that covers 40% of the city's land area and serves 30% of the population, meaning that all of the stormwater runoff and sewage is directed through

the same pipes to the Albany County Sewer District (ACSD) wastewater treatment plants (WWTP)—South Treatment Plant, Church Street, North Side of Port, Albany and the ACSD North Plant just north of the I-90 and I-787 interchange in Albany. The South Treatment facility serves most of the City of Albany while the North Plant serves Cohoes, Green Island, Watervliet and northern portions of Albany.

Combined Sewage Overflows

When stormwater runoff is high, such as during heavy precipitation events, the system becomes overloaded and must release untreated sewage and stormwater into the Hudson River. This is called a combined sewage overflow or CSO. According to a 2008 report from NYS DEC, 27 billion gallons of raw sewage and polluted stormwater discharge into New York Harbor each year from the Hudson (New York State Department of Environmental Conservation 2008). Albany contributes to this problem, albeit minimally. It is considered an area of particular concern with some of the highest E. coli and other bacteria levels of the Hudson (Albany Pool Joint Venture Team 2011). These bacteria levels often spike after precipitation events due to stormwater runoff and CSOs.

In response to this issue, the City of Albany along with the City of Cohoes, the City of Rensselaer, the City of Troy, the City of Watervliet and the Village of Green Island completed Phase I of a CSO Long Term Control Plan (LTCP) that closely examines the sewer and stormwater systems in the region in order to understand and better manage CSOs. In Albany and Troy, CSOs occur during most storms with the South Treatment Plant accounting for the highest number of CSOs throughout the system (Draft Long Term Control Plan, 2011). The LTCP reports that, "the Big C overflow in Albany accounts for 43 percent of all CSO discharged in the APCs [Albany Pool Communities]. Together, the six largest CSOs by volume, all in Albany and Troy, account for 819 million gallons (MG), two-thirds of the total Albany Pool CSO volume" (Draft Long Term Control Plan, 2011).

These overflows result in high bacteria levels. During the four wet weather events measured by the LTCP, bacteria levels exceeded New York State Standards all four times by as much as 1000 Fecal Coliform cfu/100ml near the Dunn Memorial Bridge and the Port of Albany. Two of the three wet weather measurements taken from Normans Kill at River Road also exceeded water quality standards (Draft Long Term Control Plan, 2011).

Sewage Backups

In addition to CSOs, sewage backups occur during severe wet weather events causing untreated sewages to backup into people's homes. In response to this issue, the Albany Water Board has instituted a Backwater Grant Program that assists owners of one- or two- family owner occupied properties in the installation of new backwater valves. The program received over 260 applications and approved over 235 of them.

Impacts of Climate Change

With an increase in intense precipitation events, sewage backup and combined sewage overflows will occur more frequently. In addition, the two WWTPs serving Albany are located along the Hudson River and could be subject to more frequent flooding due to sea level rise and increased precipitation. The LTCP found that the operations of the South Treatment Plant "is limited by both its hydraulic and process capacities depending on the flow conditions and Hudson River elevation. Theoretically, there would be no reliable secondary treatment capacity because the 25-year flood elevation at the plant outfall approaches the secondary clarifier weir elevation" (Albany Pool Joint Venture Team, p. 6-3, 2011). An increase in precipitation coupled with a rising Hudson, could significantly compromise Albany's sewer and stormwater system and lead to more CSOs, more sewage backups, and a decrease in water quality in the Hudson.

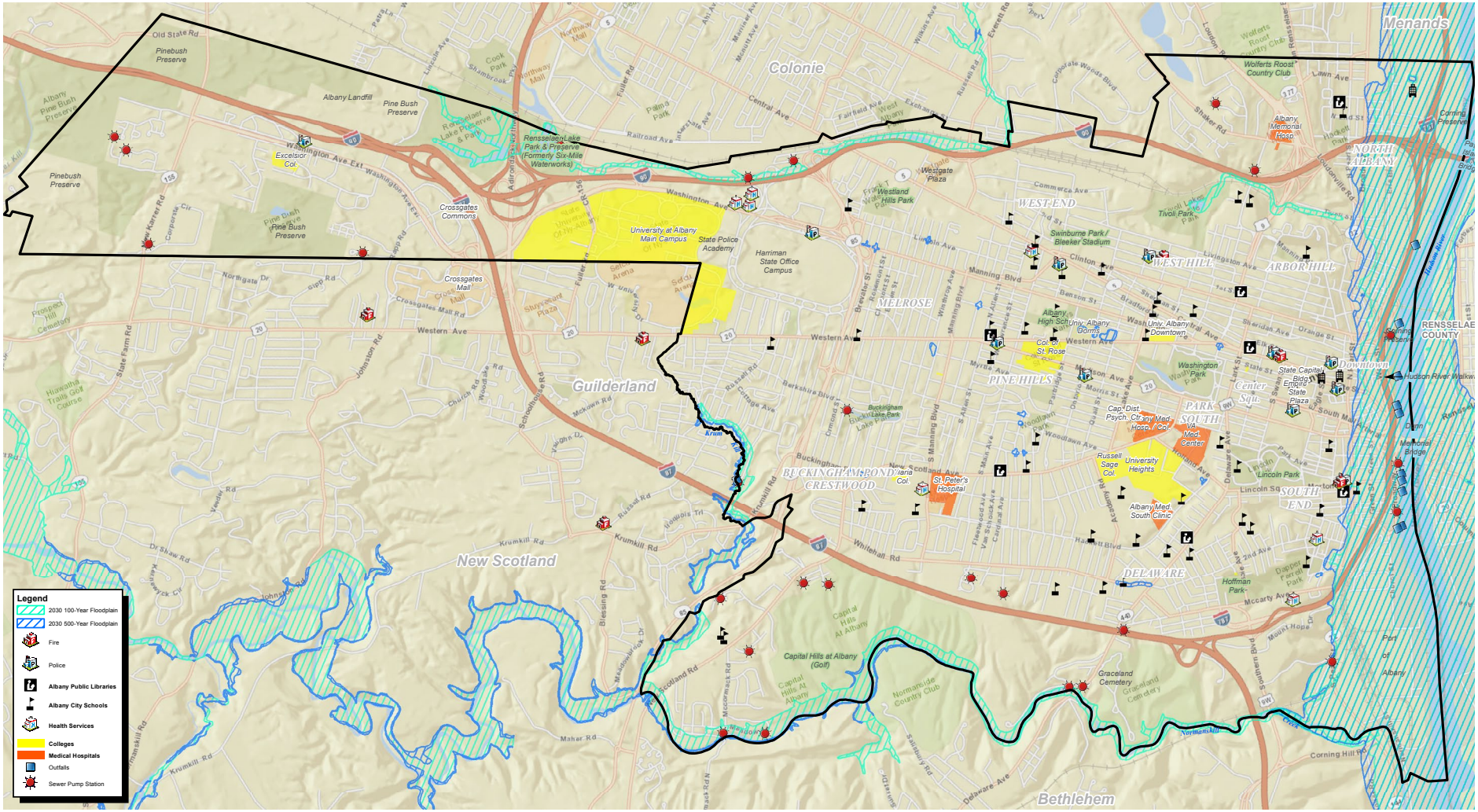
Critical Facilities

Critical facilities include fire and police stations, public libraries, schools, and health service facilities. These facilities provide vital services, especially during natural disaster emergencies. FEMA recommends that no critical facilities be located in a floodplain if possible; if a critical facility must be located in a floodplain, it should be elevated or otherwise flood proofed so that it can continue to provide services during and after a flood. Under the Floodplain Management Executive Order (11988), federal agencies funding and/or permitting critical facilities are required to avoid the 0.2 percent flood level (500-year floodplain) or protect the facilities to the 0.2 percent chance flood level (Federal Emergency Management Agency (FEMA) 2010).

All of Albany's critical facilities are currently located above the 0.2 percent floodplain elevation. However, this elevation is based on the current elevation of the Hudson, which is projected to rise throughout the century. The Giffen Memorial Elementary School could see flooding by 2030 during a 100-year flood event due to sea level rise. The nearby fire station, police station and John A. Howe Public Library may also be inundated by 2030 from a 500-year flood event **(Figure 19).**

Figure 19:
Clockwise from upper left: South Station Police, Giffen Memorial Elementary, John A Howe Public Library and the South End Fire House are all potentially vulnerable to flooding during intense precipitation events by 2030. Image Source: Google Maps Street View

Map 5: Critical Infrastructure



Energy

According to ClimAID, there are both climate and non-climate stressors on New York's energy infrastructure including rising demand due to a growing population, more energy use for cooling and electronic devices, aging infrastructure, and rapidly changing technologies and policies (NYSERDA 2011). Table 14 summarizes the climate impacts to the energy system across the state.

Some of the climate impacts that will affect Albany's energy infrastructure include:

- Low flow rivers and streams in late summer due to earlier snow-melt and warmer summers with prolonged dry periods will reduce the capacity of hydropower
- Warmer waters making it more challenging to cool water-cooled nuclear plants
- More winter storms, especially ice-storms, which can affect the frequency, duration and extent of power outages
- More frequent and extreme heat waves could cause transformers to fail

Table 14
Summary of climate risk to the New York State Energy System (NYSERDA, Table 8.7, 2011)

	Vulnerability	Principal Climate Variable(s)	Specific Climate-related Risks	Location	Crosscutting Links
Energy Supply and Distribution					
Power Supply	Thermoelectric power plants	Temperature	The thermal efficiency of power generation is affected by air temperature.	Statewide	
	Coastal power plants (including cogeneration at wastewater treatment facilities)	Extreme weather events & sea level rise	Flood risk at individual facilities depends on the likelihood and intensity of storm surges associated with extreme weather events and their interaction with sea level rise. Operational impacts may be different than impacts on fuel storage or fuel unloading operations.	Statewide	Coastal Zones
	Water-cooled power plants	Temperature	Water-cooled nuclear plants are affected by changes in the temperature of intake and discharge water, which is affected by changes in temperature.	Statewide	Water Resources
	Hydropower systems	Precipitation & temperature	Hydropower availability at individual plants is affected by the timing and quantity of precipitation, as well as snowmelt; snowmelt is also affected by seasonal temperature.	Western, Central, and Northern NYS	Water Resources, Ecosystems, Agriculture
	Wind power systems	Wind speed and direction	Availability and predictably of wind power	Western, Central, and Northern NYS	
	Solar power systems		Availability and predictably of solar power	Statewide	
	Biomass-fueled energy systems	Temperature & precipitation	Biomass availability depends on weather conditions during the growing season.	Western, Central, and Northern NYS	Ecosystems
Energy Transmission and Distribution Assets	Transmission lines (winter)	Extreme weather events	Frequency, duration, and spatial extent of outages are affected by winter storms, particularly ice storms and high winds.	Western, Central, and Northern NYS	Communications
	Transmission lines (summer)	Temperature	Sagging lines can result from increased load associated with higher temperatures.	Statewide	Communications, Public Health
	Transformers	Temperature	Transformers rated for particular temperatures may fail during prolonged periods of increased temperature.	Statewide	Communications, Public Health
	Natural gas distribution lines	Temperature, extreme weather events, & flooding	Changing temperatures may affect vulnerability to frost heave risks, which can threaten structural stability of the pipeline. Flooding risks can also jeopardize pipeline stability/operations. Extreme weather events may threaten underwater pipelines in the Gulf Coast region, a large source of natural gas supply for New York.	Statewide	
Energy Demand and Consumption					
Electricity Demand	Total demand	Temperature (heating degree days & cooling degree days) & extreme weather events	Temperature affects demand for electricity in winter, summer, and shoulder-season periods. Extreme weather events may temporarily or permanently change demand patterns.	Statewide	
	Peak demand in summer	Temperature and humidity (cooling degree days, heat index, & heat waves)	Temperature and humidity affect demand for electricity for cooling and can increase the summertime peak; increasing frequency, intensity, and duration of heat waves could be particularly problematic, leading to more brownouts and blackouts.	Southern NYS	Public Health
	Power sharing	Temperature (heating degree days)	Warming temperatures can increase summer demand in traditional winter-peaking areas, leading to reduced availability of power for downstate regions.	Statewide	
Building-sited Energy Systems*	Cooling systems	Temperature	Cooling capacity may not be sufficient if the period of days with high temperatures is lengthy.	Statewide	Public Health
	Heating systems	Precipitation	Flood risk for boilers located in basements	Statewide	
	Building envelopes	Extreme weather events	Increased severity of storm regime may reveal weaknesses in building envelopes.	Statewide	
	Mechanical and electric systems	Extreme weather events	Failure of mechanical-electrical elements is related to extreme weather conditions.	Southern NYS	Public Health

* Building-sited energy systems are not discussed in detail in this report.

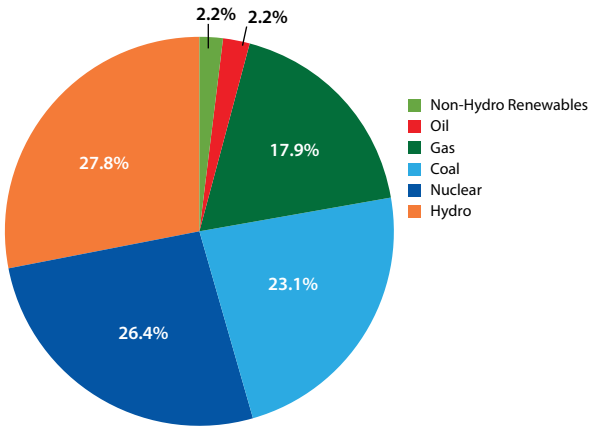


Figure 20
Fuel Mix for Upstate New York (EPA 2007)

Warmer summers increase electric demand and could lead to more brownouts and black outs, especially during heat waves (NYSERDA 2011).

Collectively, these impacts could make energy more expensive due to reduced supply, increase demand (in the summer), and higher maintenance costs.

Supply

In 2009, the City of Albany consumed 1,356,500 MWh of electricity (National Grid). The fuel mix for Upstate New York, shown in **Figure 20,** is fairly well distributed between hydropower, nuclear, gas, and coal, with approximately two-percent coming from non-hydro renewable and another two-percent from oil (EPA 2007). Climate change may threaten some of these energy supplies. For example, power plants consume large amounts of water for cooling. As regional water demand increases, there may be less available for energy production, especially during the hot and dry summer months. Hydropower production may also decline during periods of drought, when stream flows are low.

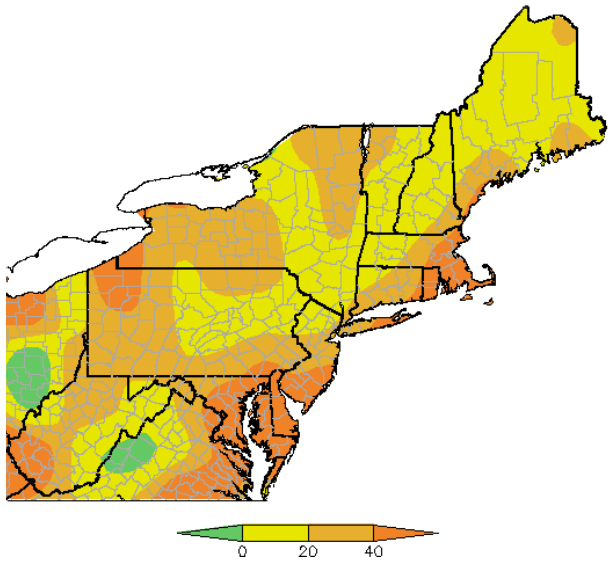
Demand

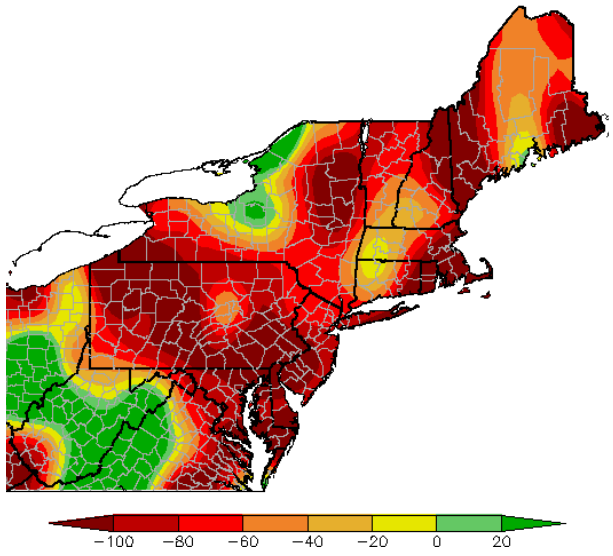
Figures 21 and 22 show that the number of Heating Degree Days (HDD) is declining while the number of Cooling Degree Days (CDD) is rising. This demonstrates that electricity demand will likely rise in the summer, while the demand for energy for heating (natural gas, electricity, or oil) could decline. ClimAID supports this claim as shown by **Table 15.** Even though the demand for heating in Albany is expected to decrease by 2020, energy demand for cooling is expected to increase and outweigh the energy savings from heating.

NYISO Zone	Weather Station	Heating Season: Decrease in MWp electricity demand in 2020s	Cooling Season: Increase in MWp electricity demand in 2020s
Zone A	Buffalo	14–27	55–111
Zone B	Rochester	9–18	53–105
Zone C	Syracuse	19–37	61–122
Zone D	Massena	5–10	7–15
Zone E	Watertown	11–21	29–57
Zone F	Albany	15–29	63–126
Zone G	Poughkeepsie	12–25	72–145
Zone J	NYC (LGA)	40–80	249–497
Zone K	Islip	27–58	194–387

Table 15
Projected changes in peak electricity demand in the 2020s compared to current peak demand (NYSERDA 2011).

Figures 21 and 22:
Maps showing the 30-year average difference in Heating Degree Days (HDD) and Cooling Degree Days (CDD) between the periods of 1971-2000 and 1961-1990. (Northeast Regional Climate Center 2009)





Mayor's Office of Energy & Sustainability
City of Albany, NY

NATURAL RESOURCES SYSTEM PROFILE

The City of Albany is home to 2,398 acres of open space, including parks, recreational fields, and nature preserves. Albany has very few wetlands, which comprise less than .04 percent of the city's total land area. Open space accounts for 17 percent of the land area in the City of Albany.

Albany's 2030 Comprehensive Plan identifies the following issues as significant to Albany's natural resources:

- Alteration of the Hudson River shoreline has left little habitat value
- Many streams have been buried and culverted, eliminating ecological value
- The majority of wetlands have been filled
- Erosion and stormwater runoff, especially during heavy rainstorms
- The city does not have a slope ordinance for construction
- The Albany Pine Bush Preserve has been affected by landfill operations and large scale commercial development
- Lack of connections and linkages between Albany's diverse collection of open spaces and natural resource areas

These issues indicate a disturbed landscape that, as a result, will be less resilient to further stresses caused by the impacts of climate change. Such impacts include changes in temperature, precipitation, and sea level, which can alter the habitat suitability for species and ecological communities and bring new invasive species, pathogens, or predators that thrive in warmer habitats. Sensitive habitats such as the Albany Pine Bush Preserve, that are already threatened by non-climate factors, such as fragmentation and development, are less able to tolerate changes in climate. **Table 16** summarizes the primary climate impacts and effects to the city's natural resources. The following sections explain these effects in further detail.

Table 16: Climate Impacts and Risks on Natural Resources in Albany				
ALBANY 2030 COMPREHENSIVE PLAN GOAL		**PRIMARY CLIMATE IMPACT**	**EFFECT**	**LOCATION**
Waterways	Preserve and protect city's waterways	Temperature & precipitation	Reduced water quality making waterways inhabitable for many cold water species such as trout and unfit for recreation	Hudson River and its tributaries
Urban Forest	Protect and enhance city's urban forest, including nature preserves, parks, open space, street trees, and trees planted on private property	Temperature	An increase in temperature could make conditions difficult for certain varieties of trees to survive. New invasive species, pathogens and predators are a serious threat to Northeast forests.	City-wide
Natural Habitat	Protect, enhance, restore and expand the city's natural habitat areas (e.g. Albany Pine Bush Preserve, Corning Preserve, Tivoli Preserve)	Sea level rise, precipitation & temperature	Erosion will be exacerbated by increased flooding and the Hudson and its tributaries will encroach on natural habitat along their banks. Increased temperatures will alter the composition of Albany's natural habitats	City-wide

"Albany's land, water, vegetation, and air perform essential functions and provide vital benefits the city and its residents"

– Albany 2030 Comprehensive Plan

Waterways

The 2030 Comprehensive Plan identifies the Hudson River as an important habitat for fish. Fish from the Hudson River south of the Corinth Dam (which is North of Albany) already have high levels of pollution and are not suitable for human consumption (New York State Department of Health 2009 - 2010). More frequent intense precipitation events, drought, increased water demand, and warmer temperatures could reduce the water quality of the Hudson and its tributaries, making it uninhabitable for many cold water species such as trout. These water bodies not only provide crucial ecological habitat, but they also provide recreational and tourism opportunities within the city.

Dissolved Oxygen and Temperature

Warmer water temperatures have a direct negative effect on water quality and stress aquatic biota, especially cold-water fish species. Warmer water holds less dissolved oxygen (DO); if oxygen levels drop below a critical threshold, biodiversity would be significantly affected as many species would not be able to live in such an environment. Many bodies of water already have low DO levels and are very vulnerable in this regard (NYSERDA 2011).

Increase in Agricultural Production

An increase of agricultural land use could negatively affect water quality. Agricultural runoff impairs water quality and is a frequently cited nonpoint source of water pollution. Fertilizers that contain nitrogen end up in waterways and can lead to algae blooms and further decrease DO levels. A study of Lake Michigan basins predicted that the presence of nitrogen in rivers could increase by up to 24 percent with climate change and expansion of corn acreage (NYSERDA 2011). The combination of increased precipitation over agricultural land would expand the probability of agricultural runoff polluting the water bodies. Conversely, during dry periods, an increase in agricultural production in the region would result in more water being drawn for irrigation, creating a reduction in stream-flow.

Invasive Species

Many invasive species thrive in a warmer climate. Increased water temperatures may increase the growing season of invasive mussel species including the Zebra mussel and Quagga mussel (NYSERDA 2011). These species crowd out other native species and often require control actions. Invasive plant species such as Common reed, Eurasian water milfoil, and Giant hogweed all thrive in warmer climates and will increasingly impact Albany's wetlands, ponds, rivers, and other wet areas.

Figure 23
Manning Boulevard, Albany, New York. Albany has an extensive urban forest that keeps the city cool in the summer, cleans the air, and provides aesthetic value. Climate change could affect this forest by the introduction and expansion of non-native pests.

Urban Forest

The city's goal of protecting and enhancing its urban forest will prove challenging in the face of climate change. New pathogens and invasive species are the primary threat to trees from climate change in the short term. However, in the long run, as climate change becomes more dramatic, native species may no longer be suitable for Albany's climate. The city may have to switch to more southern species for their tree planting **(Figure 23).** Albany has not yet conducted a comprehensive tree canopy assessment; however, the Albany 2030 Plan calls for this action. This will be useful in understanding the composition of the urban forest and how it may be affected by climate change.

Invasive Species and Pests

New pathogens and invasive species are rapidly altering forests in the Northeast. The New York State Department of Transportation (NY DOT) has listed the following pests as having caused serious problems to trees in the Northeast, including those in New York State (New York State Department of Transportation 2011).

- Hemlock Woolly Adelgid
- Emerald Ash Borer
- Asian Longhorned Beetle
- Gypsy Moth
- Forested Tent Caterpillar
- Sirex Wood Wasp

Climate change may increase the presence of some of these invasive species. For example, the Hemlock Woolly Adelgid, which attacks and kills hemlock trees, has become a significant threat to New York State. In fact, Albany County has an established population of Wooly Adelgid according to 2010 estimates (USDA Forest Service 2010). Cold winters kill the larva of this aphid-like insect; however warmer winters have expanded the range of this species into the Northeast, decimating Hemlock populations (NYSERDA 2011).

Rensselaer Lake outflow

Natural Habitat

Increased precipitation and flooding from storm events and sea level rise threatens some of Albany's urban parks and preserves. The majority of Albany's natural areas are in low-lying areas near rivers, such as the Corning Preserve, Hudson River Walkway, Rensselaer Lake Park & Preserve, and the Capital Hills at Albany golf course. Increased flooding threatens these areas. Changes in temperature and precipitation will also negatively impact sensitive and rare habitats such as the Albany Pine Bush Preserve.

Flooding

Map 6 shows the location of current 100 year and 500-year floodplains in relation to the Albany's natural resources. It also shows the projected 100 and 500-year floodplains for 2030 based on a high tide nine-inch rise in sea level along the Hudson. Preserving open space in the floodplain is an important hazard mitigation planning strategy; better to have an open field flood than homes and businesses. During Tropical Storm Irene in September 2011, most of the Hudson River

Map 6: Current and Projected (year 2030) 100-Year and 500-Year Floodplains in Albany, NY

Walkway was submerged by water and unusable for recreational purposes. However, more frequent and intense flooding could cause erosion problems and lead to the deterioration of this vital buffer, exposing more property to flood hazards and losing valuable urban green space.

Rare and Sensitive Habitats

The City of Albany is home to some very sensitive and rare ecosystems, one in particular is the Albany Pine Bush Preserve[1].

Albany Pine Bush Preserve

The Albany Pine Bush Preserve is one of approximately 20 inland pitch pine scrub oak barrens ecosystems in the world (Albany Pine Bush Preserve Commission 2011). In addition to being a globally rare ecosystem, the nearly 3,200 acre Albany Pine Bush Preserve is home to 45 of New York State's 538 "Species of Greatest Conservation Need[2]" and contains two rare natural communities (Albany Pine Bush Preserve Commission 2010) (Albany Pine Bush Preserve Commission 2011). Only 6,000

1 The Albany Pine Bush Preserve is not contained exclusively within the City of Albany; parts of the preserve are also located in Colonie and Guilderland.

2 Species of Greatest Conservation Need are designated by New York State based on the following criteria: federally or state listed as endangered, threatened, or special concern; species having 20 fewer elemental occurrences in the New York State Natural Heritage Program database; and estuarine and marine species designated by New York Department of Environmental Conservation as having the greatest conservation need. http://www.dec.ny.gov/animals/9406.html

City of Albany's Pine Bush Restoration Project

of the original 25,000 acres of Pine Bush ecosystem still exist in the region, approximately half of which is protected by the Preserve.

The Pine Bush Preserve provides habitat for over 90 species of birds, and was designated a Bird Conservation Area by the New York State Department of Environmental Conservation in 2008 (Albany Pine Bush Preserve Commission 2011). The Reserve is dominated by pitch pine scrub oak communities (984 acres) (Albany Pine Bush Preserve Commission 2011). Other communities include Appalachian oak-pine forest, red maple hardwood swamp and other wetland communities, as well as northern and southern hardwood successional stands (Albany Pine Bush Preserve Commission 2011) **(Table 17).**

The Albany Pine Bush Preserve is vulnerable to direct and indirect climate change impacts, as well as existing threats unrelated to climate. As shown in **Table 18,** the Pine Bush Preserve met five out of nine criteria that ClimAID used to determine the vulnerability of species, communities, and ecosystems to climate change. Of the six non-climate threats facing the Pine Bush Preserve, about half could be exacerbated by climate change. **Table 19** summarizes the non-climate threats currently facing the Pine Bush Preserve.

While more research is needed to determine the exact ways in which climate change will impact the Pine Bush Preserve and its inhabitants, the following sections elaborate on **Tables 18 and 19** to provide an overview of potential outcomes from the projected changes in temperature, precipitation, and sea level rise described in the Climate Overview section of this report.

Invasive Species, Pathogens, and Wildlife Impacts

The two primary invasive species in the Albany Pine Bush preserve are black locust and aspen trees (NYSERDA 2011) **(Figure 24).** Aspens are usually kept in check through fire (Albany Pine Bush Preserve Commission 2011); however, fire suppression has allowed these fast-growing plants to outcompete non-invasive vegetation (NYSERDA 2011). Other invasive species found in the Preserve include bush honeysuckle, multiflora rose, garlic mustard, purple loosestrife, common reed, and oriental bittersweet (Albany Pine Bush Preserve Commission 2011).

Climate change may cause the northern expansion of invasive species and pathogens not previously found in the Preserve, or may provide an increased competitive advantage for current invasive species (NYSERDA 2011). Conversely, a shift to a warmer climate may also reduce the presence of aspen in the Preserve. According to ClimAID, quaking

Table 17: Area of Community Types Mapped within the Albany Pine Bush Preserve (Albany Pine Bush Preserve Commission 2010)

COMMUNITY TYPE	PRESERVE (ACRES)
Natural Communities	
Pitch pine-scrub oak variants	984
Appalachian oak-pine forest	537
Red maple hardwood swamp	105
Other wetland communities	137
Open water	23
Successional Communities	
Successional northern hardwoods	254
Successional southern hardwoods	737
Successional old field	37
Disturbed/Cultural Uses	
Developed	35

Figure 24
Black Locust (Robinia pseudoacacia) is an invasive tree species currently affecting the Pine Bush Preserve.

Table 18: Albany Pine Bush Preserve Species, Community, and Ecosystem Vulnerability to Climate Change		
CLIMAID VULNERABILITY CRITERIA	**CRITERIA MET**	**EXPLANATION**
Low population levels or current status as an endangered species or species of concern	Yes	Over 45 species are considered Species of Greatest Conservation Need, and five species have been identified as specifically vulnerable to climate change in New York State (Albany Pine Bush Preserve Commission 2011).
Poor dispersal ability	Yes	The dispersal of Pine Bush species is limited by habitat fragmentation, surrounding development, and lack of suitable habitat outside the preserve.
Specialized habitat or food requirements	Yes	There are few other areas where Pine Bush communities can flourish given specific habitat requirements. The Pine Bush also supports a variety of species dependent on the rare pitch pine scrub oak community type. These unique habitat requirements could make it difficult for the Pine Bush ecosystem to adapt to a changing climate.
Specialized interactions with species that will be disrupted by climate change	Yes	The Karner butterfly, a federally listed endangered species and identified as vulnerable to climate change by the New York Natural Heritage Program, depends on the unique habitat and food sources (such as blue lupine) found in the Pine Bush Preserve. More research is needed to determine all of the complicated interactions between climate, ecological communities, and individual species within the Preserve.
Located near southern border of habitable range	No	The Pine Bush Preserve is not in the southern border of its range (New York Natural Heritage Program 2004-2005)
Low tolerance for environmental change or stress	No	The Pine Bush habitat is defined by its harsh growing conditions which include dry conditions and nutrient poor and sandy soils. As such, many species are already adapted to stressful environments.
Poor competitor with species infringing on range	Insufficient data	The Pine Bush ecosystem currently faces competition from invasive plants and pests located within the range. More information is needed to determine the impact of potential future competitors currently located outside of the Pine Bush habitat range.
Limited genetic diversity	Insufficient data	Insufficient data
Susceptibility to new pests or diseases infringing on range	Insufficient data	Insufficient data

ClimAID Vulnerability Criteria Source: NYSERDA 2011

Table 19: Non-Climate and Indirect Climate Hazards Facing the Albany Pine Bush Preserve		
HAZARD	**WORSENED BY CLIMATE CHANGE**	**EXPLANATION**
Invasive Species and Pathogens	Yes	The Preserve is affected by invasive species. In general, climate change facilitates the spread of invasive species and pathogens.
Rare and Endangered Species	Yes	With more than 45 Species of Greatest Conservation Need, there are already many vulnerable species in the Preserve. Climate change is likely to expand this list or further stress species on this list.
Wildlife Threats	Yes	Overabundance of white-tailed deer currently threatens certain plant species in the Preserve (Albany Pine Bush Preserve Commission 2010). White-tailed deer are expected to increase in New York with a changing climate (NYSERDA 2011).
Development	Potentially	Development is the biggest current threat to Albany Pine Bush habitat (Albany Pine Bush Preserve Commission 2010). Climate change may increase developmental pressure due to loss of other lands and an increase in population.
Habitat Fragmentation	No	The Preserve is already highly fragmented. Fragmentation can alter habitat conditions on edge areas, increase access for invasive species, and reduce specie dispersal ability (Albany Pine Bush Preserve Commission 2010).
Human Over Use	No	Overuse or inappropriate recreational use of Preserve lands (such as motorized vehicles) can negatively impact Preserve habitat.

Threats facing the Pine Bush Preserve displayed in this table were identified in the Albany Pine Bush Preserve Commission's Management Plan and Final Environmental Impact Statement for The Albany Pine Bush Preserve released in September 2010.

aspen is the tree species most likely to decrease in abundance and geographic area by the end of the century in New York (NYSERDA 2011). Various types of oak species are predicted to increase in abundance and geographic cover by the end of the century, so there could be a shift in the relative abundance of aspen and oak trees in the Preserve.

The ClimAID report also indicates that changes in climate could favor an increase in white-tailed deer (NYSERDA 2011). White-tailed deer are currently over populated in the Preserve, which can impact the regeneration rates of pitch pine and blue lupine, an important larval food source for the Karner blue butterfly, since deer eat the young plants (Albany Pine Bush Preserve Commission 2010). Deer also eat oak trees, so a higher number of deer may counteract the advantage that warmer temperatures provide to oak trees (NYSERDA 2011).

Rare and Endangered Species

Inland pitch pine oak scrub barrens are globally rare ecosystems. Less than 20 areas of pitch pine oak scrub barren remain in the world. The Albany Pine Bush Preserve is also home to 15 birds, 14 reptiles and amphibians, and 16 insects that are classified as Species of Greatest Conservation Need by the New York State Department of Environmental Conservation. Of these species, five were identified as vulnerable to climate change as part of a state-wide assessment as shown in

Table 20: Albany Pine Bush Preserve "Species of Greatest Conservation Need" Identified as Vulnerable to Climate Change by the New York Natural Heritage Program			
Species Name	**Ecological Community Type**	**State Conservation Status***	**Climate Vulnerability Ranking****
Karner Blue Butterfly (Lycaeides melissa samuelis)	Pitch Pine-Scrub Oak Barrens	Endangered	Extreme
Frosted Elfin (Callophrys irus)	Pitch Pine-Scrub Oak Barrens	Threatened	Extreme
Eastern Spadefoot (Scaphiopus holbrookii)	Pitch Pine-Scrub Oak Barrens	Special Concern	High
Eastern Hognose Snake (Heterodon platirhinos)	Shallow Emergent Marsh	Special Concern	High
Persius Duskywing Skipper (Erynnis persius persius)	Pitch Pine-Scrub Oak Barrens	Endangered	Moderate

Sources: Schlesinger, M.D., J.D. Corser, K.A. Perkins, and E.L. White 2011 and Albany Pine Bush Preserve Commission 2010

*This column indicates a species conservation status under the New York State Environmental Conservation Law. Endangered species are defined as "any native species in imminent danger of extirpation or extinction in New York." Threatened species are "any species likely to become an endangered species within the foreseeable future in New York." Special Concern categorizes species "at risk of becoming threatened in New York." (New York Department of Environmental Conservation 2009)

**The New York Natural Heritage Program defined extremely vulnerable species as those whose abundance and/or range is extremely likely to substantially decrease or disappear by 2050. Highly vulnerable species are those whose abundance and/or range are likely to decrease significantly by 2050, and moderately vulnerable species as those whose abundance and/or range are likely to decrease by 2050. (Schlesinger, M.D., J.D. Corser, K.A. Perkins, and E.L. White 2011)

Table 20 (Schlesinger, M.D., J.D. Corser, K.A. Perkins, and E.L. White 2011).[3] Four of these five species are found in the Preserve's pitch pine scrub oak barrens community, while one species, the Eastern Hognose Snake, is found in the Preserve's shallow and emergent marsh habitats. See Appendix A for a full list of species currently at risk in the Preserve from non-climate related threats.

Temperature, Location within Range, Dispersal Ability, Tolerance to Change, and Specialized Habitat Requirements

The forest and scrub communities located within the Albany Pine Bush preserve are not located on the southern part of their ranges and are well adapted to dry conditions (New York Natural Heritage Program 2004-2005). This indicates that the Pine Bush Preserve may tolerate some increase in temperature and increased periods of drought during the summer months. However, the pitch pine- scrub oak, Appalachian oak-pine, and pitch pine communities are found only in very specific environments in the Northeastern United States that contain rocky, sandy soil (New York Natural Heritage Program 2004-2005). Because of the small amount of land suitable for Pine Bush habitats, and being located in a highly developed area that is severely fragmented, it would be difficult for the Albany Pine Bush communities to migrate to a cooler climate.

3 The New York Natural Heritage Program calculated the climate vulnerability of 199 of New York State's Species of Conservation Need through a study funded by the New York State Wild Life Grants Program with cooperation from the U.S. Fish and Wildlife Service Division of Wildlife and Sport Fish Restoration. The NatureServe Climate Change Vulnerability Index was used to assess the vulnerability of individual species to changes in climate.

Figure 25
The Karner blue butterfly is a federally endangered species and the New York Natural Heritage Program has identified it as extremely vulnerable to climate change.

One of the best known inhabitants of the Preserve is the federally endangered Karner blue butterfly which was identified as extremely vulnerable to climate change by the New York Natural Heritage Program **(Table 20 and Figure 25).** While much is unknown about the impact of climate on the Karner blue butterfly , research shows that it lays eggs over winter in the Preserve and is believed to rely on the winter conditions such as snow pack, temperature, and humidity that could change with the climate (Albany Pine Bush Preserve Commission 2010). The Albany Pine Bush Preserve Commission is currently working with the Nature Conservancy and the Federal Karner Blue Butterfly Recovery Team to learn more about the effects of climate change on the Karner blue butterfly (Albany Pine Bush Preserve Commission 2010).

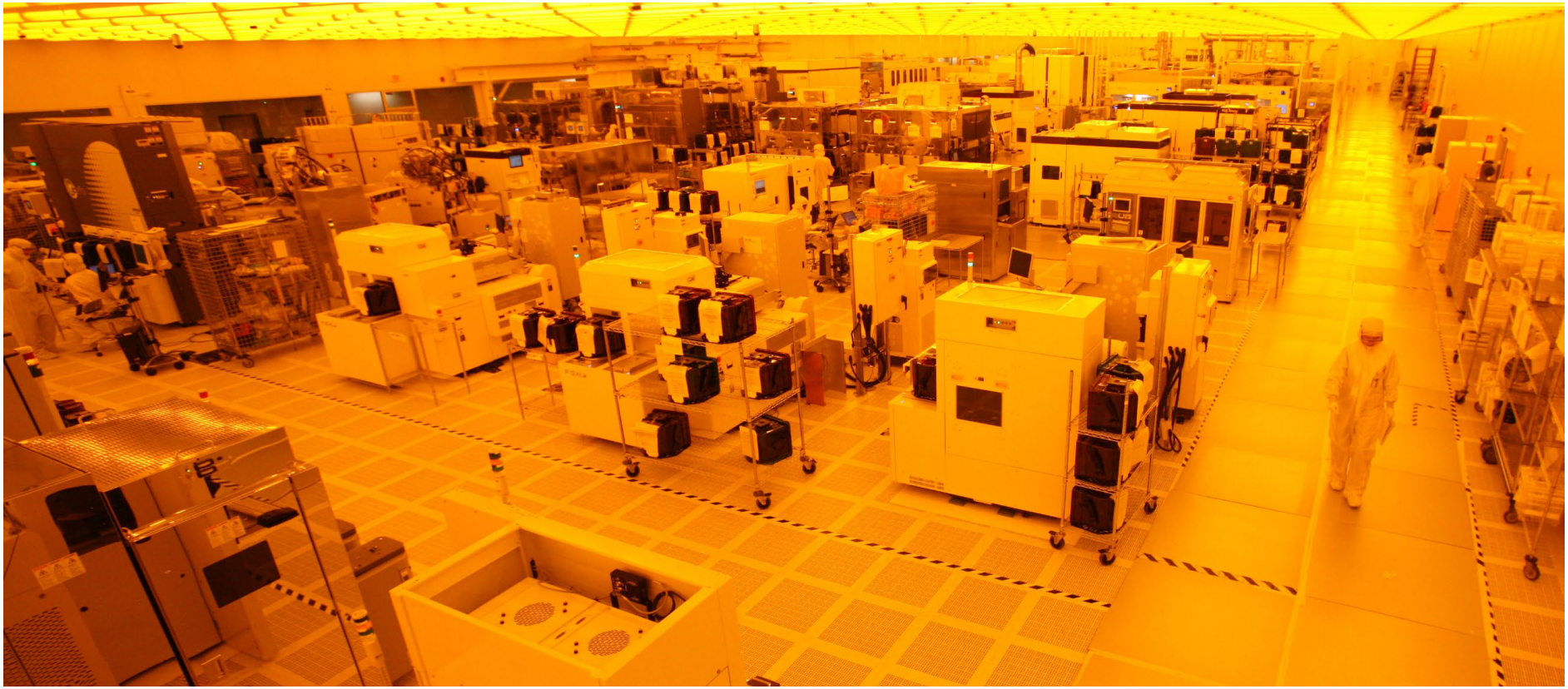
Precipitation, Flooding, and Sea Level Rise

As shown in **Map 6** on page 63, the majority of the Albany Pine Bush Preserve is not located in the 100-year or 500-year floodplains of Albany. However, areas of the Preserve near the Rensselaer Lake Park and Preserve are included in the current 100-year floodplain, which is projected to expand by 2030, potentially altering habitat. The impacts of more frequent flooding in the Pine Bush Preserve are not clear. However, changes in winter precipitation and snow pack could have a number of different impacts on the ecosystem (Albany Pine Bush Preserve Commission 2010). For example, herbivores that eat exposed winter vegetation would benefit from milder winters, while small mammals that depend on snow cover for insulation would suffer (Albany Pine Bush Preserve Commission 2010). This could have cascading effects on the ecosystem by reducing the number of saplings that survive the winter and affect predators that rely on small mammals as food sources.

Mayor's Office of Energy & Sustainability

RISK PROFILES

Climate change will not affect all systems and sectors of the Albany community equally. To help identify which systems are more vulnerable to a given changing climate conditions than others, a qualitative climate risk assessment was conducted. For this assessment, the likelihood of a changing climate condition taking place was combined with the consequence to a given system if that change does occur. The results highlighted certain systems particularly vulnerable to projected climate changes. These high-risk systems have been prioritized for adaptation action (see next section). Table 22 summarizes the results of the risk assessment and Table 23 provides brief descriptions of potential climate impacts to each of the systems based on the changing climate condition.



College of Nanoscale Science and Engineering

Table 22: Risk Assessment with Likelihood and Magnitude Results				
CHANGING CLIMATE CONDITION	**SECTOR AFFECTED**			
	PUBLIC HEALTH	**TRANSPORTATION**	**WATER AND SEWER**	**CRITICAL FACILITIES**
Average Temperature increase of 3 - 5.5 degrees F (high confidence)	High Confidence; Medium Impact	High Confidence; Medium Impact	High Confidence; Medium Impact	High Confidence; Medium Impact
17-49 days over 90 degrees F (high confidence)	High Confidence; High Impact	High Confidence; Medium Impact	High Confidence; Medium Impact	High Confidence; High Impact
5% increase in overall precipitation (medium confidence)	Medium Confidence; Medium Impact	Medium Confidence; Medium Impact	Medium Confidence; Low Impact	Medium Confidence; Low Impact
9 to 12 events with rainfall exceeding 1 inch (medium confidence)	Medium Confidence; Medium Impact	Medium Confidence; High Impact	Medium Confidence; High Impact	Medium Confidence; High Impact
17 to 26 inch rise in Hudson River water levels by 2050 (high confidence)	High Confidence; Low-Medium Impact	High Confidence; High Impact	High Confidence; High Impact	High Confidence; Medium Impact
Increase in frequency or intensity of Nor'easters (medium confidence)	Medium Confidence; Medium Impact	Medium Confidence; High Impact	Medium Confidence; Medium Impact	Medium Confidence; High Impact
Increase in frequency or intensity of Tropical Storms or Hurricanes (low confidence)	Low Confidence; High Impact	Low Confidence; High Impact	Low Confidence; High Impact	Low Confidence; High Impact
Increase in frequency or intensity of thunderstorms (low confidence)	Low Confidence; Medium Impact	Low Confidence; High Impact	Low Confidence; High Impact	Low Confidence; High Impact

*****All in 2050 time range**

Impact Ranking

Impact is a determination of an events scale (e.g., the area, or number of people affected) and intensity (e.g., the degree of damage caused). For this exercise, a "low impact" was used to describe an impact that had minimal effect on the identified system; a "medium impact" indicated moderately significant effects on the system; and a "high impact" indicates an affect that causes major disruptions to the identified system.

Confidence Ranking

Confidence is the likelihood of a changing climate condition occurring. Rankings for confidence were derived from the ClimAID report. A "low confidence" indicates that there is uncertainty about the change in frequency, intensity or severity of a changing condition due to climate change; a "medium confidence" indicates that there is relatively strong likelihood that the projected changing climate condition will occur; and a "high confidence" indicates an impact that is extremely likely (or already occurring).

Table 22: Risk Assessment with Likelihood and Magnitude Results (Continued)

CHANGING CLIMATE CONDITION	SECTOR AFFECTED			
	ENERGY	WATER QUALITY	URBAN FOREST	NATURAL HABITAT
Average Temperature increase of 3 - 5.5 degrees F (high confidence)	High Confidence; Medium Impact	High Confidence; Medium Impact	High Confidence; High Impact	High Confidence; High Impact
17-49 days over 90 degrees F (high confidence)	High Confidence; High Impact	High Confidence; Medium Impact	High Confidence; Low Impact	High Confidence; Medium Impact
5% increase in overall precipitation (medium confidence)	Medium Confidence; Low Impact	Medium Confidence; Medium Impact	Medium Confidence; Low Impact	Medium Confidence; Low Impact
9 to 12 events with rainfall exceeding 1 inch (medium confidence)	Medium Confidence; High Impact	Medium Confidence; Medium Impact	Medium Confidence; Medium Impact	Medium Confidence; Medium Impact
17 to 26 inch rise in Hudson River water levels by 2050 (high confidence)	High Confidence; High Impact	High Confidence; High Impact	High Confidence; Low Impact	High Confidence; Medium Impact
Increase in frequency or intensity of Nor'easters (medium confidence)	Medium Confidence; High Impact	Medium Confidence; Medium Impact	Medium Confidence; Medium Impact	Medium Confidence; Medium Impact
Increase in frequency or intensity of Tropical Storms or Hurricanes (low confidence)	Low Confidence; High Impact	Low Confidence; Medium Impact	Low Confidence; Medium Impact	Low Confidence; Medium Impact
Increase in frequency or intensity of thunderstorms (low confidence)	Low Confidence; High Impact	Low Confidence; Medium Impact	Low Confidence; Medium Impact	Low Confidence; Medium Impact

*****All in 2050 time range**

Impact Ranking
Impact is a determination of an event's scale (e.g., the area, or number of people affected) and intensity (e.g., the degree of damage caused). For this exercise, a "low impact" was used to describe an impact that had minimal effect on the identified system; a "medium impact" indicated moderately significant effects on the system; and a "high impact" indicates an affect that causes major disruptions to the identified system.

Confidence Ranking
Confidence is the likelihood of a changing climate condition occurring. Rankings for confidence were derived from the ClimAID report. A "low confidence" indicates that there is uncertainty about the change in frequency, intensity or severity of a changing condition due to climate change; a "medium confidence" indicates that there is relatively strong likelihood that the projected changing climate condition will occur; and a "high confidence" indicates an impact that is extremely likely (or already occurring).

Table 23: Risk Results with Description of Potential Impacts				
CHANGING CLIMATE CONDITION	**SECTOR AFFECTED**			
	PUBLIC HEALTH	**TRANSPORTATION**	**WATER AND SEWER**	**CRITICAL FACILITIES**
Average Temperature increase of 3 - 5.5 degrees F (high confidence)	Medium Impact (Longer growing seasons reduce air quality and lead to increased pollen counts; longer breeding seasons and ranges for pests and disease vectors)	Medium Impact (Increased temperatures could strain existing infrastructure, leading to buckling, potholes, and more rapid deterioration of infrastructure)	Medium Impact (Increased demand due to rising temperatures could erode supply)	Medium Impact (Increasing temperatures could lead to more emergency situations, additional strain on emergency personnel and stressing existing response strategies)
17-49 days over 90 degrees F (high confidence)	High Impact (High heat days increase risk of heat-related illness, reduce air quality)	Medium Impact (Worker safety concerns; rider discomfort; bucking tracks and roads)	Medium Impact (Increased demand due to heat waves could erode supply)	High Impact (Increased temperatures will necessitate more emergency personnel and treatment of vulnerable populations)
5% increase in overall precipitation (medium confidence)	Medium Impact (Increased rates of mold and increased risk of gastrointestinal diseases)	Medium Impact (Increases in rainfall could further stress transportation systems leading to disruptions in service	Low Impact (Additional average precipitation could further strain water treatment and wastewater treatment facilities)	Low Impact (Increases in average flooding could cause more flooding, thereby disrupting emergency personnel response times
9 to 12 events with rainfall exceeding 1 inch (medium confidence)	Medium impact (Increase in respiratory illness from mold and toxic flood reside in homes)	High Impact (Disruption of transportation systems	High Impact (More combined sewer overflows (CSOs) and sewage backups)	High Impact (Flooding can result in service disruption and create impediments to emergency personnel reaching victims)
17 to 26 inch rise in Hudson River water levels by 2050 (high confidence)	Low-Medium Impact (While few people live along the Hudson, rising water levels threaten to flood the area and cause more mold and toxins in businesses and homes in the vicinity)	High Impact (Could lead to flooding and permanent inundation of key transportation infrastructure)	High Impact (Wastewater treatment plant infrastructure exposed to flooding due to proximity to Hudson. People migrating to the region from coastal areas or the west could increase demand)	Medium Impact (Roads and infrastructure surrounding the Hudson will likely become inundated which could delay or prevent emergency response personnel)
Increase in frequency or intensity of Nor'easters (medium confidence)	Medium Impact (Wind speeds and flooding can cause physical injury and a number of indirect damages)	High Impact (Increased likelihood of degrading roads and system disruptions)	Medium Impact (More intense of frequent storms can stress the stormwater system leading to combined sewer overflows and sewage backups)	High Impact (Effects such as wind, rain, hail, or snow can lead to an increased demand for emergency services but also create barriers that prevent emergency personnel response)
Increase in frequency or intensity of Tropical Storms or Hurricanes (low confidence)	High Impact (Wind speeds and flooding can cause physical injury and a number of indirect damages)	High Impact (Increased likelihood of degrading roads and system disruptions)	High Impact (More intense of frequent storms can stress the stormwater system leading to combined sewer overflows and sewage backups)	High Impact (Effects such as wind, rain, hail, or snow can lead to an increased demand for emergency services but also create barriers that prevent emergency personnel response)
Increase in frequency or intensity of thunderstorms (low confidence)	Medium Impact (Wind speeds and flooding can cause physical injury and a number of indirect damages)	High Impact (Increased likelihood of degrading roads and system disruptions)	High Impact (More intense of frequent storms can stress the stormwater system leading to combined sewer overflows and sewage backups)	High Impact (Effects such as wind, rain, hail, or snow can lead to an increased demand for emergency services but also create barriers that prevent emergency personnel response)

*****All in 2050 time range**

Impact Ranking
Impact is a determination of an event's scale (e.g., the area, or number of people affected) and intensity (e.g., the degree of damage caused). For this exercise, a "low impact" was used to describe an impact that had minimal effect on the identified system; a "medium impact" indicated moderately significant effects on the system; and a "high impact" indicates an affect that causes major disruptions to the identified system.

Confidence Ranking
Confidence is the likelihood of a changing climate condition occurring. Rankings for confidence were derived from the ClimAID report. A "low confidence" indicates that there is uncertainty about the change in frequency, intensity or severity of a changing condition due to climate change; a "medium confidence" indicates that there is relatively strong likelihood that the projected changing climate condition will occur; and a "high confidence" indicates an impact that is extremely likely (or already occurring).

Table 23: Risk Results with Description of Potential Impacts (Continued)

CHANGING CLIMATE CONDITION	SECTOR AFFECTED			
	ENERGY	WATERWAYS	URBAN FOREST	NATURAL HABITAT
Average Temperature increase of 3 - 5.5 degrees F (high confidence)	Medium Impact (Low flow rivers and streams in late summer due to earlier snow-melt and warmer summers will reduce the capacity of hydropower; Warmer waters affect water-cooled nuclear plants)	Medium Impact (Reduced water quality making waterways inhabitable for many cold water species and unfit for recreation; reduced dissolved oxygen levels may lead to lower biodiversity)	High Impact (An increase in temperature could make it hard for certain species of trees to survive; warmer winters could allow insects and pests to expand their ranges)	High Impact (Invasive species, pathogens, and shifting predators can disrupt ecosystems)
17-49 days over 90 degrees F (high confidence)	High Impact (More frequent and extreme heat waves could cause transformers to fail; increased electric demand could lead to more brownouts and black outs)	Medium Impact (Reduced water quality making waterways inhabitable for many cold water species and unfit for recreation)	Low Impact (Could stress urban forests causing weaker trees to fail)	Medium Impact (Increased temperatures can add further strain to flora and fauna, causing species and systems to deteriorate)
5% increase in overall precipitation (medium confidence)	Low Impact (More precipitation falling as ice will likely stress transmission lines, leading to an increased risk of brown and black outs)	Medium Impact (Reduced water quality making waterways inhabitable for many cold water species and unfit for recreation)	Low Impact (More precipitation, particularly falling in heavier rainfall events, can wash away soil and key nutrients)	Low Impact (Additional precipitation could cause changes in key ecosystem dynamics and lead to an increase in flooding events)
9 to 12 events with rainfall exceeding 1 inch (medium confidence)	High Impact (Increased risk of flooding at key energy infrastructure facilities)	Medium impact (Reduced water quality making waterways inhabitable for many cold water species and unfit for recreation)	Medium Impact (More precipitation can wash away soil and key nutrients)	Medium Impact (Flooding of urban parks and natural systems could cause changes in ecosystem structure and function)
17 to 26 inch rise in Hudson River water levels by 2050 (high confidence)	High Impact (Increased risk of flooding at key energy infrastructure facilities)	High Impact (Rising water levels can erode the stream bank causes sedimentation and degrading water quality)	Low Impact (Rising Hudson water levels can cause flooding of certain tree stocks, leading to their deterioration and/or death)	Medium Impact (Erosion will be exacerbated which can lead to sedimentation and natural habitats)
Increase in frequency or intensity of Nor'easters (medium confidence)	High Impact (More winter storms, especially ice-storms, which can affect the frequency, duration and extent of power outages)	Medium Impact (Increased storminess can lead to higher rates of erosion)	Medium Impact (Effects of storms such as wind can cause severe trees damage including the loss of trees)	Medium Impact (Effects of storms can cause high erosion rates, damage ecosystems, and cause loss of life to flora and fauna)
Increase in frequency or intensity of Tropical Storms or Hurricanes (low confidence)	High Impact (More storms can affect the frequency, duration and extent of power outages)	Medium Impact (Increased storminess can lead to higher rates of erosion)	Medium Impact (Effects of storms such as wind can cause severe trees damage including the loss of trees)	Medium Impact (Effects of storms can cause high erosion rates, damage ecosystems, and cause loss of life to flora and fauna)
Increase in frequency or intensity of thunderstorms (low confidence)	High Impact (More storms can affect the frequency, duration and extent of power outages)	Medium Impact (Increased storminess can lead to higher rates of erosion)	Medium Impact (Effects of storms such as wind can cause severe trees damage including the loss of trees)	Medium Impact (Effects of storms can cause high erosion rates, damage ecosystems, and cause loss of life to flora and fauna)

*****All in 2050 time range**

Impact Ranking
Impact is a determination of an event's scale (e.g., the area, or number of people affected) and intensity (e.g., the degree of damage caused). For this exercise, a "low impact" was used to describe an impact that had minimal effect on the identified system; a "medium impact" indicated moderately significant effects on the system; and a "high impact" indicates an affect that causes major disruptions to the identified system.

Confidence Ranking
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Climate + Energy
Focus Areas
1. Climate Adaptation
2. Economic Development
3. Energy
4. Food Systems
5. Land Use & Livable Communities
6. Transportation
7. Solid Waste
8. Water
9. Governance
PlaceMatters
crowdrise

RECOMMENDATIONS

The following recommendations to create a more resilient Albany are provided based on the assessment of Albany's vulnerability to climate change and on the city's existing actions. These recommendations are short-term actions that could feasibly be undertaken within the next five years.

Sub-Sector	Strategy	Description	Sector/Department/ Implementer	Cross-cutting issues	Link with LWRP	Mitigation Overlap
SOCIAL						
Public Health & Wellbeing	Educational Campaign	Implement an educational campaign focused on engaging citizens, businesses and institutions on climate change resiliency practices and initiatives, including the locations and hours of cooling centers, the potential harm of standing water, evacuation routes, and best practices for dealing with power outages.	Development and Planning, Department of General Services, Fire and Emergency Services, Police, Utilities, Recreation, Office of Special Events	Public Health		
	Public Health Impacts Assessment	Continue to assess public health impacts of climate change and develop response plan with strategies to mitigate impacts. Implement awareness programs related to the public health impacts of climate change.	State and County Public Health Officials, Development and Planning, Fire and Emergency Services, Police	Public Health		
	Integrated Two-Way 911 System	Identify locations of vulnerable populations (those who live alone, seniors, low income areas, others at-risk, etc.) and provide each home with a window card (see www.seattle.gov/emergency/programs/snap/organized.htm) to indicate if help is needed. Have public safety officials or resident neighborhood response teams go door to door during extreme weather including heat and flooding events as well as during service (power outages) disruptions. The City should establish a voluntary list of residencies who would be checked on during such events.	Fire and Emergency Services, Police	Public Health		
	Energy Demand and Heat Health Warnings	Alert public during extreme heat events to power down unnecessary electronics in order to reduce strain on the grid and prevent blackouts, as well as take heat-related health precautions. Improve awareness of cooling center.	Utilities	Energy Supply		X
	Sustainable local food production	The Northeast is well-positioned to increase agricultural production due to a longer growing season and increased precipitation. The City should promote opportunities for sustainable, small scale and organic food production with in the City and region. Encourage back yard and rooftop vegetable gardens, community gardens and the preservation of productive agricultural lands, including vacant urban land. Also take into account the potential need for crop adaptation.	Development and Planning, Department of General Services, Capital District Community Gardens, Cornell Cooperative Extension	Economic Vitality, Green Jobs, Food Security		
	Build and support neighborhood networks.	Studies show that neighborhoods with strong neighborhood networks and social ties are far more resilient. We can also add in there the concept of creating and supporting neighborhood emergency response teams to be activated in emergencies. Often, neighbors are the first responders. The fire and police departments could offer training.				
Air Quality	Air quality Warnings and Education	Use media outlets to increase awareness of risk associated with extreme heat. Target at-risk populations, outdoor workers and those who exercise outdoors.	Albany County Department of Health, Fire and Emergency Services	Public Health		
	Preventative care for children with asthma	Albany's high asthma hospitalization rates indicates a lack of preventative care. The Department of Health should work with local health care providers to identify means of providing preventative care to these populations.	Health Care Providers, State and County Health Officials	Public Health		
Heat Related Illness	Extended pool and spray park hours	Extend pool and spray park hours during heat waves.	Department of Recreation	Public Health		
	Recreational water and shade features	Incorporate recreational water features in parks and plan trees in parks and along streets, especially in dense urban areas.	Department of Recreation, Department of General Services - Engineering, Development and Planning	Public Health, Quality Of Life, Increased Property Values		X
	Mobile cooling facilities	Send mobile cooling facilities into high risk neighborhoods such as dense urban neighborhoods (heat island affect) and low-income areas.	Fire and Emergency Services	Public Health		
	Distribute generators/air conditioners to at-risk residents during service disruptions/high heat days	This strategy targets residents who have special medical needs that require power, as well as have medical restrictions that prevent them from leaving home.	Fire and Emergency Services, Albany Housing Authority, Albany County Department of Health	Public Health		

Sub-Sector	Strategy	Description	Sector/Department/ Implementer	Cross-cutting issues	Link with LWRP	Mitigation Overlap
INFRASTRUCTURE						
Public Transportation	Work from home during disruptions to transportation network	Ensure that municipal employees are equipped to work from home when flooding prevents access to downtown Albany in order to maintain other services.	All municipal departments			
	Identify strategies for at-risk transportation infrastructure	There are three strategies for adapting infrastructure: Accommodate (i.e. elevate), retreat, or abandon. Link these ratings with capital improvement schedules and implement appropriate stormwater BPMs.	Department of General Services, Albany County, New York State, CSX, Albany Port Commission, CDTA, Development and Planning		X	
	Paint bus roofs white	London has painted the roofs of their iconic red buses white in order to keep passengers cooler.	CDTA			X
	Maintain/improve bus cooling systems	Ensure that buses will be able to keep passengers comfortable and function properly with increased heat.	CDTA			
	Bus station/stop improvements	Enhance stations and stops to provide protection from the elements such as structures or trees for heat relief.	CDTA	Reduced Urban Heat Island Effect		X
Roads	Pavement removal day	Implement a pavement removal day where residents can apply to have their pavement torn up in order to create more pervious surfaces. This has been done in urban areas such as Somerville, MA by employing teams of volunteers.	Department of General Services, Development and Planning, CANA	Water Quality, Urban Heat Island Effect, Urban Forest, Stormwater Runoff, Flooding		X
	Incorporate green infrastructure BPMs into complete streets and consider excessive heat events when selecting materials.	Green infrastructure such as swales, rain gardens, and permeable pavers alongside roads, as well as permeable pavement, can help capture stormwater runoff and mitigate road flooding. Excessive heat events may impact the durability of road surfaces.	Department of General Services, Department of Water and Water Supply, Development and Planning, New York State	Water Supply, Water Quality	X	X
	Implement a green alley program	Transform low-volume roads with impervious pavement in order to increase water infiltration and reduce urban flooding.	Department of General Services, Development and Planning, Department of Water and Water Supply	Water Supply, Water Quality		X
Water						
Green Infrastructure	Implement a citywide green infrastructure program and increase urban greening through a Green Area Factor ranking system.	Trees and other vegetation absorb many harmful chemicals and particular matter that pollute the air. Based on Berlin's Biotope Factor Ranking system (BFR), Albany could create a similar system that ranks surfaces based on its greenery and how pervious it is This ranking is used to calculate a number applied to various parts of the city (lower requirements in urban areas, higher in low-density areas) in order to increase the overall greenness and reduce impervious surfaces. For an example of this ranking system, go to http://www.stadtentwicklung.berlin.de/umwelt/landschaftsplanung/bff/index_en.shtml	Development and Planning, Department of General Services, Department of Water and Water Supply	Urban heat Island Effect, Energy Demand, Urban Forest, Stormwater Runoff, Flooding	X	X
Water Supply	Require new development projects to demonstrate projected water use	New development projects would(including agricultural and other industry) would be required to demonstrate projected water use in order to ensure Albany does not grow beyond its water capacity. Projects should demonstrate water conservation strategies in order to minimize their impact on the water supply, such as duel flush toilets. In addition, toilets and sinks should be designed to operate during blackouts provide incentives for retrofits.	Development and Planning, Department of Water and Water Supply, Department of General Services - Engineering	Water Supply	X	
	Enact Water Efficient Landscaping Standards	Adopting green landscaping policy can reduce the need for irrigation and application of pesticides and fertilizers. Pesticides and fertilizers create harmful runoff and reduce water quality. Best practices for water-efficient landscaping include planting native and drought resistant species, drip irrigation, minimized lawn space and use of harvested rainwater.	Common Council, Development and Planning, Department of Water and Water Supply, Department of General Services - Engineering	Water Supply	X	

Sub-Sector	Strategy	Description	Sector/Department/ Implementer	Cross-cutting issues	Link with LWRP	Mitigation Overlap
Sewer Treatment and Stormwater Management	Incorporate projected precipitation data and Hudson River tide levels in future stormwater/ CSO mitigation projects and plans	Ensure that future planning efforts around water are using projections from the most up to date climate models	Department of Water and Water Supply, Development and Planning	Water Quality	X	
Municipal Solid Waste in Flood-prone Zones	Safeguard toxic materials and MSW in floodplane zones.	Develop and adopt policies regarding the citing, permitting, and maintenance of MSW and other similar facilities in designated and projected flood-prone zones to ensure that dispersal of toxic materials and MSW does not occur during flooding events.	Buildings and Regulatory Compliance, Development and Planning	Water Quality, Public Health	X	
Critical Facilities						
	Identify vulnerable communications infrastructure	Ensure that communications systems are designed with several redundancies to enhance overall resilience and availability during extreme events.	Department of Fire and Emergency Services, Police, Department of General Services, Development and Planning	Public Safety, Economic Vitality	X	
	Create a plan to address flooding for at-risk critical facilities	All critical facilities identified as at-risk to future flooding by the vulnerability assessment should be required to create a plan in the event of a flood. Strategies include locating critical appliances and electronics on the second floor and ensuring that there are additional flood protection measures in place.	Department of Fire and Emergency Services, Police, Department of General Services, Development and Planning	Public Safety	X	
Energy						
	Increase local renewable energy sources	Implement strategies identified in the Climate Action Plan to increase local renewable energy supply such as solar panels and wind turbines	Mayor's Office of Energy & Sustainability, and Development and Planning	Public Health, Green Jobs, Economic Vitality		X
	Solar Powered generators at critical facilities	Invest in solar powered generators. Diesel generators have significant negative impacts on air quality and should not be used especially during extreme heat events.	Fire and Emergency Services, Police, Mayor's Office of Energy and Sustainability, Development and Planning	Air quality, Public Safety		X
	Implement cooling strategies	Cool strategies include green roofs, white roofs, strategically planted trees, green walls and urban greening. Many of these strategies are also addressed in other recommendations.	Development and Planning, Department of General Services - Engineering	Public Health, Urban Heat Island Effect, Water Supply, Water Quality, Stormwater Runoff, Urban Forest, Flooding		X
Buildings/Development						
Property Damage	Design standards and building codes	Develop design standards and building and zoning codes that address the impacts of climate change. These might include no build zones, renewable energy incentives, green building requirements, and freeboard incentives for flood prone areas.	Common Council, Law Department, Buildings and Regulatory Compliance Development and Planning	Public Safety, Economic Vitality	X	X
	Flood overlay district/ zones and Permit Review Vulnerability Assessments	A vulnerable area overlay district includes both temporal and spatial planning requirements to reflect changes in sea level and flood inundation. Land in this area would be subject to additional building codes and land-use regulation in order to protect property from flooding. New development could be required to conduct a vulnerability assessment as part of the permit review process, similar to the City of Boston.	Development and Planning	Public Safety, Economic Vitality	X	
	Work to become a Class 1 Community under FEMA's Community Rating Systems	"The Community Rating System (CRS) is a voluntary program for NFIP-participating communities. The goals of the CRS are to reduce flood losses, to facilitate accurate insurance rating, and to promote the awareness of flood insurance. The CRS has been developed to provide incentives for communities to go beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding. A Class 1 Community receives a 45% premium discount. "	Development and Planning	Economic Vitality	X	

Sub-Sector	Strategy	Description	Sector/Department/ Implementer	Cross-cutting issues	Link with LWRP	Mitigation Overlap
NATURAL RESOURCES						
Water Quality	Stream restoration	Cold water streams are critical environments. Stream restoration can help maintain these environments. Special attention should be paid to ensure that a healthy tree canopy exists along the banks to keep the streams cool.	Department of General Services, Department of Water and Water Supply, Development and Planning	Water Quality, Biodiversity		
	Accommodating coldwater species migration	Ensure coldwater species can migrate up stream (remove barriers) if water gets too warm.	Department of Water and Water Supply, NYSDEC, Development and Planning, Department of General Services	Biodiversity		
	Improve riparian buffers	Riparian buffers are vital for reducing non-point source run-off from urban and agriculture run-off. Measures should be taken to ensure that such buffers are maintained and protected, especially in the face of increased flooding which could rapidly erode and eliminate these buffers.	Department Water and Water Supply, Department of General Services, Albany Port Commission, Development and Planning	Water Quality, Flooding, Public Safety	X	
Urban Forest	Conduct tree canopy assessment and implement comprehensive street tree planting program.	Understanding the current tree canopy is critical for projecting and enhancing it. This assessment should include the health, and diversity of the trees.	Department of General Services, Development and Planning	Public health, urban heat island effect, energy, water supply, water quality, stormwater runoff, urban forest, flooding		X
	Modify tree planting guide	This guide will inform and encourage the planting of non-invasive trees and trees that can still survive in a warming climate. The guide should be promoted for use beyond street trees and be applicable for all public and private tree planting.	Department of General Services, Development and Planning	Public health, urban heat island effect, energy, water supply, water quality, stormwater runoff, urban forest, flooding		X
Natural Habitat	Prevent future fragmentation and development	Ensure that habitats, particularly those areas within the Corning Preserve and the Pine Bush Preserve, are not further fragmented or compromised by development by protecting or restoring key parcels that connect larger patches of habitat.	Albany Pine Bush Preserve Commission, New York Department of Environmental Conservation, Development and Planning, Department of General Services		X	X
	Work with Albany Pine Bush Preserve Commission to protect remaining pine bush habitat not in preserve	As a particularly sensitive habitat, the city should work with the Commission, as well as the Towns of Colonie and Guilderland, to protect the remaining unprotected parcels of Pine Bush habitat.	Albany Pine Bush Preserve Commission, New York Department of Environmental Conservation, Development and Planning, Department of General Services		X	X
	Invasive species removal programs	Coordinate with Albany Pine Bush Preserve Commission and local watershed organizations to initiate invasive species removal days.	Albany Pine Bush Preserve Commission, New York Department of Environmental Conservation, Development and Planning, Department of General Services		X	
	Incorporate more natural features in Corning Preserve and along the waterfront park	Provide natural habitat as much as possible in open space planning to support biodiversity and as a measure of flood control.	New York Department of Environmental Conservation, New York Department of State, Development and Planning, Department of General Services, Albany Port Commission		X	
	Work with the Albany Pine Bush Preserve Commission and others to study impacts of climate change on the habitat and communities pine bush ecosystem and particularly vulnerable species	Incorporate the impacts of climate change into the management plans for the Preserve and for particularly vulnerable species, such as the Karner Blue Butterfly.	Albany Pine Bush Preserve Commission, New York Department of Environmental Conservation, Development and Planning, Department of General Services			

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Pine Bush Native Plant Nursery

APPENDIX A:
AT-RISK SPECIES IN THE ALBANY PINE BUSH PRESERVE

The following table was taken directly from the Management Plan and Final Environmental Impact Statement for The Albany Pine Bush Preserve released in September 2010 from the Albany Pine Bush Preserve Commission. It lists all species currently at-risk in the Albany Pine Bush Preserve without factoring in climate change.

Albany's Pine Bush Restoration Project at the Albany Landfill.

Table 4. Rare, Declining and Vulnerable Species within the Ecological Communities of the Albany Pine Bush.

Ecological Communities	Status	Rare, Declining, and Vulnerable Species
Pitch Pine-Scrub Oak Barrens		***Invertebrates***
	SGCN	Barrens Dagger Moth *(Acronicta albarufa)*
		A Noctuid Moth *(Apharetra dentate)*
Pine Barrens Vernal Pond		Dusted Skipper *(Atryonopsis hianna)*
	SGCN	Broad-lined Catopyrha *(Erastria coloraria)*
Pitch Pine-Scrub Oak Barrens	SGCN	Bird Dropping Moth *(Cerma cora)*
	SGCN	A Noctuid Moth *(Chaetaglaea cerata)*
Pitch Pine-Scrub Oak Forest	SGCN	A Noctuid Moth *(Chytonix sensilis)*
	SGCN, E	Persius Duskywing Skipper *(Erynnis persius persius)*
Pitch Pine-Scrub Oak Thicket	SGCN, SC	Mottled Duskywing Skipper *(Erynnis martialis)*
	SGCN, SC	Inland Barrens Buckmoth *(Hemileuca maia maia)*
	SGCN, T	Henry's Elfin *(Callophrys henrici)*
	SGCN, T	Frosted Elfin *(Callophrys irus)*
	SGCN	Barrens Itame *(Itame sp 1)*
	SGCN, E	Karner Blue Butterfly *(Lycaeides melissa samuelis)*
		A Noctuid Moth *(Macrochilo bivittata)*
		Edwards' Hairstreak *(Satyrium edwardsii)*
		Pine Barrens Zanclognatha *(Zanclognatha martha)*
	SGCN, E	Regal Fritillary *(Speyeria idalia)*
	SGCN, T	Tawny Crescent *(Phyciodes batesii batesii)*
	SGCN, E	Ringed Boghaunter *(Williamsonia lintneri)*
		Plants
		Yellow Giant-Hyssop *(Agastache nepetoides)*
		Side-oats Grama *(Bouteloua curtipendula var. curtipendula)*
		Schweinitz's Flatsedge *(Cyperus schweinitzii)*
		Bayard's Malaxis *(Malaxis bayardii)*
		Virginia False Gromwell *(Onosmodium virginianum)*
		Slender Marsh Bluegrass *(Poa paludigena)*
		Amphibians and Reptiles
	SGCN, SC	Jefferson Salamander *(Ambystoma jeffersonianum)*
	SGCN, SC	Smooth Green Snake *(Liochlorophis vernalis)*
	SGCN, SC	Northern Black Racer *(Coluber constrictor)*

Table 4. continued

Ecological Communities	Status	Rare, Declining, and Vulnerable Species
Pitch Pine-Scrub Oak Barrens		*Amphibians and Reptiles*
	SGCN, SC	Eastern Box Turtle *(Terrapene carolina)*
	SGCN, SC	Eastern Rat Snake *(Scotophis alleghaniensis)*
	SGCN, SC	Spotted Turtle *(Clemmys guttata)*
	SGCN, SC	Eastern Hognose Snake *(Heterodon platirhinos)*
	SGCN, SC	Eastern Spadefoot *(Scaphiopus holbrookii)*
	SGCN, SC	Eastern Worm Snake *(Carphophis amoenus)*
	SGCN, SC	Fowler's Toad *(Anaxyrus fowleri)*
		Birds
	SGCN	Golden-winged Warbler *(Vermivora chrysoptera)*
	SGCN	Black-throated Blue Warbler *(Dendroica caerulescens)*
	SGCN	Yellow-breasted Chat *(Icteria virens)*
	SGCN	Whip-Poor-Will *(Caprimulgus vociferus)*
	SGCN	American Woodcock *(Scolopax minor)*
	SGCN	Black-billed Cuckoo *(Coccyzus erythropthalmus)*
	SGCN	Brown Thrasher *(Toxostoma rufum)*
	SGCN	Tennessee Warbler *(Vermivora peregrina)*
	SGCN	Prairie Warbler *(Dendroica discolor)*
	SGCN	Sharp-shinned Hawk *(Accipiter striatus)*
	SGCN	Cooper's Hawk *(Accipiter cooperii)*
	SGCN	Wood Thrush *(Hylocichla mustelina)*
	SGCN	Blue-winged Warbler *(Vermivora pinus)*
Forests		***Birds***
Appalachian oak-pine forest	SGCN	Sharp-shinned Hawk *(Accipiter striatus)*
	SGCN	Cooper's Hawk *(Accipiter cooperii)*
Pine-northern/hardwood forests	SGCN	Red-shouldered Hawk *(Buteo lineatus)*
	SGCN	Wood Thrush *(Hylocichla mustelina)*
	SGCN	Blue-winged Warbler *(Vermivora pinus)*
	SGCN	Black-throated Blue Warbler *(Dendroica caerulescens)*
	SGCN	Ruffed Grouse *(Bonasa umbellus)*
	SGCN	Scarlet Tanager *(Piranga olivacea)*

Table 4. continued

Ecological Communities	Status	Rare, Declining, and Vulnerable Species
Wetlands		***Amphibians and Reptiles***
Pine Barrens Vernal Pond	SGCN, SC	Jefferson Salamander *(Ambystoma jeffersonianum)*
Red Maple Hardwood Swamp	SGCN, SC	Spotted Turtle *(Clemmys guttata)*
Shallow Emergent Marsh	SGCN, SC	Eastern Hognose Snake *(Heterodon platirhinos)*
	SGCN, SC	Eastern Spadefoot *(Scaphiopus holbrookii)*
	SGCN, SC	Fowler's Toad *(Anaxyrus fowleri)*
	SGCN, SC	Common Snapping Turtle *(Chelydra serpentina)*
	SGCN, SC	Wood Turtle *(Glyptemys insculpta)*
	SGCN, SC	Musk Turtle *(Sternotherus odoratus)*

Status: SGCN = Species of Greatest Conservation Need, SC = Special Concern, E= Endangered, and T = Threatened.


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