Chapter 9: Climate Adaptation

UNDERSTANDING CLIMATE CHANGE

Climate change is not a new phenomenon. What is new, however, is the rate of climate change over the last century and the ability of science to measure contributions made by human activity. What is notable about the increased rate of climate change is the effect it has on all natural systems.

The processes that spur climate change impact all facets of life. The term "adaptation" refers to adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects. Given that these processes are already underway, adaptation and mitigation is the recommended framework for sustaining current living conditions on Earth. The terms are inter-related, and broadly defined as:

Adaptive capacity: the ability or potential of a system to respond successfully to climate variability and change

Mitigative capacity: the ability to diminish the intensity of the natural (and other) stresses to which it might be exposed

Understanding the basic scientific evidence of climate change, policy actions taken to address it, and the ongoing need for assessment to identify areas of impact, is necessary to the climate adaptation process on global, national and regional scales. While some preventive and mitigative actions may be too late, adaptation is an evolving process that must begin now.

There are many natural processes at work that influence climate characteristics. One important phenomenon affecting Earth's climate is the greenhouse effect. This process involves the capture of sunlight radiated from earth back to the atmosphere, such that the temperature of earth remains warmer than it would be without this process and therefore conducive to the survival of humans and other species (see Figure 1 on page 228).

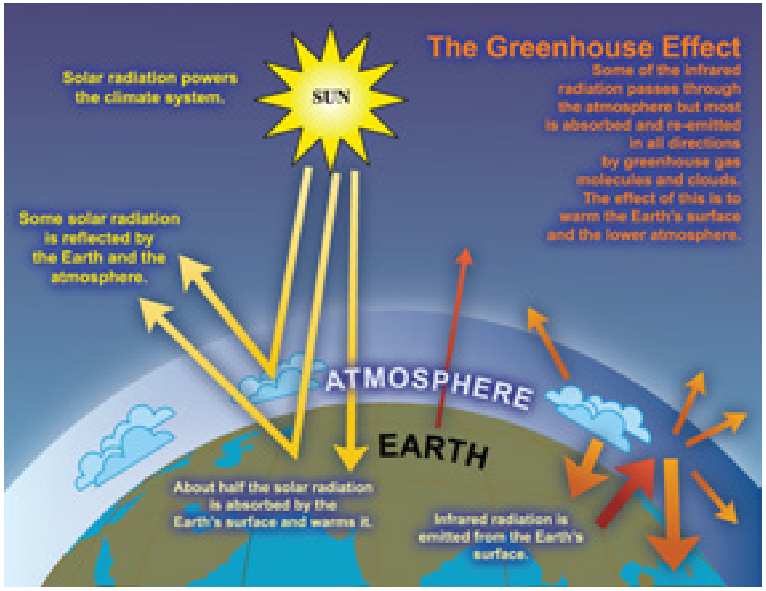


FIGURE 1–The Greenhouse Gas Effect

According to the Intergovernmental Panel on Climate Change (IPCC):

Without the natural greenhouse effect, the average temperature at Earth's surface would be below the freezing point of water. Thus Earth's natural greenhouse effect makes life as we know it possible. However, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming.

The trapping effect of the greenhouse gases (GHG) at work in the natural greenhouse effect is accelerated with the addition of GHGs from human activities, such as fuel combustion for electricity generation, vehicle transport, and the animal-released methane from agricultural processes.

Global and National Climate Change

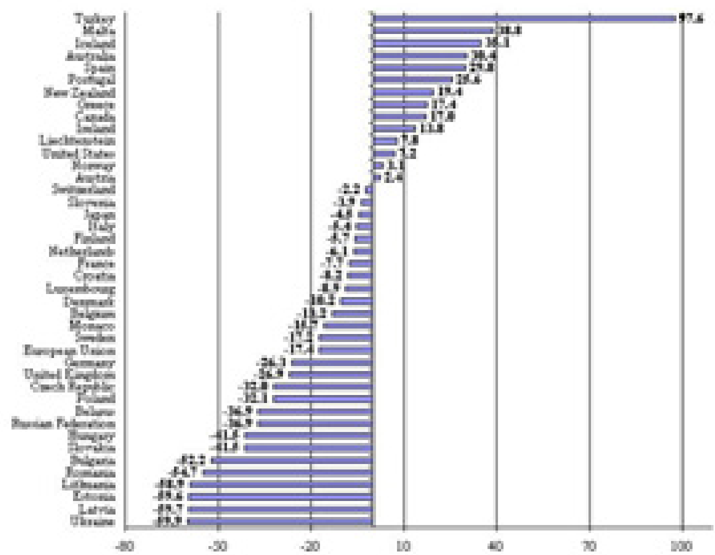
The United States Climate Action Report for 2010 (Fifth National Communication under the UN-FCCC) indicates that climate changes are underway and projected to grow across the nation. These changes include heavy downpours, rising temperature and sea level, rapidly retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows.

Climate change impacts are occurring in different regions of the world. Climate change issues such as greenhouse gas emissions, temperature fluctuation and sea level rise will affect nearly all nations at different scales.

Greenhouse Gas Emissions

Across the globe GHG emissions rates vary, particularly given the timeframe of analysis conducted and the state of development of individual nations. Table 1 shows the percent change from 1990 emissions levels for all parties to the United Nations Framework Convention on Climate Change (UN-FCCC). For example, based on 2009 emissions data, the United Kingdom has seen a 26.9% decline in emissions.

TABLE 1–Changes in GHG emissions excluding LULUCF (%)



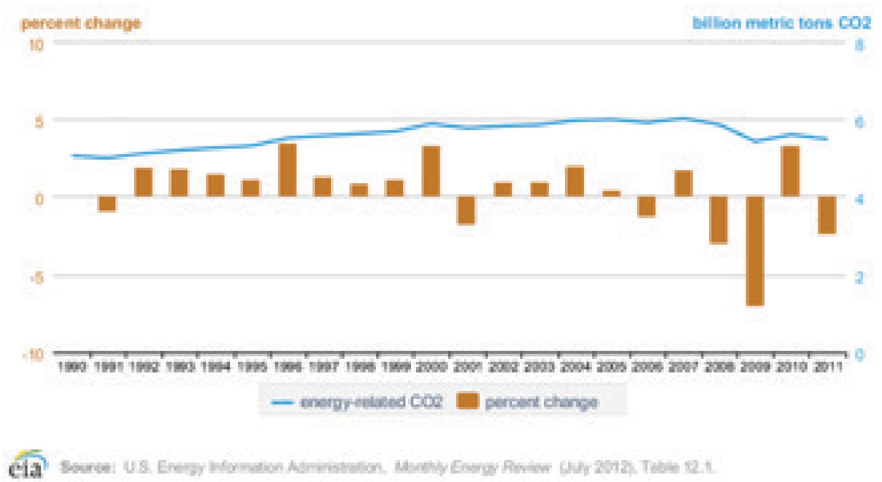
note: "Excluding Land Use, Land Use Change and Forestry (LULUCF)" refers to the exclusion of carbon sinks such as forests, which would reduce the overall emissions total due to the carbon storage potential of trees.

Global emissions levels are expected to rise according to projections generated through scenario modeling efforts. Scenarios cover a range of potential actions (including business as usual) affecting GHG emissions in the future. Global climate models generally indicate that emissions rates will continue to rise, and even if emissions were to stabilize, their impacts would continue to be felt in the long-term:

+ Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the time scales required for removal of this gas from the atmosphere.

United States emissions totaled 6,821.8 teragrams or million metric tons of CO2e in 2010. This total represents an increase of 10.5% over 1990 emissions levels. Energy-related emissions increased in the United States during 2010 (just over 3% from 2005 levels), following a slight decline in 2009 (see Figure Table 2).

TABLE 2–Energy-related carbon emissions, 1990-2011



Of the three most regularly reported greenhouse gases, carbon dioxide (CO2) emissions are highest for the nation in the fossil fuel burning sectors of electricity generation, transportation and industry, respectively, while the highest methane (CH4) emissions result from natural gas systems and enteric fermentation processes of agricultural livestock. National nitrous oxide (N2O) emissions are highest in the agricultural soil management sector, which involves the application of fertilizers to farmland.

National emissions trends and projections fluctuate primarily based on shifts in fossil fuel combustion. The Energy Information Agency (EIA) forecasts that "energy-related CO2 emissions in 2035 are only 3 percent higher than in 2010 (as compared with a 10-percent increase in total energy use)," due to the projected decline in carbon intensity of fuels combusted.

Temperature

In 2005, global temperatures were the warmest on record. Temperature data has been tracked for over a century and scientists have observed that global warming equates to a temperature rise of 1.1°F in the past three decades and 1.4°F in the past century. Figure 2 illustrates the warming trend of the last century. IPCC temperature projections include a 0.4oF warming trend over each decade for the next two decades. According to the National Climatic Data Center, the first eight months of 2012 were the hottest ever recorded in the continental United States.

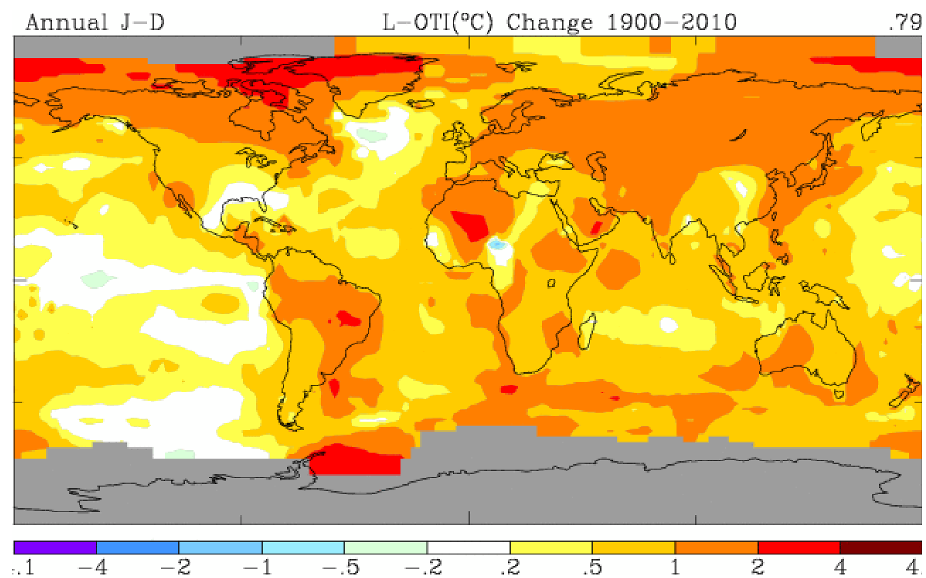


FIGURE 2–Global Temperature Changes during the 20th Century - 1900-2010

The summer period of June, July and August was also the third hottest ever recorded. The nation is averaging 4 degrees Fahrenheit above average for the year. This represents a full degree higher than the same period in 2006, which was the second hottest January-August on record. Record keeping began in 1895.

As an indicator of average daily temperature fluctuation, heating and cooling degree days indicate the number of days above or below 65 degrees Fahrenheit in a year. From 2001 to 2008 the number of heating degree days averaged 4,259, which was 3.8 percent below the 20th-century average. Over the same period, the annual number of cooling degree days averaged 1,335, which was 5.4 percent above the long-term average.

Sea Level

Sea levels are measurably rising across the globe. According to the IPCC's Fourth Assessment report:

"Rising sea level is consistent with warming. Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm/yr and since 1993 at 3.1 [2.4 to 3.8] mm/yr, with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets. Whether the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend is unclear"

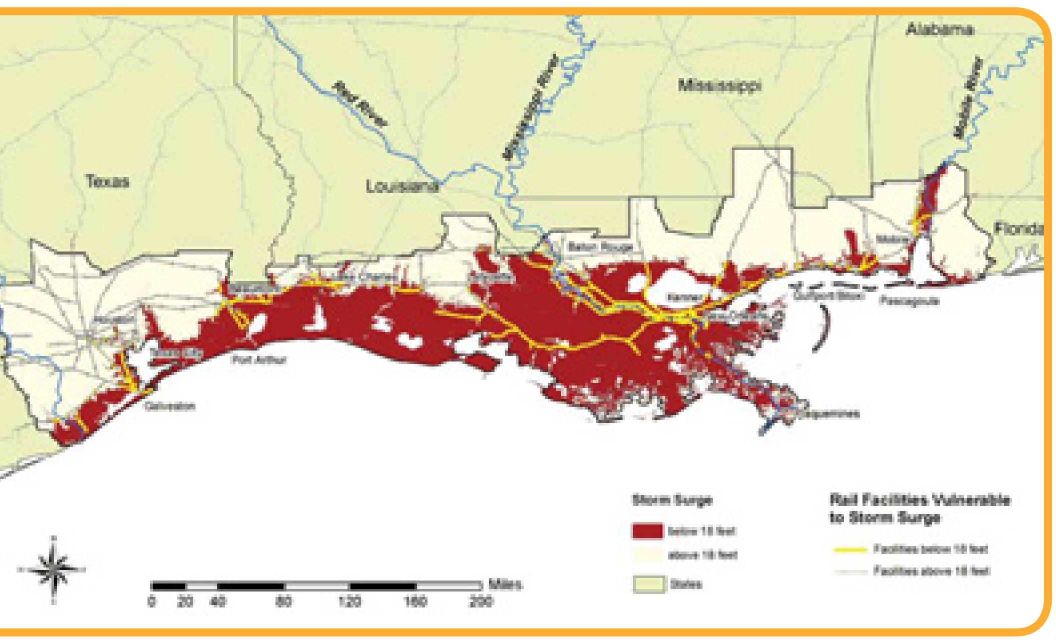


FIGURE 3—Sea Level Rise along the Gulf Coast

Along the Gulf Coast alone, approximately 3,864 kilometers (2,400 miles) of major roadways and 396 kilometers (246 miles) of freight rail lines are at risk of permanent flooding within 50-100 years as climate change and land subsidence combine to produce a projected sea level rise of approximately 1.2 meters (4 feet).

Melting of glaciers and ice sheets is occurring in conjunction with global temperature increase to create sea level rise. Additionally, changes in snowfall, ice and length of frozen periods resulting from temperature increase, are also impacting water bodies, such as lakes. Given the interdependence of all ecological processes, melting patterns leading to sea level rise are impacting ecosystems at all scales.

Records indicate that most of the United States coastline has experienced sea level rise equivalent to 2-3 millimeters per year. United States regions experiencing sea level rise will continue to experience impacts in sectors such as transportation. Along the Gulf Coast alone, approximately 3,864 kilometers (2,400 miles) of major roadways and 396 kilometers (246 miles) of freight rail lines are at risk of permanent flooding within 50–100 years as climate change and land subsidence combine to produce a projected sea level rise of approximately 1.2 meters (4 feet) (see Figure 3).

Impacts from rising sea level include higher and more frequent flooding of wetlands and adjacent shores; expanded flooding during severe storms and high tides; increased wave energy in the near-shore area; upward and land-ward migration of beaches; accelerated coastal retreat and erosion; intrusion into coastal freshwater aquifers; damage to coastal infrastructure; and significant impacts on the coastal economy.

These impacts are being felt within the coastal population centers and beach ecosystems of New York State where the coastline has risen by approximately one foot since 1900. Hurricane Sandy, the super storm which struck the northeast in October 2012, destroyed homes and devastated shoreline communities when sea levels in the New York metropolitan area rose 14 feet above average low-tide levels.

Arctic Sea Ice

The Arctic ice cap has been melting at a faster rate in recent years, and melting is reducing not only the breadth, but also the depth of the ice cover- an indication that ice thickness is declining due to multiple years of warming. In September 2012, sea ice covering the Arctic Ocean fell to the lowest extent in the satellite record, which began in 1979. Satellite data analyzed at the National Snow and Ice Data Center shows that Arctic sea ice cover reached its lowest extent ever recorded on September 16. The ice cap is 49 percent smaller than the 33-year average obtained from satellite observations.

Arctic warming can have significant effects on weather throughout New York State and along the east coast by contributing to a weather pattern called the "Greenland Block". The term refers to conditions that develop when warming temperatures occur over Greenland for several weeks, causing additional warming trends to occur in a northwest direction across the Arctic. The block contributes to a change in the jet stream which results in the movement of cold air moving southward, causing major winter storms in the Great Lakes region and along the east coast. The duration of these weather patterns typically last for weeks, rather than an entire winter season. The shifting jet stream from the Greenland Block contributed to the nine-day winter storm event in February 2007 (with 140 inches of snow in Oswego County), the massive snow storm that hit the east coast in February 2010, and the persistent lake effect snow that closed schools and impacted travel in Oswego County during 2011.

Challenges Associated with Climate Change

Policy Challenges

To date, there is no comprehensive climate policy at the global or national level. In 1992, the United Nations (UN) established the Framework Convention on Climate Change (UN-FCCC) in order to articulate global concern for the changing climate. Since 1992, the UN has convened conferences of the parties to develop global climate change policy and adaptation measures. The first conference took place in 1997 in Kyoto, Japan, and the most recent conference was in Durban, South Africa, in 2011. Each of these conferences attempted to strengthen global commitments to climate change adaptation and mitigation amid scientific uncertainty, resource constraints and issues of equity. The global policy context has evolved throughout the last decade, with much of the focus on the responsibility of developed countries to address the challenge of disproportionate burdens of climate change impacts on the developing world.

Over the last decade, nationally, climate change policy has remained a consistently challenging and bipartisan issue. The United States Environmental Protection Agency (EPA) declared that greenhouse gas emissions posed human and environmental health risks under the Clean Air Act in 2009. National policy regarding the limits of toxic air pollutants by coal-fired power plants was also implemented by the EPA under the Clean Air Act in 2011. The federal Interagency Climate Change Adaptation Task Force published its Progress Report on Federal Actions for a Climate Resilient Nation in 2011, outlining the need for climate adaptation strategies across the United States and articulating the efforts already underway at the federal level. Challenges regarding resource constraints and federal versus state action on climate change remain. Despite the lack of comprehensive national climate policy, growing membership to organizations such as ICLEI Local Governments for Sustainability and increases in commitments such as the United States Conference of Mayors Climate Protection Agreement signify an emerging consensus regarding local government action to address climate change. Furthermore, ongoing development of global sustainability indices and emissions accounting tools continue to influence regional planning and policy-making in the United States.

At the state level, New York has instituted executive orders regarding energy efficiency and conservation, developed aggressive statewide emissions reductions targets, and undertaken climate change adaptation assessments. In 2010 New York State released an interim progress report on the state climate action plan, and the New York State Sea Level Rise Task Force produced its "Report to the Legislature." In 2011, the state published "ClimAid: Responding to Climate Change in New York State" (ClimAid), outlining climate change impacts and areas for adaptation. New York's aggressive emissions reduction goal (80% by 2050) presents a challenge for climate action within all social, economic and environmental sectors.

Equity and Environmental Justice

The term, "environmental justice" refers to the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. The issue of climate change, whether considered in terms of temperature rise, emissions or public health, affects all people- and also some more than others. The global issue of equity arises regarding how developed countries continue to develop- emitting more than developing countries, thus disproportionately contributing to climate change and all of its associated impacts. Additionally, equity and justice are a challenge when considering the adoption and implementation of global climate policy; given the lack of resources within developing countries and their desire to grow as other developed countries have, climate change policy must address the issue of resource distribution and development rights.

At a regional level, equity and environmental justice issues are apparent in planning decisions. The lack of water experienced by one community, in the event of drought induced by a warming climate, may be precipitated by the planning and resource consumption patterns of another community. Additionally, limiting air pollution in one region, while permitting growth and associated pollution to increase in another, presents equity challenges for communities living under each set of circumstances. Awareness and consideration of equity and justice issues is a key component of climate adaptation planning.

Justifications for Climate Adaptation Measures

Climate adaptation is the widely accepted framework for anticipating and preparing for climate change, with the goal of achieving community resilience, often through a "no-regrets" policy-making approach. Community resilience is defined as the "capability to anticipate, prepare for, respond to, and recover from significant multihazard threats with minimum damage to social well-being, the economy, and the environment," and a no-regrets approach entails implementing adaptation measures that have negative net costs due to the generation of benefits that outweigh the cost of implementing the adaptation measure. Many economic, social and environmental benefits provide justification for building community resilience through climate adaptation planning.

Key economic considerations involve the need to anticipate regulatory and policy changes to reduce compliance costs for municipalities over time, and to accurately assess the cost burden to communities associated with rising insurance premiums and varying levels of risk coverage. Given the uncertainty of climate change policy trajectories, nationally and globally, it is important for communities to anticipate changes in the regulatory environment through a no-regrets planning approach. Just as industrial manufacturers install pollution control equipment in order to comply with environmental regulations, communities must develop strategies that target areas of risk or vulnerability to the impacts of climate change, such as aging infrastructure or development in floodplains. These strategies include prevention education for property owners to counteract growing insurance premiums, so that residents and businesses are aware of the safety level of their assets, or developing mechanisms to cover risk that is not assumed by the insurance industry (Figure 4).

Climate adaptation measures ensure the ongoing protection of public health and safety in the face of changing climate conditions. Public health impacts such as heat-related illness, insect-borne diseases such as the West Nile Virus, and poor air quality must be considered in

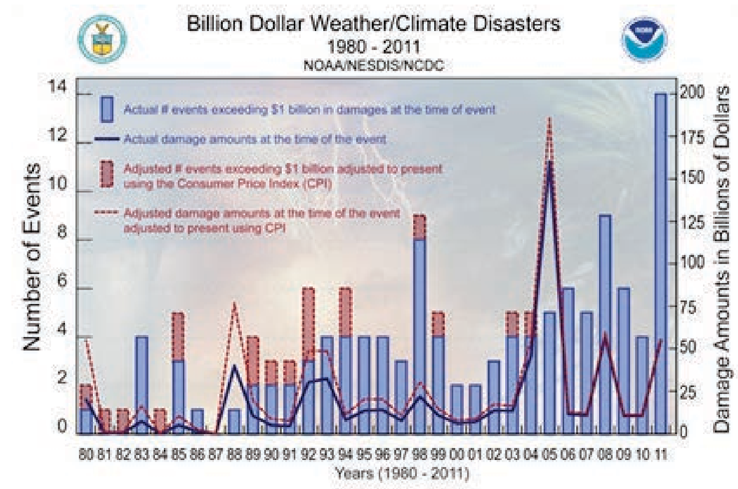


FIGURE 4–Sea Level Rise along the Gulf Coast

climate adaptation planning, as a way of building flexibility into health service provision and adequately preparing institutions to handle these impacts. To build community resilience, all public institutions- including public health agencies and public documents such as comprehensive plans- must build adaptation measures into their planning processes. These social considerations can result in secondary benefits such as improved efficiency or economic opportunity, which also contributes to community resiliency.

The protection of ecosystem health and ecosystem services comprises an important environmental consideration in climate adaptation planning. Ecosystem services encompass many natural processes that are categorized into three functions: provisioning services (e.g., raw material provision such as timber), regulating services (e.g., water flow regulation through natural storage processes), and cultural services (e.g., recreational or spiritual value of ecosystems). Climate change impacts will affect all ecosystems, including their ability to provide these ecosystem services, at different scales. Effective no-regrets climate adaptation planning takes the value of these services into consideration as a means of protecting and enhancing community resources.

Chapter Objectives

The Central New York region has an opportunity to be a leader in climate adaptation. This portion of the regional plan is meant to equip Central New York communities with the foundation to explore adaptation strategies appropriate for their conditions and vulnerabilities. Central New York is already a leader in environmental sustainability and conservation. While our communities can learn from the adaptation efforts of other regions, we must seize the opportunity to identify existing best practices and tools that increase regional resilience.

Many states and communities have already taken the lead in climate adaptation- communities such as Keene, New Hampshire and Boulder, Colorado have created climate adaptation plans and implementation strategies. Central New York cities, towns and villages have the chance to benefit from preparedness and flexibility, and reap co-benefits such as shared resources and efficiency that are involved in climate adaptation planning.

This chapter identifies areas for adaptation in Central New York communities with the goal of creating a more sustainable and resilient region amidst the uncertainty of global climate change impacts. Climate adaptation strategies necessitate a systems approach to planning and policy-making, which leads to many social, economic and environmental benefits. While areas for monitoring, assessment and continuous improvement exist, actions taken today will make a significant impact when paired with long-term planning efforts.

INVENTORY OF EXISTING CLIMATE CONDITIONS

Climate impacts throughout the northeast are expected to cause warmer temperatures and increased frequency of storm events. Warming trends will result in longer growing seasons, warmer winters, and summer heat stress. Increased winter precipitation is also expected, along with increased variability and extreme events. The potential impacts of climate change emphasize a critical need in Central New York for the implementation of green infrastructure, protection and expansion of wetland resources, and improved buffer zones around sensitive ecosystems.

Climate characteristics in Central New York are influenced by land topography and national weather trends. Extreme events occasionally impact the region and include periods of excessive heat (the summer of 2012 is an example), flooding from heavy precipitation events and spring snow-melt, and lake-effect snowfall because of the region's close proximity to Lake Ontario. Climate conditions will continue to have a significant impact on Central New York's diverse economy, with precipitation and temperature impacts on agriculture, industry, commerce, and recreation. Temperature and precipitation increases in Central New York are anticipated to cause increased flooding and stormwater runoff with secondary impacts on wastewater treatment plants and pollutant loading to water resources. Warming trends are expected to result in longer dry periods during the summer months, while contributing to the northward spread of invasive species. Increased temperatures are expected to cause lower tributary flow rates and water levels in lakes, rivers and streams, with a shift in aquatic species composition.

The New York State ClimAid report identified the following observed climate changes throughout the state:

1. Annual average temperatures in New York State have risen about 2.4 degrees since 1970, with winter warming exceeding 4.4 degrees.
2. Sea level along New York's coastline has risen about one foot since 1900.
3. Since 1900, there has been no discernible trend in annual average precipitation for the state as a whole.
4. Intense precipitation events (heavy downpours) have increased in recent decades.

The following sections address the priority risks associated with climate change in Central New York including water resources, forest ecosystems, agriculture, energy, and public health. The last section of the chapter presents a table with recommendations designed to address Central New York's goals for climate adaptation.

Temperature

New York's climate is in the process of changing and data shows evidence of warming temperatures, especially during the winter months. The average annual temperature is 47.4°F but since 1970, average temperatures throughout the state have increased by approximately 0.6° F per decade. Winter warming has increased by over 1.1°F per decade. The state has also experienced more frequent days with temperatures above 90° F.

The first half of 2012 had the warmest temperatures in 118 years of record-keeping (Figure --). Temperature anomalies for July show that twenty first century temperature increases are already in the top 10 readings on record. In Syracuse, summer temperatures reached record highs. 101oF was recorded on July 17 while the normal for that time period is 79oF. In 2012, Syracuse had the fourth warmest June to August period out of the 111 years of record-keeping. The average temperature was 72.7 degrees, which is 3.4 degrees above the 30-year normal. Temperature trends are evident when viewing the average air temperature recorded between 1951 and 2011 at the Hancock Airport Weather Station in Syracuse (Figure 5).

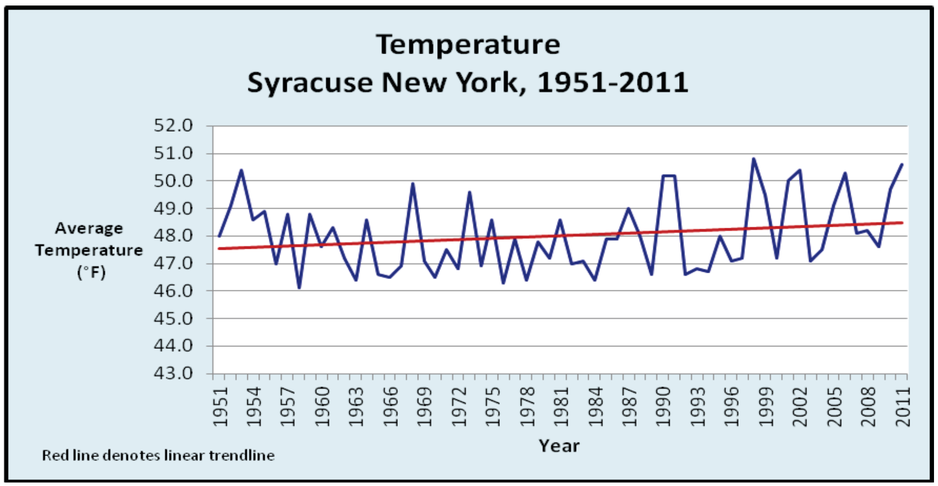


FIGURE 5–Change in Temperature Syracuse New York, 1951-2011

According to modeling estimates, temperatures in New York State are expected to increase by 1.5 to 3°F by the 2020s, 3 to 5.5°F by the 2050s, and 4 to 9°F by the 2080s. The warming trend is expected to impact all sectors of society and all regions of the State. Risks associated with temperature increases in Central New York include a greater frequency of intense heat waves, increased likelihood of summer droughts, and periods of extreme rainfall that will likely affect food production, natural ecosystems, and water resources.

Winter weather conditions in Central New York could be influenced by climate change as well as the presence of an El Niño or La Niña. El Niño, part of the El Niño Southern Oscillation (ENSO), refers to a fluctuation in sea-surface temperatures over the tropical Pacific Ocean which causes the water to be warmer than average. During the La Niña phase, like the past two winters, water is colder than average over the same area. Both phases of ENSO can have profound effects on weather patterns in this region and around the globe. The relative strength of El Niño will also influence the amount of snowfall for the northeast. A weak system will produce above normal snowfall and a strong system will produce snowfall levels below average.

Central New York Greenhouse Gas Emissions Inventory

Methodology

The Central New York greenhouse gas (GHG) inventory took place from June-December 2010. This analysis was conducted for all five counties in the Central New York region, with an initial baseline assessment completed at the county level and a final allocation of emissions to the municipal level. This work was done in coordination with the nine other regions of the state through the New York State Greenhouse Gas Working Group, which aggregated the methodologies developed by each region and then selected recommended approaches to include in a NYGHG protocol. This document serves as the basis for future analyses by each region, and will function as a benchmark for future protocol iterations.

Methodologies developed by the EPA, ICLEI, The Climate Registry, and others formed the basis for protocol development and regional inventory analysis. Additionally, reporting follows a similar paradigm used in the United States National Inventory Report and Intergovernmental Panel on Climate Change standards to ensure consistency. Sectors analyzed include energy generation, residential, commercial and industrial energy use, solid waste, agriculture, on-road transportation, non-road transportation, land use and forestry, industrial processes, and wastewater treatment.

Results

Central New York emissions comprise 4% of New York State totals (254 million $MTCO_2e$ in 2008). Considered in aggregate, the region's emissions total 9.9 million metric tons of CO_2e ($MMTCO_2e$). This total does not take into account carbon sinks, such as forests, which store and capture carbon so that it is not released into the atmosphere (see appendix – for additional regional GHG inventory information). The per capita emissions for the region are 13 $MTCO_2e$ per resident (Figure 6).

Transportation sources, such as gasoline used by passenger vehicles, are the largest sources of emissions in Central New York, at 43% of the region's carbon footprint. Stationary fuel combustion from sources such as residential heating fuel follows at 27% of the region's carbon footprint (see Figure 7).

The Central New York gross regional product (GRP) totaled over $31 billion in 2010. Emissions per dollar of GRP are approximately 0.0003 $MTCO_2e$. Emissions are forecasted to grow 19% across these sectors by 2030, which is the mid-point evaluation year for the state GHG reduction goal of 80% by 2050. The transportation sector is the primary source of projected emissions growth over the next eighteen years. As part of the baseline for assessing climate change impacts, the regional GHG inventory provides analysis that will aid communities in targeting specific sectors for climate action and adaptation planning processes.

Precipitation

New York has a temperate climate with annual precipitation of 47" per year. Precipitation rates are normally sufficient in Central New York to maintain municipal and industrial water supplies, transportation and recreation resources, and provide enough moisture during the growing season for agricultural crops, lawns, gardens, shrubs, forests, and woodlands. The average annual precipitation in New York State, however, has been increasing in both intensity and annual totals.

Precipitation in Central New York is impacted by cyclonic storms which pass from the interior of the country through the St. Lawrence Valley. Lake Ontario also provides a source of significant winter precipitation in the form of "lake-effect" snow (refer to section d.). The precipitation rate averages approximately three inches per month throughout the year. Snowfall is moderately heavy with an annual average just over 100 inches. There are about 30 days per year with thunderstorms, mostly during the warmer months. Annual precipitation totals for Syracuse New York are presented in Figure 8 on page 236.

Intense precipitation events, characterized by heavy downfalls, have increased in New York State in recent decades. Central New York has recorded an increase in heavy precipitation, more winter precipitation falling as rain, reduced snowpack and earlier spring snowmelt resulting in earlier peak river flows. Projections for future precipitation rates are less certain, however, than projections for temperature. ClimAID analyses for New York suggest that precipitation levels may increase, especially during the winter months, but the nature of this change is unclear.

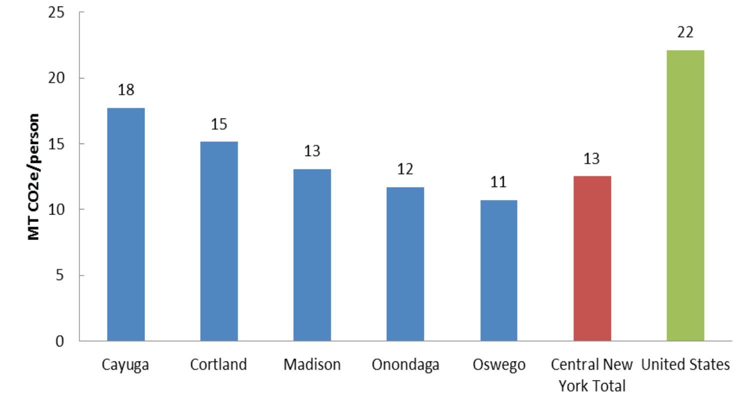


FIGURE 6–Per Capita Emissions by County

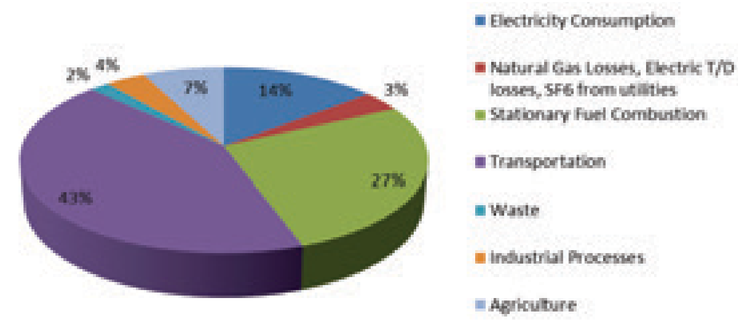


FIGURE 7–Total Emissions by Sector (excluding LULUCF)(in $MTCO_2e$

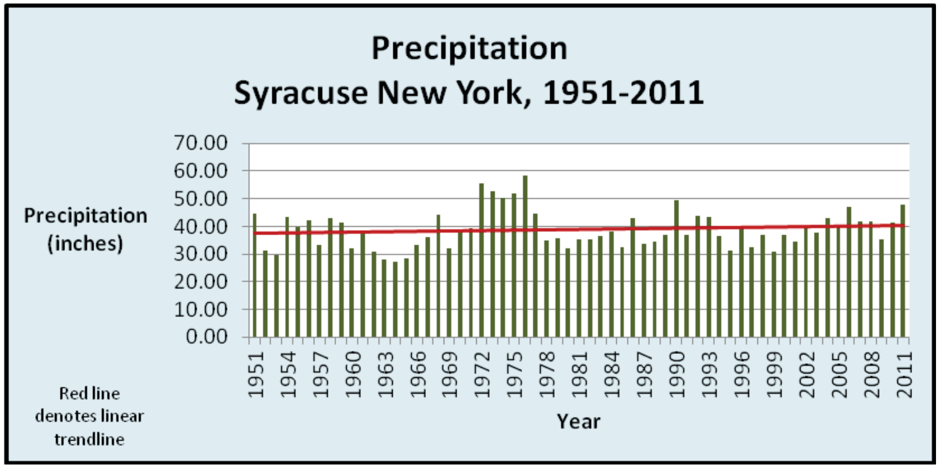


FIGURE 8—Change in Precipitation Syracuse New York, 1951-2011

Drought

Severe drought conditions in Central New York are rare but dry periods occasionally occur, resulting in declining water supplies and low soil moisture for field crops and other vegetation. The last major drought in the region occurred in 1999 and it lasted for four months. A very dry spring and summer caused major crop failures and some wells ran dry. Many streams and rivers were also brought to their lowest recorded levels. In 2012, Syracuse experienced its 9th driest summer with only 6.39 inches of rainfall. This is 4.27 inches below the 30-year normal.

Flooding

Flooding and extreme precipitation events in Central New York threaten public health and safety by contaminating drinking water, threatening food and water supplies, weakening infrastructure and promoting insect-borne diseases. Flooding is normally influenced by a combination of climate and topographic characteristics. The greatest potential for flooding in Central New York is typically seen during the early spring when heavy precipitation, warming temperatures, and rapid snowmelt produce heavy flows and high tributary runoff rates. Conditions can be further exacerbated by ice jams, saturated soils, beaver dams, clogged storm sewers, and dam failures.

Flooded road in Oswego County, 2010

Photo credit: Gary Walts, The Post-Standard

Significant flooding in Central New York is more common in the municipalities that are located within the Erie Ontario Lowlands, a region characterized by flat terrain and high groundwater levels. Municipalities in this region include the towns of Sullivan, Lenox, the Cities of Oneida and Syracuse, and the villages of Chittenango and Canastota, among others. During periods of heavy runoff and high flow rates, large quantities of water flow down the tributaries and often cause erosion. Flooding occurs when these waters reach the lowland region. Flood waters often contain large quantities of sediment and transport tree limbs and other debris that cause logjams.

FEMA Flood Zones

The Federal Emergency Management Agency (FEMA) is conducting a nationwide effort to update its flood insurance maps. In Central New York, re-delineation of flood boundaries has resulted in many new properties requiring flood insurance and significant changes for local residents that will need new or upgraded flood insurance policies. Several local, state and federal officials within Central New York have raised issues with the FEMA mapping process, which has caused a delay in final decisions regarding flood maps for areas in Onondaga County.

Community Rating System (CRS)

The Community Rating System (CRS) is a voluntary program for communities that participate in the National Flood Insurance Program (NFIP). The program is designed to reduce flood damages to insurable property, strengthen and support the insurance aspects of the NFIP, and encourage a comprehensive approach to floodplain management. CRS credits are awarded for floodplain management activities. Flood insurance premium discounts are also awarded as a way to promote flood hazard awareness and mitigation while strengthening floodplain management strategies. CRS premium discounts are offered as incentives for communities to go beyond the minimum floodplain management requirements and to develop extra measures to protect areas from flooding. Twenty-nine communities in New York State are participating in CRS. The City of Syracuse (Onondaga County) and the Village of Moravia (Cayuga County) are the only municipalities in Central New York that participate.

Water infrastructure

Wastewater and water delivery infrastructure is also vulnerable to the impacts of climate change. New York has more than 600 wastewater treatment plants serving over 15 million people, and more than 30% of the state's treatment facilities and systems are over 60 years old.[58] Under strict water pollution standards, infrastructure improvements have been made statewide; however, older systems, such as CSOs, present an ongoing risk in the event of climate change impacts, such as flooding or heavy precipitation events.

Infrastructure that is situated in areas where flooding is likely to occur is a priority climate vulnerability in Central New York. Water supply and wastewater treatment systems throughout Central New York are expected to be impacted by climate change especially with increased flooding in low lying and flood-prone areas (see Table 3 on page 237). The map in Figure 10 on page 238 shows FEMA flood zones in relation to treatment plants and power plants. The potential for increased frequency of flooding events throughout the region emphasizes the need for community leaders to consider alternative flood policies and future land use and development trends.

TABLE 3—Wastewater Treatment and Power Generation facilities located in FEMA floodplan in Central New York

County	Number of Wastewater Treatment Plants Located in the Floodplain	Number of Power Plants Located in the Floodplain
Cayuga	3	0
Cortland	0	0
Madison	1	0
Onondaga	4	3
Oswego	1	5

Snow Cover

Since the 1920s, Northern Hemisphere snow cover has steadily declined, despite increased precipitation. According to the National Research Council, between 1966 and 2005, the total area of Northern Hemisphere snow cover shrank by approximately 1.4 percent per decade. Snowfall deficits for Syracuse in relation to other cities throughout the United States are displayed in Figure 9.

Location	Departure from average through Feb 1, 2012	Snowfall through February 1	Average for entire season
Syracuse, NY	-45.8"	31.8"	116"
Buffalo, NY	-37.6"	24.6"	94"
Duluth, MN	-36.7"	16.9"	81"
Rochester, NY	-33.1"	16.7"	92"
Sault Ste. Marie, MI	-31.9"	54.3"	117"
Erie, PA	-29.9"	36.5"	89"
Williston, ND	-26.9"	1.8"	42"
Muskegon, MI	-24.5"	39.5"	96"
Marquette, MI	-24.0"	93.9"	141"
Bismark, ND	-23.8"	5.9"	44"

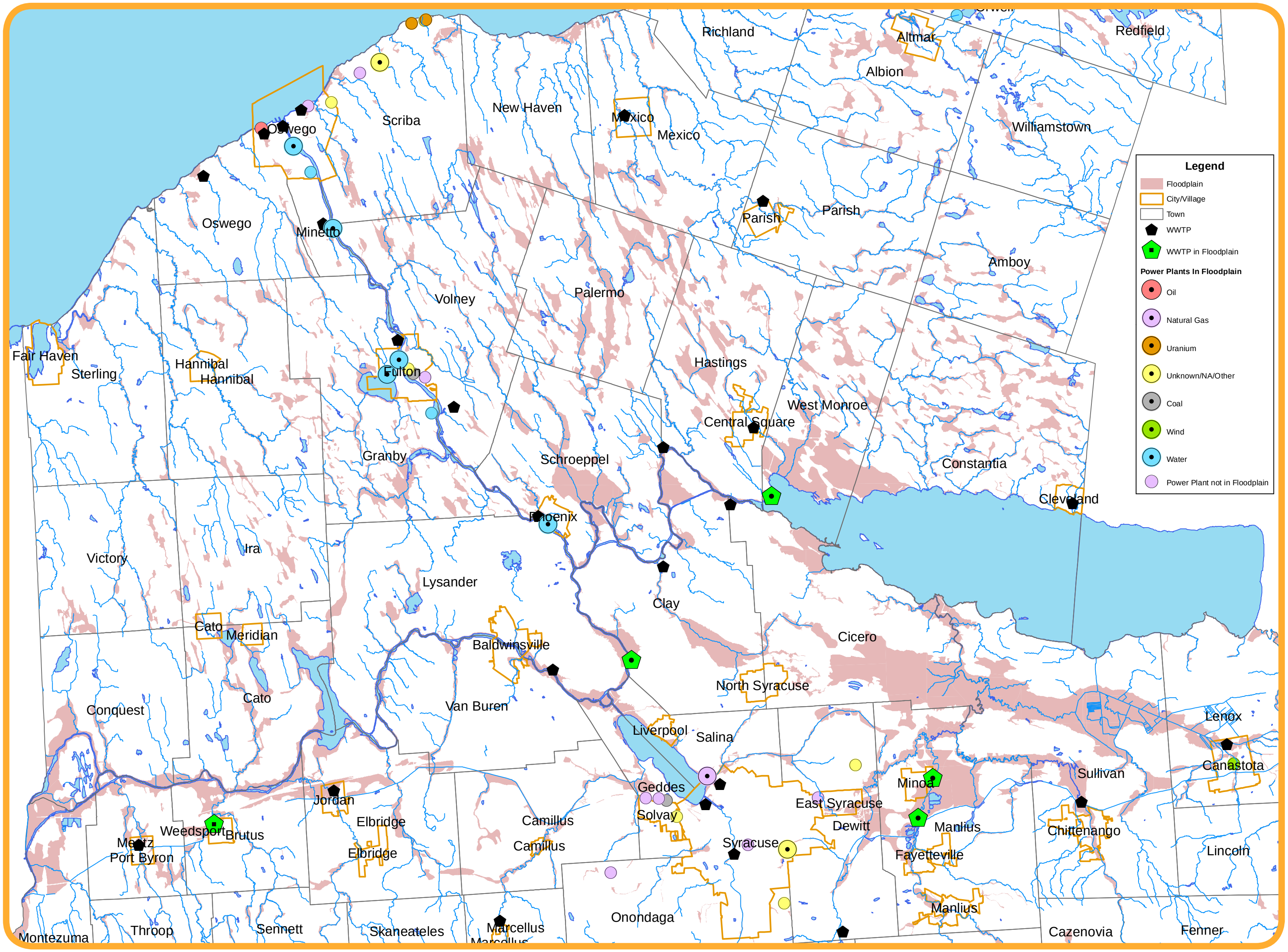
FIGURE 9—Biggest U.S. snowfall deficits for the winter of 2011 - 2012

Topography, elevation, and proximity to Lake Ontario influence the amount of snowfall throughout Central New York. The depth of snow cover is presented in Figure 11 on page 239.

The long term trend for the past sixty years shows increasing snowfall for the Syracuse region, but a decreasing trend is apparent from 2003 to 2009. If snow cover continues to decrease in Central New York, soil temperature and depth of freezing will be impacted. Additionally secondary effects on root biology, soil microbial activity, nutrient retention, and the overwintering capacity of insects, seeds, and pathogens could have far-reaching consequences.

FIGURE 10– Infrastructure situated in areas of flooding vulnerability in Central New York

The map to the right depicts FEMA flood zones in relation to treatment plants and power plants. Infrastructure that is situated in areas where flooding is likely to occur is a priority climate vulnerability in Central New York. Water supply and wastewater treatment systems throughout Central New York are expected to be impacted by climate change especially with increased flooding in low lying and flood-prone areas (see Table 3 on page 237).



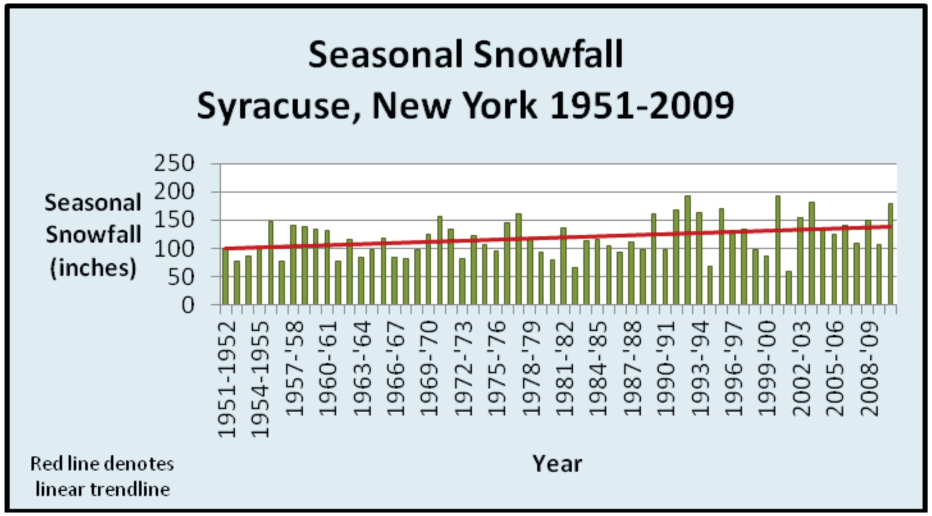


FIGURE 11–Change in Seasonal Snowfall in Syracuse, NY 1951 - 2009

"Lake-effect snow" is a term that refers to snow that falls near a large lake at a high rate per hour. It forms when cold air masses move over a large lake with warmer water temperatures. When the bottom layer of air is warmed by the lake water, moisture from the lake evaporates into the cold air. The moisture rises, then cools and condenses, forming clouds, and producing snow. Lake-effect clouds often form in narrow bands. The size and direction of these bands and the resulting rate of snow fall changes depending on the shape of the body of water, the temperature differential, and the prevailing wind direction and speed.

Due to the proximity to Lake Ontario, all counties in Central New York are susceptible to lake-effect snowfall but Oswego County, located in the Tug Hill region, is especially vulnerable because of its position in relation to the prevailing westerly winds. The area is recognized as having a short growing season and as being one of the wettest and snowiest areas of New York State.59 The large amount of snowfall throughout the Tug Hill region each winter impacts flood events in the spring when the snow melts.

Variability

Rather than simply focusing on the annual totals in temperature or precipitation, it is important to consider the variation in these totals over time. Snowfall totals, for example, for the Syracuse area show increasing variation (Figure 12). The graph shows that the distance between the red trend line and the data points connecting the blue line grow increasingly farther apart from 1990-2012. This indicates that the disparity in annual snowfall totals from year to year, and over specific periods, is growing larger now than in the recent past (since the 1950s).[60]

Lake effect snow sign in Central New York

Increased variation in snow and precipitation levels are monitored because of their effect on ecosystems, agriculture and recreation. Cornell University cites the potential for "changing precipitation patterns" corresponding to increasing winter precipitation and decreased summer precipitation as a result of climate change in New York State.61 These impacts have the potential to contribute to drought, flooding and changes in stream flow patterns. The combination of changing rates of precipitation, combined with changing precipitation totals will be an important consideration in building the adaptation capacity of Central New York communities.

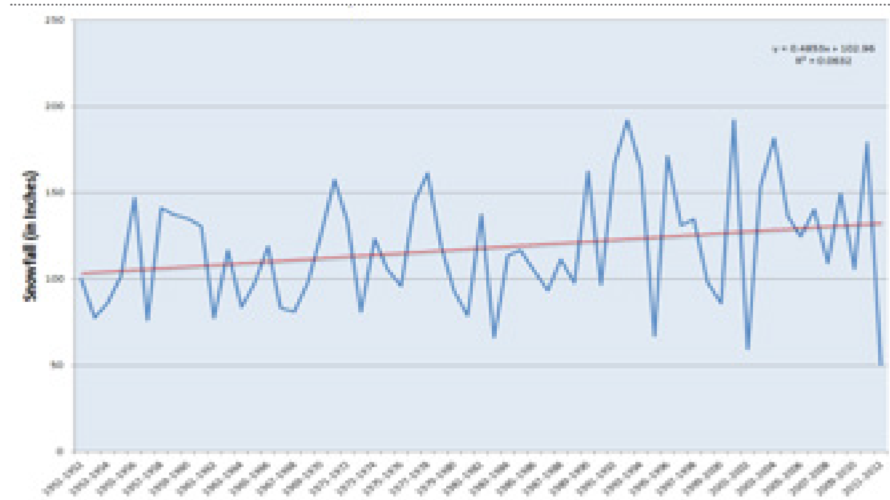


FIGURE 12–Syracuse Annual Snowall

Water Resources

Across the state, water quality and quantity comprise areas of vulnerability to climate change. The potential impacts include increases in heavy downpours and localized flash flooding; increases in frequency and length of dry periods in the summer which could lead to water shortages and conflicts; and impacts from increased temperatures on water ecosystems.[62] Heavy precipitation rates increase in stormwater runoff with impacts on wastewater treatment plants and pollutant loading to water resources. Lower tributary flow rates and water levels in lakes, rivers and streams could cause a shift in aquatic species composition and a reduced capacity of tributaries to assimilate effluent from wastewater treatment plants.[63] The frequency of downpours has also increased over the past fifty years and this trend is expected to continue. Warmer air temperatures are expected to continue with impacts on the water cycle. This will have consequences for water temperatures in lakes and streams, and changes are anticipated with the quantity and timing of snowfall, rainfall, and evaporation. The warmer temperatures are extending the summer recreation season in Central New York, resulting in more time for people to enjoy fishing, boating, and other outdoor opportunities and contributing to economic benefits for the recreation industry.

Nearly all studies that analyzed data from the Northeastern United States have estimated that annual stream flow should show primarily temporal change as a result of climate impacts such as precipitation variation. Additionally, these studies project increased late winter and spring flows and a shift in the timing of spring snowmelt. This means that even if there is more annual stream flow, it may be distributed unevenly over the year with lower flows in the late summer and autumn and higher flows in the late winter and spring. This temporal shift in flow rates has already been observed in stream records.[64]

Lakes can potentially serve as efficient barometers of environmental trends because they respond rapidly to physical and biological changes. Since Central New York has experienced a gradual increase in air temperature, lake data has been analyzed to determine the presence of corresponding increases in water temperature. Lake temperature trends are significant because higher water temperature affects lake fisheries and overall biological productivity. Higher air and water temperature normally contributes to increasing algae production and decreasing dissolved oxygen concentrations. These conditions can then accelerate the biological stress on lake organisms.[65] The following section presents information on water temperature from lakes located throughout the Central New York region.

Lake Ontario

Year-round temperatures in Central New York communities are moderated by the influence of Lake Ontario. A long-term warming trend has been recorded throughout the Great Lakes in recent years. According to the Great Lakes Environmental Research Laboratory (GLERL), there is also a long-term downward trend in Great Lakes wintertime ice cover, although there is considerable year-to-year variability. According to GLERL data, Lake Ontario has been running at or above normal temperatures during the past six years but temperatures are not at unprecedented levels. Limnologists predict that if the Great Lakes continue with record warm temperatures, the region could experience above-average lake-effect snowfall.[66]

The water budget of Lake Ontario and the other Great Lakes will continue to be influenced by regional warming trends, with direct implications for drainage basin runoff rates, direct precipitation onto the lakes, and evaporation from the lake surfaces. Central New York is frequently impacted by storm and frontal systems moving eastward across the continental United States. Winter temperatures are moderated considerably by Lake Ontario, and areas in Oswego County are often faced with higher snow fall due to lake-effect snow. The moderating effect of Lake Ontario on temperatures is especially important during the spring and fall. The lake waters warm slowly in the spring, which reduces the warming of the atmosphere over adjacent land areas. Plant growth is impacted by this process and a variety of freeze-sensitive crops, namely tree and vine fruits, benefit from these conditions. In the fall, the lake water cools at a slower rate than the surrounding land areas and serves as an extended source of heat. The cooling of the atmosphere at night is moderated or reduced, the occurrence of freezing temperatures is delayed, and the growing season is lengthened for freeze-sensitive crops and vegetables.[67]

Citizens Statewide Lake Assessment Program

The Citizens Statewide Lake Assessment Program (CSLAP) is a lake monitoring and education program administered by the NYSDEC and New York State Federation of Lake Associations. Since 1985 the program has provided dependable water quality and physical data from over 240 lakes, ponds, and reservoirs throughout New York State. Based on current monitoring data, it is not clear if there is a direct correlation between water temperature and climate change in Central New York during the timeframe evaluated through CSLAP. Thirty-six lakes in the CSLAP's Central Region were sampled between 1986 and 2009. Data shows that the frequency of higher water temperatures has increased, but most lakes have not exhibited any definitive long-term warming trends. The CSLAP summary for this time period indicates that:

> Since 1986, the frequency of higher than normal air and water temperatures has increased, and the frequency of lower than normal temperatures has decreased. This may be the strongest signal in the CSLAP dataset that global climate change has affected Central region lakes, although these trends are not statistically strong[68]

Twenty eight CSLAP lakes are located in the five-county Central New York region but of this total, only 18 have been sampled long enough to evaluate temperature trends. As of 2011, only DeRuyter Reservoir (Madison County) had exhibited an increasing water temperature trend (correlation coefficient > 0.5 and P value < 0.02) and three lakes - Duck (Cayuga County), Melody (Cortland County), and Craine (Madison County) - showed slightly increasing water temperature trends (correlation coefficient > 0.33 and P value < 0.05). The remaining 14 lakes showed no discernible water temperature trends. In future sampling seasons, CSLAP will continue to evaluate global climate change in New York state lakes through the collection and analysis of surface and hypolimnetic (lake bottom) temperatures and through an evaluation of ice-in and ice-out dates.

Onondaga Lake Water Temperature

Onondaga Lake water temperature data provided by the Onondaga County Department of Water Environment Protection was analyzed to evaluate potential impacts from climate change. Maximum, minimum, and average water temperatures were collected during a 27-year period (1985 to 2011) from a depth of less than six meters. The data was then plotted on three separate graphs to show summer (May to September), winter (October to April), and 12-month averages. Water temperatures exhibited minimal variation on all three graphs and no clear trends could be established.

Oneida Lake Water Temperature

Scientists at the Cornell University Biological Field Station (CUBFS) have documented an increasing trend in Oneida Lake water temperature during the summer months. Researchers routinely measure lake water temperature on a weekly or daily basis at various depths and locations. Data shows that June to August temperatures have increased significantly since 1975. The total increase in the 36 years from 1975 to 2011 is 1.6°C (or 2.9°F).[69] Temperature measurements collected from 1968 to 2005 showed similar increases at ten meter depths.[70]

In addition to air temperature, zebra mussels may have a minor influence on lake water temperature in Oneida Lake. Since the first observation of zebra mussels in Oneida Lake in 1991, the filter feeding bivalves have caused a decrease in algae concentrations in the water column which allows for increased light penetration to lower lake depths. Increased light penetration promotes the growth of aquatic vegetation, increases bottom-dwelling algae mats, and may also increase lake water temperatures.[71][iii] While zebra mussels may have a more significant impact on deeper lakes, research indicates that the increase in water clarity associated with the zebra mussel populations has only minor effects on the hydrodynamics of Oneida Lake.[72]

Fisheries

Oneida Lake fisheries data has been collected by the CUBFS since the mid-1950s. Their research provides an important assessment of the walleye and yellow perch fisheries, while documenting valuable insights into the response of lake ecosystems to issues such as exotic species and climate change. According to researchers, warming water temperatures may be contributing to fish community changes such as increased populations of largemouth and smallmouth bass, gizzard shad, and other species near the northern extent of their range. Additionally, at the southern edge of their range, Burbot may be in decline.73 The lake water warming trend is also thought to have caused the elimination of cisco, a cold-water relative of the whitefish.74 Elsewhere, brook trout, commonly found in New York State tributaries, are at risk due to changes in habitat resulting from climate change and the presence of invasive species. Brook trout are expected to become increasingly vulnerable as water and air temperatures rise.

Ice Cover

Ice cover can be an additional way to observe the impacts of climate change. Researchers at the CUBFS routinely monitor physical characteristics and chemical parameters on Oneida Lake while taking a special interest in the impacts of climate warming. Their data indicates that water temperature and ice duration trends reflect warmer conditions.[75]

CUBFS research shows that ice cover on Oneida Lake has lasted for shorter periods of time in recent decades. Ice formation usually begins in December and complete ice cover occurs in late December or

January. For the first time in recorded history, complete and sustained ice cover did not occur during the winter of 2002. Records of ice break-up (ice-out dates) are available from the Oneida Fish Culture Station in Constantia, CUBFS, and various diaries compiled back to 1826. The ice-out date has decreased by eleven days during this time period. CUBFS data shows that ice duration was, on average, about one month shorter in 2012 than in 1975.[76] Ice duration for the winter of 2011-2012 was only 25 days, the shortest recorded since 1975. The annual number of days of ice cover is expected to be reduced by 39% to 86% over the coming century, while inter-annual variation in ice cover duration will increase.[77]

Ice thickness is an additional indicator of warming trends. According to the CUBFS, ice thickness reached as much as 120cm in the mid to late 1970s, and within the last decade, maximum ice thickness has averaged about 31 to 36cm. Winter ice fishing is also impacted by warming trends. Anglers regularly drilled through over two feet of ice thirty years ago, but now twelve to fifteen inches is more common.[78] People are less likely to fish during the winter months unless the ice cover is solid. As a result, local businesses have experienced declining revenues during the winter months.

Plant Hardiness Zones

In January 2012, the United States Department of Agriculture issued its new Plant Hardiness Zone Map (Figure 13). This resource serves as a valuable tool for gardeners, farmers, researchers and policy makers. The map was changed in part to reflect shifting climate patterns across the United States.[79] This is the first revision of the hardiness zones since 1990. The new map shows how the average temperature bands have moved slowly upward over the last 20 years. The new map is approximately one 5-degree Fahrenheit half zone warmer than the previous map throughout much of the United States.[80]

The map updates were made using more sophisticated and fuller data collection. With new technology, maps are now developed to assess the effects of elevation, prevailing winds, bodies of water, and urban heat islands. Although climate is a complicated and multifaceted function, this clear trend toward warming temperatures is an additional indication of a changing climate. Syracuse and most of Central New York moved from zone 5a to zone 5b, an indication that winter temperatures are warmer than they used to be. Parts of Oswego and Auburn moved from zone 5b to the warmer 6a zone.

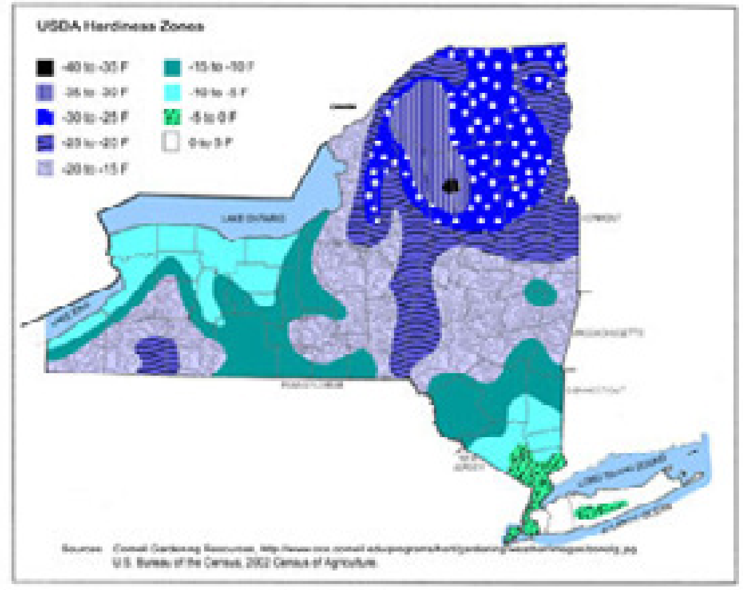


FIGURE 13–USDA Hardiness Zones

Storm Event Frequency

Storm intensity is influenced by air temperatures. As air temperature rises, the moisture in the atmosphere increases which contributes to a greater intensity and frequency of precipitation events. Warming air temperatures are caused by emissions of heat-trapping gasses in the atmosphere including pollution from fossil fuels. Warm temperatures in the atmosphere cause higher levels of evaporation which intensifies the water cycle. As a result, precipitation events are more intense and result in higher levels of rainfall. Over 80 million daily precipitation records from 1948-2011 have been analyzed for the United States, producing the following findings:

+ Extreme downpours – rainstorms and snow falls are now happening 30 percent more often on average across the contiguous United States than in 1948.
+ New England has experienced the greatest change with intense rainstorms, now happening 85 percent more often than in 1948.

- Not only are extreme downpours more frequent, but they are more intense. The total amount of precipitation produced by the largest storm in each year at each station increased by 10 percent over the period of analysis, on average across the contiguous United States. [81]

New York State experienced a 64% increase in extreme precipitation frequency from 1948-2011.82 On average, storms that used to occur every 12 months now occur every 7.7 months in the mid-Atlantic region, and from 1948-2011, the largest annual storm precipitation measured by weather stations across New York increased by 25%.83 According to meteorologists, the total annual amount of precipitation has been changing, as well as the distribution and intensity. As an example, Tropical Storm Lee resulted in significant damage for Central New York. In May 2011, Governor Cuomo formally requested that President Obama declare a major federal disaster for 26 counties in New York State, including Cayuga, Madison, and Onondaga counties. FEMA estimated more than $38 million in infrastructure repair and debris removal.

Air Quality

Air quality is a concern for New York State. The increasing presence of air pollutants over the last century has been stemmed by regulation under the Clean Air Act and the increasing efficacy of pollution control equipment. However, the factors that contribute to climate change, namely greenhouse gas emissions and temperature increases, continue to adversely affect air quality.

New York has several counties that fluctuate in attainment status for certain criteria air pollutants (e.g., nitrogen dioxide, ozone, carbon monoxide, particulate matter, sulfur dioxide, and lead).[84] The pollutants that the state is currently mandated to address under non-attainment regulations are ozone and particulate matter (under 2.5 micrometers). Given that various sectors and processes emit criteria air pollutants, coordination among decision-makers to improve air quality is required. Ozone levels, for example, can have an adverse effect on human health, ecosystems and agriculture. High concentrations irritate nasal, throat and bronchial tissues and the pollutants attack certain components of the body's defense system. High concentrations of ozone can also harm forests (thereby altering wildlife habitats), reduce crop yields, and damage materials such as rubber, plastics, synthetic fibers, dyes and paints.[85]

Forest Ecosystems

Climate change is likely to have substantial effects on the composition and function of New York State forest ecosystems.[86] Changes in forest composition as a result of increasing temperatures may pose an additional threat to animal species already identified as endangered, threatened, or of special concern to the state.[87] Forests may also experience an increase in insect populations due to climate change because the longer, warmer growing seasons provide an opportunity for additional insect generations per year, while allowing insects to migrate farther north of their normal range. In addition, climate change affects trees through drought stress, which reduces their ability to resist insect infestations.

In the eastern United States, invasive insects combine with air pollutants to amplify increasing climate stresses on forests. Ground level ozone reduces or eliminates growth advantages by added warmth and atmospheric CO_2. Acid rain continues to reduce forest tree growth while nitrate deposition saturates forests, reduces growth, and contributes to pollution of streams and estuaries. As a result, the health of older trees and seedlings is vulnerable to climate extremes.[88] Additionally, in Central New York, temperatures may eventually become too warm for species such as sugar maple trees. The maple syrup season has decreased by 2 to 4 days in the past thirty years.[89]

Invasive Species

Climate change is influencing the rate and extent of invasive species in Central New York. Hydrilla, an aquatic plant that was recently identified in the Cayuga Lake inlet, is an example of the northward spread of invasive plants that once preferred warmer temperatures to our south. More invasive pests will arrive as the temperature becomes warmer and some will likely move farther north if they cannot survive higher temperatures. Plant and animal species that are stressed by climate change are more susceptible to invasive pests and pathogens.

Climate change in New York State is influencing the loss of hemlock forests which are currently threatened by an invasive insect called the woolly adelgid.[90] NYSDEC officials predict that warming trends could make it easier for the insect to continue its northward spread.[91] The hemlock woolly adelgid (HWA) is an aphid-like insect that feeds on hemlock trees by extracting nutrients from the needles. Trees become badly damaged and often die after several years. The HWA was first discovered in New York State in the early 1980s and infestations are now found in 25 counties. In Central New York and other areas, the concern is that this infestation will have cascading, far-reaching effects on a variety of wildlife species and their ecosystems.

Eastern hemlocks provide a unique and essential role in the forest ecosystem by creating a damp and shaded microclimate that supports plant communities. The trees maintain cool stream water temperatures for fish and stream salamanders and provide important winter habitat and food for wildlife. Declines in hemlock from HWA can result in the loss of unique plant and animal populations and drastic changes to ecosystem processes.[92] Brook trout, commonly found in New York State tributaries, are especially at risk because they rely on Hemlock forests to provide cold water and shade necessary for their survival. In addition, the loss of hemlock forests would cause more sunlight to penetrate to the forest floor, warmer soil and water temperatures, and an increase in the number of invasive plants that normally do not exist in the cooler, shady conditions found under a healthy hemlock forest. Continued monitoring is needed, along with the development of indicators to mark the extent of invasive species movement and the ability to provide a rapid response to new infestations.

Energy

TABLE 4—New York State HDDs and CDDs from 2000-2010

Table Data Source: NOAA

Year	HDDs	CDDs
2000-2001	6,028	502
2009-2010	5,495	944
% difference	9% decline	88% increase

Note: Heating Degree Days (HDD), Cooling Degree Days (CDD)

Potential statewide climate change impacts related to the energy sector include increases in peak demand loads for cooling as the occurrence of heat waves increases; temperature increases reduce the efficiency of power plants due to decreased cooling capacity; hydropower plants are impacted by drought conditions resulting from decreased precipitation; transformers and distribution lines are affected by extreme weather events; and biomass availability is affected by weather conditions during the growing season.[93]

Heating and cooling degree days are indicators of temperature increase or decrease over an annual timeframe but these measures are also indicative of energy use, given that heating degree days often correlate with natural gas used for heating, and cooling degree days correlate with electricity used for cooling. Table 4 illustrates a statewide warming trend, the increased demand for electricity for cooling, and the decreased demand for heating.

There are secondary impacts on the energy sector that might also result from climate change, such as supply and availability of natural gas and electricity markets, which in turn will affect energy prices. For example, the vulnerability of transmission infrastructure and shifting investor confidence combined with changing insurance pricing strategies will likely shift utility cost burdens onto consumers in the form of higher energy prices.

Agriculture

Dairy production is the largest component of New York State's agricultural sector and apples and grapes lead New York fruit crops in value. The agriculture sector encompasses more than 34,000 farms that contribute $4.5 billion annually to the state's economy.[94] Precipitation and temperature conditions in Central New York contribute to a diverse agricultural industry, especially field crops such as alfalfa, oats, and corn. The temperature buffering effect from Lake Ontario supports a productive fruit tree industry, especially apples and peaches.

Warming temperatures and increased atmospheric CO2 are expected to have both positive and negative impacts on agriculture in Central New York. A longer growing season may provide economic benefits to the agricultural sector but may also require a shift to different crop varieties that are more tolerant to heat and drought conditions. There may also be decreased productivity of certain agricultural sectors such as dairy and grapes, resulting from heat stress and changes in frost or thaw cycles.[95] Increasing temperatures will also have an indirect influence on the rising cost of food.

A warming climate is changing the timing of spring planting. Plant growth characteristics are determined by temperature, sun, rainfall, and humidity. Plant bloom dates in the Northeast are now occurring approximately four to eight days earlier than in the 1960s. Across New York, the last frost is now eight days earlier than in the 1970s. By the end of the century, New York's growing season is projected to be four to six weeks longer.[96] Longer growing seasons could potentially increase crop yield if precipitation and nutrient rates are sufficient. Some crops, however, may have yield or quality losses as a result of summer drought, increased frequency of strong rainfall events, higher summer temperatures, inadequate winter chill period, increased risk of freeze due to variable winters, and increased insect, disease, and weed pressures. With increasing temperatures, milk production may decline for dairy herds exposed to prolonged heat stress. Expanded water management issues could develop due to changes in the frequency of flooding, drought, and other precipitation events. The extended growing season is also expected to increase the potential for weeds and insect pests which could lead to additional use of herbicides and pesticides.

Public Health

Reduced air quality caused by increased emissions, smog, wildfires, pollens, and mold resulting from global warming processes is expected to contribute to increased respiratory-related illness throughout the state and Central New York region, and will contribute to potential increases in temperature-related deaths and vector-borne (e.g. carried by mosquitoes or other insects) diseases. [97] New York State had 20 heat-related deaths in 2011,[98] compared with just 10 in 2010.[99] This 50% increase across the state is reflected in the national increase of 206% from 2009-2010 (138 deaths up from 45).[100]In the absence of climate adaptation measures, there is increased likelihood of food and waterborne disease as well as an increased demand for health services. Reduced water quality will also create public health and economic challenges.[101] Asthma and cardiovascular disease, both prevalent in Central New York, and all New York State regions, are expected to increase as a result of climate impacts such as temperature change and reduced air quality due to higher pollen and mold levels.

A concern within Central New York communities is the growing population of mosquitoes which have the potential to spread diseases such as the West Nile Virus (WNV) and eastern equine encephalitis (EEE). The risk of human exposure to WNV and EEE is expected to rise with the increase in temperatures and moisture.[102] Warmer temperatures, longer summers, and mild winters make it possible for mosquito eggs to survive the winter and contribute to increasing populations.[103] Lyme disease is also expected to increase in Central New York. The disease is caused by the bacterium, Borrelia Burgdorferi, and is transmitted to humans through the bite of infected blacklegged ticks. The occurrence of Lyme disease in Central New York appears to be getting worse, and since 2008 the number of Lyme disease cases in Onondaga County alone has risen from 14 to more than 127 cases in 2011. Mild winters, a longer summer season, and higher deer densities are thought to be contributing factors that will potentially increase with climate change.[104]

Hazard Mitigation Planning in Central New York

Hazard mitigation refers to activities that reduce loss of life and property by lessening the impacts of natural, technological and man-made disasters. It is often considered to be the first of the four phases of emergency management which include mitigation, preparedness, response and recovery. Proactive mitigation leads to more cost-effective projects, while reactive mitigation tends to lead to severe damage repair and often more costly fixes.

The Disaster Mitigation Act of 2000 is federal legislation that requires state and local governments to prepare local plans that will evaluate natural hazards and the strategies to mitigate them. Disaster mitigation planning in Central New York, an important step in creating more resilient communities, includes measures to adapt to climate-related impacts. Continued development and public availability of hazard mitigation plans is critically important in order to strengthen the ability of local communities to respond to natural disasters in an efficient and immediate manner. Table 5 on page 246 shows the status of mitigation plans in Central New York.

TABLE 5–Status of mitigation plans in Central New York

County	Title	Date Complete
Cayuga	In progress	Cayuga County doesn't have a Hazard Mitigation Plan but a resolution was recently presented at the Judicial & Public Safety committee authorizing the County Planning and Emergency Services Department to accept a New York State Office of Emergency Management/FEMA grant to develop one. The County Emergency Management staff will be administrating the grant and Planning will be providing technical assistance. The Hazard Mitigation officer is housed in the Cayuga County Department of Planning and Economic Development. A Steering Committee has been developed and a kick-off meeting with the city, town, and village representatives was held on September 26th. Tetra Tech EM Inc. will coordinate the project.
Madison	Madison County Multi-Jurisdictional Hazard Mitigation Plan (2004)	Estimates are provided on the value of building inventories, transportation systems, and utilities. Hazards are described for floods, hurricanes, winter storms, transportation accidents, fires, ice storms, tornados, and ice jams. Extensive summaries are presented for each municipality with detailed plans for specific threats such as severe storms, dam failure, flooding, fire, and power failure. Hazards addressed in Madison County report include severe storms, transportation accidents, winter storms, fires, ice storms, floods, hurricanes, tornados, ice jams, infestation, extreme temperatures, epidemics (human and animal), droughts, earthquakes, dam/ levee failure, and wildfire. Comprehensive information about flood prone areas is included.
Onondaga	Onondaga County Multi-Jurisdictional Hazard Mitigation Plan (2010 with 2011 revisions)	Onondaga County's comprehensive plan includes detailed information for each municipality on the governing body, growth and development trends, comprehensive plans, natural hazard event history, legal and regulatory capabilities, and fiscal capability. The plan includes the identification and prioritization of hazard mitigation initiatives including everything from retrofits to logjam removals. The plan will be updated within a 5-year cycle. Hazards addressed in Onondaga County report include severe storms, Severe winter storms, Floods, Ground failure (landslides, subsidence), Earthquake, Drought, Extreme temperatures, Floods, Hail, Hurricane, Ice jams, Infestation , Wild fire, Windstorms
Oswego	Multi-Jurisdictional Hazardous Mitigation Plan (updated 2012)	Oswego County received national recognition as being a "Storm Ready Community". The county office works closely with New York State, the National Weather Service, and the local public safety community to improve the county's readiness to respond to potentially dangerous weather situations. Hazards addressed in the Oswego County report include: severe storm, ice storm, earthquake, tornado, flood, wildfire, winter storm (severe), ice jams, coastal storm, extreme temperature, landslide, drought, terrorism, dam failure, fire, epidemic, hazmat, and radiological emergencies. The County has a 10-mile Emergency Preparedness Zone around their three nuclear power plants and developed a Radiological Emergency Preparedness Plan (current as of March 2011) in the event of nuclear emergencies. The County reviews, revises, and exercises the emergency preparedness plan on an annual basis with representatives of the nuclear industry and New York State.
Cortland	Cortland County Hazardous Mitigation Plan (1012)	Hazards addressed in the Cortland County report include severe storms, floods, and earthquakes. Information is also included on mitigation strategies and plan maintenance procedures. The Cortland Hazard Mitigation Plan was adopted by FEMA in July 2011 and was approved by 19 municipalities in February 2012 but this information is not yet available on the county website.

FINDINGS

Scientific evidence to support the occurrence of climate change is creating a critical need for action at the global, national, regional, and local levels. In Central New York, there is an immediate need for the implementation of green infrastructure, protection and expansion of wetland resources, and improved buffer zones around sensitive ecosystems. Despite uncertainties associated with the complex issue of climate change, enough information is available to develop scientifically credible, no-regrets strategies that address climate-related threats and impacts. Individuals in the public and private sector, including stakeholders from state and local agencies, non-profit organizations, businesses, and citizens are encouraged to take actions now that will reduce the negative impacts of climate change.

Information is provided below on the impacts of climate change that have been documented at the global, national, state, and regional levels.

Global and National Findings

The trapping effect of the greenhouse gases (GHG) at work in the natural greenhouse effect is accelerated with the addition of GHGs from human activities, such as fuel combustion for electricity generation, vehicle transport, and animal-released methane from agricultural processes. These emissions sources contribute to global climate change.

+ Global warming has resulted in a temperature rise of 1.1°F in the past three decades and 1.4°F in the past century.
+ Global temperature projections include a 0.4o F warming trend over each decade for the next two decades.
+ In 2010, United States GHG emissions increased 10.5% over 1990 emissions levels.
+ Many communities have already taken the lead in climate adaptation planning- communities such as Keene, New Hampshire, Boulder, Colorado and Homer, Alaska.
+ New York State and Central New York Findings
+ The first half of 2012 was the warmest period over 118 years of record-keeping.
+ Temperature in Syracuse increased by less than one degree F over the past 60 years.
+ Temperatures are expected to rise across the state: 1.5-3°F by the 2020s, 3-5.5°F by the 2050s, and 4-9°F by the 2080s.
+ Annual precipitation rates have increased by approximately 2.8 inches over the past 60 years.
+ Heavy precipitation events are increasing in New York, with a 64% increase in extreme precipitation frequency from 1948-2011.
+ Heat waves are likely to become more frequent, intense, and longer in duration; the number of cold days (minimum temperature at or below 32 degrees F) per year will decrease.
+ Increasing water temperatures will have consequences for aquatic ecology in local lakes and streams.
+ Increasing air temperatures will continue to impact the water cycle, with changes anticipated in the quantity and timing of snowfall, rainfall rates, and evaporation. This will impact the local economy, with changes anticipated for recreation, forestry, and agriculture.
+ Warming trends will increase the northward movement of plant and animal species.
+ Increased flooding in flood zones and along Lake Ontario and other shorelines could impact public safety and infrastructure.
+ Wastewater and water delivery infrastructure is vulnerable to the impacts of climate change. New York has more than 600 wastewater treatment plants serving over 15 million people, and more than 30% of the state's treatment facilities and systems are over 60 years old. Older systems and combined sewer overflows present an ongoing risk from increased precipitation and severe storm events.

STRATEGIES AND RECOMMENDATIONS

Central New York Climate Adaptation Goal and Targets

Priorities are marked with an asterisk (*)

Goal:

ADAPT SUCCESSFULLY TO A CHANGING CLIMATE AND IMPROVE THE RESILIENCE OF THE REGION'S COMMUNITIES, BUSINESSES, INFRASTRUCTURE AND NATURAL SYSTEMS.

Targets:

+ Decrease the economic value of property vulnerable to storm surges and flooding (by relocating critical infrastructure from parcels crossed by floodplains) by 10% (below 2012 levels) by 2030.
+ Double the number of Climate Smart Communities (over 2012 levels) by 2020.

Strategy #1: Conduct vulnerability and risk assessments, and cost-benefit analyses in order to identify key areas for climate adaptation in Central New York communities.

1. **Recommendation 1a:** Conduct carbon foot-printing assessments to establish baseline greenhouse gas data; implement municipal climate action plans and greenhouse gas reduction measures as part of the Climate Change Innovation Program and Climate Smart Communities programs.*
   + **Potential Projects:** Climate Action Plans in the Town of DeWitt, Village of Skaneateles, Town of Preble, City of Oswego and City of Cortland; GHG Inventories in the Village of Fayetteville, City of Auburn and Town of Cazenovia.
2. **Recommendation 2a:** Retrofit power plants, wastewater treatment facilities, transportation and water delivery infrastructure located in hazard-prone areas to protect them from damage; identify facilities that are viable candidates for retrofitting based on cost effectiveness versus relocation.

Strategy #2: Develop systems to prepare for and respond to more frequent flooding events.

1. **Recommendation 2a.** Transform vacant properties and abandoned lots to parks by installing plants, trees, and rain gardens that will control flooding, enhance soil infiltration, and reduce stormwater runoff.*
2. **Recommendation 2b.** Conduct structural and facility inventories that incorporate flood and wind parameters (e.g. first floor elevations, roof types, structure types).*

+ **Potential Project:** conduct inventories using methods employed by FEMA's Rapid Observation of Vulnerability and Estimation of Risk Program (ROVER).

3. **Recommendation 2c.** Correct conditions that contribute to flooding such as the repair of damaged or old creek and road culverts; the removal of abandoned bridges, debris and log jams; and maintenance of catch basins to facilitate stormwater management capacity.*

   + **Potential Project:** Emulate county log jam programs in Onondaga and Madison counties

Strategy #3: Implement measures that mitigate the impacts of climate change on infrastructure.

1. **Recommendation 3a.** Conduct vulnerability assessments of power plants, water treatment facilities, roads and bridges, and telecommunication systems that are located in flood zones or on steep slopes that are prone to erosion.*

   + **Potential Project:** Utilize tools, such as ICLEI ADAPT, to outline assessments and adaptation planning measures

2. **Recommendation 3b.** Implement zoning to prevent new development in flood-prone or high hazard areas and update building codes to require more effective flood-resistant structures in flood zones.

3. **Recommendation 3c.** Bury existing power lines where feasible and safe, and require this for new construction projects, in order to minimize damage and outages resulting from heavy precipitation and severe storm events.

4. **Recommendation 3d.** Repair deficient combined sewer infrastructure to improve capacity during high-water events and implement storage and reuse systems for wastewater (grey water) in all treatment plants to reduce impacts on infrastructure, water quality and ecosystems during heavy precipitation and flooding events.*

5. Recommendation 3e. Repair deteriorating flood control structures along Central New York water bodies.

   + **Potential Project:** Little York Lake dam. Construction of the dam was completed in 1956 but it is now in need of repair. Little York Lake is located on the West Branch of the Tioughnioga River in the Susquehanna River Basin in the Cortland County Town of Homer.

6. **Recommendation 3f.** Implement green infrastructure plans along Central New York watershed corridors.

   + **Potential Project:** Flood and stormwater control measures for new and existing development along Oneida Creek in the City of Oneida that include installation of porous pavement, wet weather management systems for parking areas, bioretention basins, rain gardens, and riparian buffers.

Strategy #4: Create a central repository of regional climate data and provide channels for the distribution of climate information.

1. **Recommendation 4a.** Develop a Central New York Climate Change Clearinghouse with current data and historical trends for temperature, precipitation, lake water temperature, storm event, public health, and surveillance and monitoring data.*

Strategy #5: Develop and implement emergency and hazard mitigation plans.

1. **Recommendation 5a.** Assist Central New York municipalities in fulfilling requirements to become "StormReady" communities (administered by the National Weather Service) to help them prepare for and mitigate effects of extreme weather-related events through upgraded emergency preparedness infrastructure. Create local StormReady Advisory Boards to help in the development of specific local laws for storm preparedness.
   + **Potential Project:** Partner with Oswego County, which recently received national recognition as a StormReady community, to expand model to the rest of the region
2. Recommendation 5b. Coordinate with NYS Thruway to distribute hazard event information to Thruway travelers.
   + **Potential Project:** Implement a "reverse 911" call-back system to notify residents of emergency information and evacuation routes (utilize the NY Alert/NOAA weather alert systems)

Strategy #6: Implement agricultural practices that support environmental, economic, and social sustainability.

1. Recommendation 6a. Improve cooling capacities in dairy barns and animal facilities through the installation of fans, sprinklers, and cooling systems.
2. Recommendation 6b. Increase local food sources and production through co-ops, farmers markets, and community supported agriculture; and double the size and number of community gardens.*

Strategy #7: Promote open space conservation, implement smart growth strategies, and protect forest ecosystems to increase regional climate mitigation potential.

1. **Recommendation 7a.** Protect and restore wetlands and floodplains to strengthen the capacity of natural systems to respond to severe weather events, rapid stream flow rates, and flooding; promote the use of wetland banking, constructed wetlands, and the review of local laws to support wetland protection during plan review and new construction.*
2. **Recommendation 7b.** Create additional urban tree management programs to reduce heat island effect, impacts from insects and disease, and energy use.
   + **Potential Project:** Expand and implement best practices from the City of Syracuse Urban Forest Masterplan and planning efforts across the region
3. **Recommendation 7c.** Continue to implement the Camillus Valley/Nine Mile Creek expansion project and others referenced in the 2009 NYS Open Space Plan to build local resilience.

Strategy #8: Develop climate adaptation education opportunities in order to increase the number of Climate Smart Communities in Central New York.

1. **Recommendation 8a.** Host a vulnerability assessment and adaptation workshop.*

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