Regional Costs of Climate-Related Hazards for the New York State Building Sector

Final Report | Report Number 18-11b | June 2018

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

University at Buffalo School of Architecture and Planning

NYSERDA's Promise to New Yorkers:

NYSERDA provides resources, expertise, and objective information so New Yorkers can make confident, informed energy decisions.

Mission Statement:

Advance innovative energy solutions in ways that improve New York's economy and environment.

Vision Statement:

Serve as a catalyst – advancing energy innovation, technology, and investment; transforming New York's economy; and empowering people to choose clean and efficient energy as part of their everyday lives.

Cover Image: FEMA/Ryan J. Courtade

CONTACTS

Amanda Stevens, Project Manager
NYSERDA
17 Columbia Circle
Albany, New York 12203-6399
amanda.stevens@nyserda.ny.gov

Nicholas B. Rajkovich, Principal Investigator
University at Buffalo School of Architecture and Planning
Hayes Hall, University at Buffalo
Buffalo, New York 14214
rajkovic@buffalo.edu

PROJECT PREPARED BY

Ray, Paul, Nicholas B. Rajkovich, Michael E. Tuzzo, Martha Bohm, and Bart Roberts

PROJECT ADVISORY COMMITTEE

Claire Barnett, Healthy Schools Network
Joseph Borowiec, NYSERDA
Robert Carver, NYSERDA
Tom Eisele, New York City Mayor's Office of Recovery and Resiliency
Jeff Jones, Healthy Schools Network
Kim Knowlton, Natural Resources Defense Council and Columbia University's Mailman School of Public Health
Dana Kochnower, New York City Mayor's Office of Recovery and Resiliency
Ann Kosmal, U.S. General Services Administration
Alison Kwok, University of Oregon
Chris Pyke, U.S. Green Building Council
Jodi Smits Anderson, Dormitory Authority of the State of New York (DASNY)
Robert G. Shibley, University at Buffalo School of Architecture and Planning
Kevin Stack, Northeast Green Building Consulting, LLC
Ernest Sternberg, University at Buffalo Department of Urban and Regional Planning
Alex Wilson, Resilient Design Institute

PREFERRED CITATION

Ray, Paul, Nicholas B. Rajkovich, Michael E. Tuzzo, Martha Bohm, and Bart Roberts. 2018. Regional Costs of Climate-Related Hazards for the New York State Building Sector. New York State Energy Research and Development Authority (NYSERDA), Albany, New York.

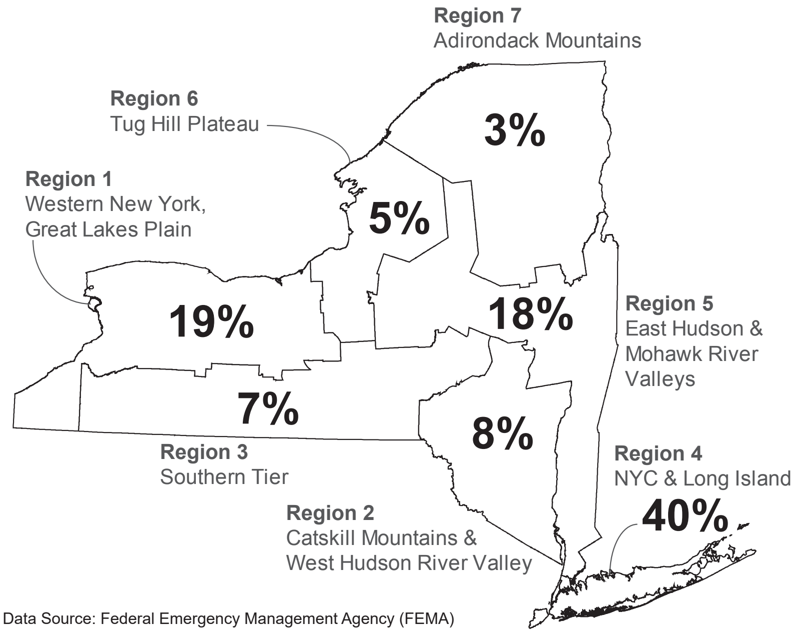
Table of Contents

Executive Summary

Buildings are part of the most important and ubiquitous elements of modern life. They are found in every corner of the State and play a role in daily life. They are also some of the most economically significant investments we make as a civilization. In total, New York State is home to more than 5 million buildings, which takes up 13 billion square feet of space, valued at approximately $2 trillion (in 2014 dollars).

Regional Distribution of Buildings across ClimAID Regions (2015)

% Share of Total Number of Buildings in NYS



Data Source: Federal Emergency Management Agency (FEMA)

ECONOMIC LOSSES AND BUILDING STOCK VULNERABILITIES

One of a building's primary role is to protect us from the elements; therefore as our climate and exposure to these elements change, buildings must adapt. A critical first step in adaptation is to understand the current vulnerabilities of our building stock. The research presented in this report considers the historic building-related economic losses from four major hazard types: winter storms, hurricanes, severe storms, and flooding. While other hazards—such as pest infestations, extreme heat, sea level rise, and wildfires—are considered in other volumes of this research, lack of data precluded their inclusion in this report (the following table provides a summary of each climate hazard).

In terms of property damage losses from 1960–2014, the most significant hazards were hurricanes and flooding, causing a total of more than $11 billion and $7 billion, respectively. Both were enormously destructive, but were presented in very different ways. Hurricanes happened rather infrequently and caused extraordinary amounts of damage—Superstorm Sandy caused an estimated $10.75 billion in property damage—but flooding was widespread and occurred on a regular basis. Losses from flooding added up to a massive figure over time. For some regions, such as ClimAID Region 3 (Southern Tier) and ClimAID Region 5 (East Hudson and Mohawk River Valleys), flooding caused greater total losses than hurricanes and higher-than-expected average losses per event (see page 6 for more information). Efforts to prepare buildings for these climate hazards will greatly increase their ability to cope with a changing climate.

Additionally, there are significant differences in the scale of losses between regions. ClimAID Region 4 (New York City and Long Island) has seen the most damage over the years ($11.32 billion), but this figure accounts for only 0.8% of its total building stocks' current assessed value. Conversely, total damage in ClimAID Region 2 (Catskill Mountains and West Hudson River Valley) and ClimAID Region 3 (Southern Tier) accounted for 3% of their total building stocks' current assessed value. This suggests less populated regions may be disproportionately affected by hazard events as compared to more populated regions.

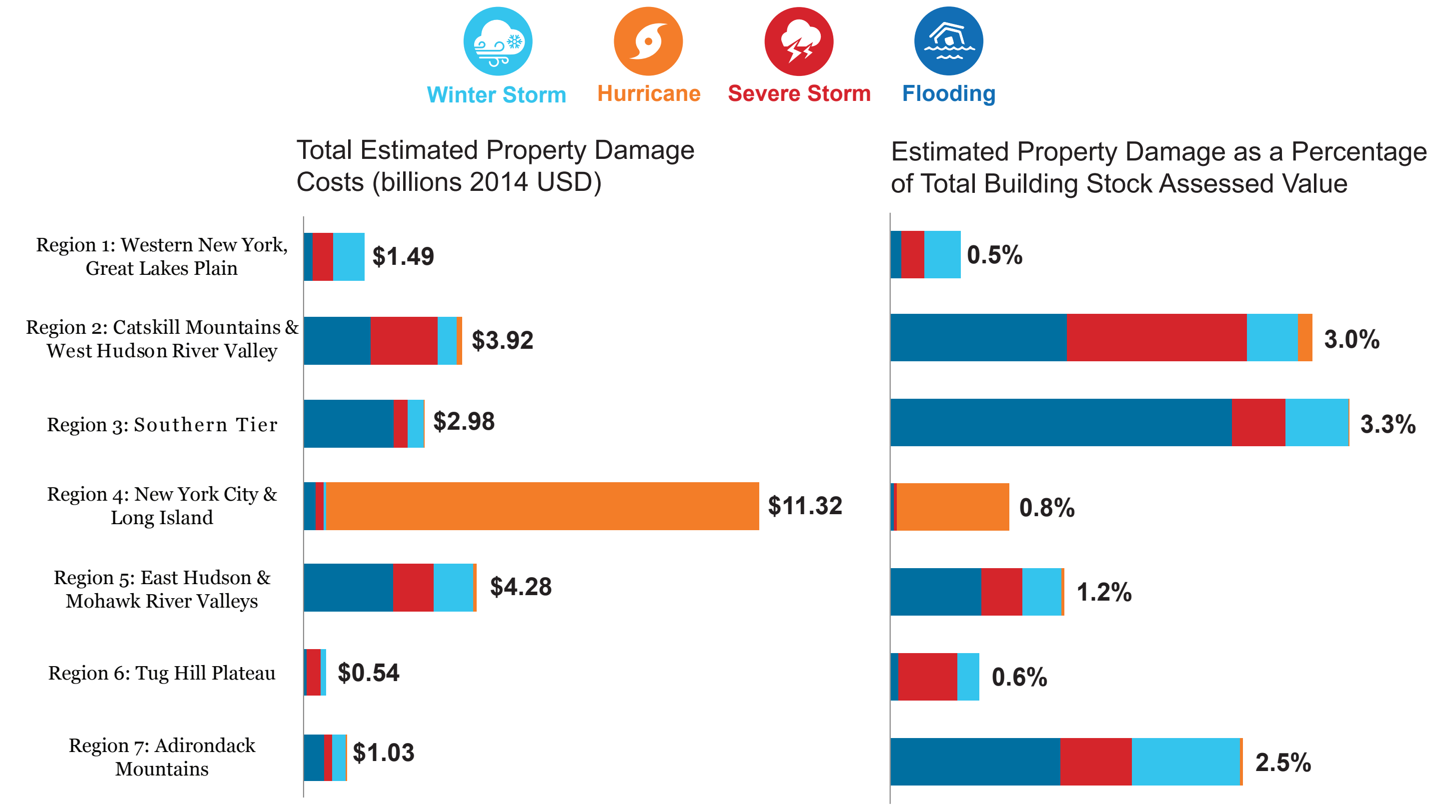
REGIONAL ADAPTIVE CAPACITY

Adaptive capacity is the ability of a system to adjust to actual or expected climate stresses, or cope with the consequences. Regional economies, and more specifically, the building sector, are like any other system. They are formed by a complex network of actors including building owners, developers, design and construction professionals, materials suppliers, and property managers. How well they are able to prepare for and recover from hazards events defines their inherent adaptive capacity. Analysis of regional labor data and linkages between companies suggests that regions without a large- or medium-sized central city (ClimAID Region 3: Southern Tier, Region 2: Catskill Mountains and West Hudson River Valley, and ClimAID Region 7: Adirondack Mountains) may have relatively lower adaptive capacities. They have the most square feet of building area per construction firm, which suggests these regions may have a lower capacity to prepare for or recover from hazard events than other regions in the State.

SUMMARY OF CLIMATE HAZARDS

Hazard	Common Causes of Building Damage	Considered in Report?	Availability of Historical Damage Costs
Hurricanes	Hurricanes produce severe winds, intense precipitation, and storm surge.	Yes	Historical data are available from Spatial Hazard Events and Losses Database for the United States (SHELDUS).
Flooding	Riverine overbank flooding, flash floods, alluvial fan floods, mudflows or debris floods, dam- and levee-break floods, local draining or high groundwater levels, fluctuating lake levels, ice-jams, and coastal flooding can lead to complete structural failure.	Yes	
Severe Storms	Intense precipitation events (not including snow events) that occur over a short period of hours or even minutes can cause wind and water damage.	Yes	
Winter Storms	Snow, ice, high winds, blizzard conditions, and lake effect snowstorms can cause significant damage to both buildings and building systems.	Yes	
Pest Infestations	Pests, like termites, can compromise the strength of structural elements and interfere with weather protection systems.	No	Pest infestations in the Northeast region of the country may increase in the future, but they have not historically been a notable problem in New York.
Extreme Heat	Extreme heat does not typically cause direct building damage but does pose a threat to the health of building occupants. This threat is addressed in earlier ClimAID volumes that cover public Health.[1] Additionally, a number of research studies also address this threat, such as *Projecting Heat-Related Mortality Impacts under a Changing Climate in the New York City Region*[16] and *Predicting Indoor Heat Exposure Risk during Extreme Heat Events.*[15]	No	Not applicable
Rising Sea Levels	Sea level rise can exacerbate risks from hurricanes and tropical storms and has the potential to permanently inundate buildings in the future.	No	Since rising sea level is a slow-moving hazard and has not directly caused damage to buildings, historical damage costs are not available. Other organizations such as *Climate Central* and the *New York City Panel on Climate Change* have begun to assess the future exposure of buildings to climate hazards in high risk coastal areas of the state like New York City.
Wildfires	Wildfires can directly cause damage to buildings and property, especially those near forested areas.	No	As droughts and heat waves are projected to increase, wildfires will likely increase as well, but they have historically caused minimal damage to buildings in New York State.

PROPERTY DAMAGE ESTIMATES BY REGION (1960–2014)



Data Source: Spatial Hazard Events and Losses Database for the United States (SHELDUS), Federal Emergency Management Agency (FEMA)

ECONOMICALLY SIGNIFICANT CLIMATE HAZARD SUMMARY

Region	Cause of Highest Average Cost per Event	Cause of Greatest Disproportionate Damage*
REGION 1: Western New York/Great Lakes Plain	Winter Storms: $1.54 million per event	Winter Storms
REGION 2: Catskill Mountains & W. Hudson River Valley	Hurricanes: $43.69 million per event	Flooding
REGION 3: Southern Tier	Flooding: $7.33 million per event	Flooding
REGION 4: New York City & Long Island	Hurricanes: $3.60 billion per event	Hurricane
REGION 5: East Hudson & Mohawk River Valleys	Hurricanes: $27.35 million per event	Flooding
REGION 6: Tug Hill Plateau	Flooding: $0.45 million per event	Flooding
REGION 7: Adirondack Mountains	Hurricanes: $4.56 million per event	Flooding

* Disproportionate damage refers to the hazard that historically had the greatest disparity between the share of all regional events and the share of total regional damage. This can also be thought of as the greatest deviation from the cost of damage that would be expected given the number of events that have occurred. The greater the deviation from the expected, the greater the disproportionate damage. Data Source: SHELDUS, FEMA

KEY FINDINGS FROM ANALYSIS OF HISTORICAL COST DATA

Hurricanes have been the most destructive climate-related events.

Superstorm Sandy was the most costly event from 1960 to 2014, causing a total of $10.75 billion in property damage (42% of all property damage during that time frame).

Hurricanes take a toll on more than just New York City and Long Island.

Hurricanes caused the greatest per-event property damage costs in Regions 2 (Catskill Mountains and West Hudson River Valley), 5 (East Hudson and Mohawk River Valleys) and 7 (Adirondack Mountains). Per-event property damage costs were $43.57 million, $27.35 million, and $4.56 million, respectively. However, flooding events in these regions caused a greater-than-expected share of damage costs.

Flooding events are widespread, frequent, and costly.

Though not as costly per event as hurricanes, flooding events were the most common across the State, causing an average of $5.09 million per event.

Flooding events were the most economically significant hazard event in Region 3 (Southern Tier), causing the highest per-event property damage ($7.33 million per event) and a higher-than-expected share of damage costs.

New York City and Long Island sustained the most building damage but did not sustain the most damage per total building value.

Region 4 (New York City and Long Island) has the greatest concentration of buildings in the state (40% of all buildings, 51% of total square feet, and 58% of total value in the state), and it has had the greatest exposure to hurricanes. Three hurricanes were responsible for $10.77 billion in property damage between 1960 and 2014. Although the region has recorded the highest damage costs, those costs were relatively low as a percentage of its total building stock value (0.8%). Additionally, the region is home to the greatest concentration of construction firms and employees, suggesting it may have greater capacity to prepare for and recover from hazard events.

Winter storms are not widespread, but they caused the most damage in the Western New York/Great Lakes Plain Region (ClimAID Region 1).

Winter storms were the most economically significant hazard event in Region 1 (Western New York/Great Lakes Plain), causing the highest per-event property damage ($1.54 million per event) and a higher-than-expected share of damage costs.

Decentralized regions are hit harder than other regions.

Regions without a large or medium-sized central city (Region 3: Southern Tier, Region 2: Catskill Mountains and West Hudson River Valley, and Region 7: Adirondack Mountains) are disproportionately impacted by hazard events and may have relatively lower inherent capacity to prepare for or recover from them. Hazard events in these regions caused more than double the property damage in other regions when property damage is measured as a percentage of the total value of the building stocks in each region. Additionally, Region 3 (Southern Tier) and Region 7 (Adirondack Mountains) have the most square feet of building area per construction firm and construction employee, which suggests these regions may have a lower capacity to prepare for or recover from hazard events than other regions in the State.

The Tug Hill Plateau Region (ClimAID Region 6) has had the lowest exposure to climate hazards.

Region 6 (Tug Hill Plateau) saw the second-lowest number of hazard events (1,905 events) and the lowest total property damage ($535 million) from 1960 to 2014.

Introduction

As public awareness of the impacts of climate change has grown, NYSERDA has significantly increased efforts to better understand and forecast both gradual changes and extreme events. In 2011, NYSERDA released *Responding to Climate Change in New York State* (ClimAID),[1] which provides climate projections for the State, as well as detailed information on New York's adaptation strategies and vulnerability to climate change. This report builds on the work of the original 2011 ClimAID report and its corresponding update released in 2014.[2] The analysis presented here adds to the growing body of knowledge about adapting buildings for a changing climate. Furthermore, by exclusively addressing the economic impacts on New York's building sector, this assessment fills a critical gap in the previous ClimAID reports.

Historical insurance statistics suggest that economic losses due to climate hazard events have been increasing over time.[3,4] According to the National Oceanic and Atmospheric Administration (NOAA), the number of events that cause more than $1 billion dollars in damage increased in the past 35 years. A total of 48 of these events occurred in New York State since 1980, accounting for 23% of all such events in the United States during that same time period.[5]

While it is clear these economic losses are increasing over time, there are varying degrees of certainty the increasing frequency of climate hazard events are attributable to climate change. For some events like extreme heat and cold, there is a higher degree of confidence associating them with climate change, while other events like severe storms and extreme ice and snow events have a lower degree of confidence.[6] Furthermore, urbanization and other socioeconomic changes increased the number of valuable assets exposed to climate hazards. These changes include population growth along the coasts and in large cities, an overall increased population, more wealth and expensive holdings subject to damage, and lifestyle and demographic changes that expose lives and property to greater risk.[4]

Whether increasing costs are largely due to climate change, socioeconomic factors, or a mix of both, it is clear that the vulnerability of buildings will need to be addressed in order to avoid future losses, limit costs, and possibly prevent both. This is particularly important since buildings—and other related infrastructure—support our physical well-being and provide space for economic activities. Buildings are also some of the most expensive investments that our society makes, but because they cannot be moved in times of crises, they must withstand whatever hazards come their way.

Our ability to prepare buildings for the future will depend on a clear understanding of the potential risks related to a changing climate. The Task Force on Climate-related Financial Disclosures (TCFD) provides a useful framework for understanding climate-related financial risks that can be adapted to directly address the building sector. The framework was originally developed by leaders from the financial industry and led by the Financial Stability Board to provide recommendations for understanding and disclosing broader financial risks and opportunities related to climate change. They describe climate-related risks in terms of two distinct types—transition risks and physical risks—both of which will impact the State's building sector. Transition risks will stem from the transition to a low-carbon economy, and physical risks will stem from the physical impacts on the built environment. Both types of risk have the potential to inflict harmful impacts on the building sector, but they may also create new opportunities. A summary of the potential impacts and opportunities related to buildings that have been identified by the TCFD is provided.[7]

Climate-related financial impacts

- Increased operating costs (e.g., compliance costs, increased fossil fuel costs, damage repairs)
- Write-offs or retirement of existing facilities due to damage or lack of financial viability (stranded assets)
- Re-pricing of assets (e.g., land valuations)
- Increased insurance premiums or reduced availability of insurance in “high-risk” locations
- Costs associated with development of new technologies (e.g., research and development)

Climate-related financial opportunities

- Decrease in operating costs (through cost reductions if buildings are made more efficient)
- Reduced exposure to fluctuations in energy prices (through the use of lower-emission energy sources and the adoption of new technologies)
- Increased demand for new products
- Increased capital availability as more investors favor lower-emissions investments
- Increased market valuation through resilience planning (e.g., infrastructure, land, buildings)

Stakeholders throughout the building sector should consider these broad impacts and opportunities when planning for the future.

The research presented in this report narrows the focus to the potential financial implications for the building sector in New York State and has the broad goal of helping policymakers and building owners understand how each region in the State has been impacted by climate hazards in the past and what capacity they may have to react to them in the future. Armed with this information, building owners and policymakers will be able to make strategic decisions in preparing buildings for future exposure to climate events.

Findings rely on careful analysis of historical climate hazard cost data, building stock estimates, and labor data to assess the inherent vulnerability of each region's building stock and adaptive capacity. For the purposes of this report, vulnerability and adaptive capacity are defined as follows:

> ***Vulnerability*** is the degree to which buildings are susceptible to and unable to cope with adverse impacts of climate change. Vulnerability is a function of exposure and sensitivity. Exposure is the degree to which buildings are in direct contact with climate variables and/or may be affected by long-term changes in climate conditions or by changes in climate variability, including the magnitude and frequency of extreme events. Sensitivity is the degree to which buildings will respond to a change in climate, either beneficially or detrimentally.[1]
>
> ***Adaptive Capacity*** is the ability of a system to adjust to actual or expected climate stresses or cope with the consequences. Actions that build adaptive capacity aim to lessen the physical, social, or economic impacts of climate change or take advantage of new opportunities emerging from a changing climate.[1]

This research aims to meet five objectives:

1. Describe what climate hazards may affect the State's buildings in the future.
2. Assess the inherent vulnerability of the State's buildings through analysis of historical property damage attributed to climate hazard events.
3. Provide a more nuanced description of how buildings in each of the State's ClimAID regions have been affected by these hazard events.
4. Understand how the adaptive capacity of each region's building sector might affect its ability to prepare for or recover from future hazard events.
5. Identify gaps in knowledge that must be bridged in order to more effectively prepare the State's building sector for a changing climate.

The geographic scope for this analysis is New York State, with a focus on the ClimAID regions. The extents of these seven regions are based on a variety of factors, including type of climate and ecosystems, watersheds, and dominant types of agricultural and economic activities.[1] The broad geographical regions are Western New York/Great Lakes Plain (Region 1); Catskill Mountains and the West Hudson River Valley (Region 2); the Southern Tier (Region 3); the coastal plain composed of the New York City metropolitan area and Long Island (Region 4); the East Hudson and Mohawk River Valleys (Region 5); the Tug Hill Plateau (Region 6); and the Adirondack Mountains (Region 7).

Methodology

Data sources used for this research were selected to remain consistent with existing climate-related research in New York State. Data from University of South Carolina's Spatial Hazard Events and Losses Database for the United States (SHELDUS)[8] were used to estimate historic property damage from climate hazards. The use of this data is consistent with the New York State Department of Homeland Security and Emergency Services Hazard Mitigation Plan (2014)[9], which also used SHELDUS data to quantify the economic impact of hazards including coastal erosion, drought, flood, hurricanes, severe storms, winter storms, and wildfires. Additionally, New York State's ClimAID regions were used as the primary geographic unit of analysis to align with NYSERDA's ClimAID reports, including *Responding to Climate Change in New York State* (2011)[1] and *Climate Change in New York State: Updating the 2011 ClimAID Climate Risk Information* (2014).[2]

Historical damage losses from climate hazards were estimated using a three-step process:

1. Define the building stock.
2. Aggregate historical property damage (SHELDUS data).
3. Supplement missing hurricane data (FEMA data).

DEFINING THE BUILDING STOCK

Building stock data were provided by the Federal Emergency Management Agency's (FEMA) Hazus-MH software. This software is typically used for risk management and hazard planning, but it also provides geospatial estimations for a range of building variables, including number of buildings, building square footage, building type, and building value. The data are provided for each census tract in New York State. This information was aggregated at the regional and State levels for analysis.

AGGREGATING HISTORICAL PROPERTY DAMAGE

Historical property damage data collected by SHELDUS were used to estimate climate hazard related impacts on buildings from 1960 to 2014. Each county within New York State has a total cost and total number of events for each climate hazard for each month within the dataset. For example, SHELDUS reports that Erie County had six winter storm hazards that caused $6,250,000 in property damage in November 2014. These county-level data were aggregated to determine the region-level totals for each year.

Since the data are provided at the county level, it is possible for a single hazard to be counted more than once if it impacted multiple counties within one region. For example, the winter storms that struck Western New York in November of 2014 impacted multiple counties within ClimAID Region 1, including Chautauqua, Erie, Genesee, Livingston, and Wyoming Counties. In the SHELDUS dataset, this storm is recorded as one event in each region; therefore, a simple summation of all events at the county level would not accurately represent the total number of events that occurred at the regional level. To address this, the regional aggregation involved an intermediate step to calculate the number of regional events and total costs.

The regional aggregation of SHELDUS data was done by dividing the total cost by the total number of events within each county. These averages were then added to generate a more accurate count of events within the county. The total cost for each county was divided by the total number of events to create an average cost per event for each county. This average was then distributed and added with the average cost per event of other counties within the region. The total number of events after this process more accurately represents the total number of hazards that impacted the region each month. The following chart exhibits a hypothetical set of total costs for each county within a region—the total cost within each county is divided by total number of events to generate an average cost per event. This average is then distributed and added together with the other counties within the region.

Example Aggregation of Regional Costs

2014	January		Winter Storm Events			
County	**Total Cost**	**Total Events**	**1**	**2**	**3**	**4**
Cayuga	$14,000	1	$14,000	-	-	-
Chautauqua	$31,000	2	$15,500	$15,500	-	-
Erie	$83,000	4	$20,750	$20,750	$20,750	$20,750
Genesee	$61,000	3	$20,333	$20,333	$20,333	-
Livingston	$10,000	1	$10,000	-	-	-
Monroe	$18,000	1	$18,000	-	-	-
Niagara	$15,000	1	$15,000	-	-	-
Ontario	$14,000	1	$14,000	-	-	-
Orleans	$18,000	1	$18,000	-	-	-
Seneca	-	-	-	-	-	-
Wayne	$24,000	1	$24,000	-	-	-
Wyoming	$67,000	3	$22,333	$22,333	$22,333	-
Yates	-	-	-	-	-	-
Region Event Costs			**$3,750**	**$1,750**	**$1,250**	**$1,000**

SUPPLEMENTING HURRICANE DATA

One limitation of the SHELDUS database is the underreporting of losses due to hurricanes and tropical storms. To correct this, SHELDUS data for hurricanes were supplemented with loss data from the FEMA Public Assistance Data for Presidential Disaster Declarations. To maintain consistency with the SHELDUS data, Presidential Disaster Declaration costs from FEMA were restricted to items that accounted for property damage, including protective measures, water control facilities, public buildings, and public utilities (damage category codes B, D, E, and F). Costs excluded from this analysis included those allocated to roads and bridges, and State management (damage category codes C and Z).

LIMITATIONS

The methodology and the data sources used have some limitations. First, the data used to quantify property damage are historical and are used to describe how the State's building stock has been impacted by climate hazard events in the past. While this can shed some light on the relative vulnerability of the building stock in each region, it cannot predict the future conditions that these buildings will face or how the building sector may adapt to meet new challenges.

Second, since property damage figures are used as a proxy for building damage figures, findings may overestimate damage. A fraction of historical damages may have affected only the grounds of buildings and not the buildings themselves.

Last, the geographic extents of New York's ClimAID regions do not necessarily reflect how the many regional and metropolitan economies across the State are actually organized. Some regions, such as Western New York, combine two or more regional economies, and others—like those that border the Hudson River—split regional economies in half. This can overstate or exclude large employers, material suppliers, and workers in the regional analysis and may produce results that do not completely reflect the true behavior of each economy. This may be particularly true for the Catskill Mountains and West Hudson River Valley Region (ClimAID Region 2) and the East Hudson and Mohawk River Valleys (ClimAID Region 5). While the regional economy in this part of the State normally spans the Hudson River and is closely tied to New York City, the ClimAID boundaries restrict the region to the western portion of the Hudson River, where there is less development and the border does not extend to New York City. This can result in underestimation of economic activity and capacity. In contrast, the eastern side of the river (the East Hudson and Mohawk River Valleys Region) borders New York City and extends far north to include the cities of Albany and Utica—two cities that are considered by the New York State Department of Labor (DOL) to be the centers of completely different regional economies.

The New York State Building Stock

The first step in assessing impacts is to understand what types of buildings are at risk and where they are across the state. For this analysis, buildings are considered to be either residential or non-residential. A more detailed look at the building types included in each category can be found in the table below.

In total, there are over 5 million buildings in New York State containing 13.78 billion square feet of space. These buildings are collectively worth over $2 trillion (in 2014 dollars). Across the state, non-residential space accounts for a smaller share of total buildings (9.9%) and total square footage (25.4%), but it is estimated to have a higher square footage value ($178/sf) than residential space ($167/sf).

New York State is home to a wide array of community types, including densely packed urban cities, mid-sized cities, many small towns, and large expanses of rural and natural lands. While historically dense mid-sized cities are spread across the State, the landscape of buildings is dominated by the New York City and Long Island Region.

HAZUS-MH BUILDING TYPES

Non-Residential	Residential
Agriculture	Single Family
Commercial	Multifamily
Education	Other
Government	
Healthcare	
Industrial	
Religion	

This region accounts for only 3% of the land area in New York State but is home to almost 40% of the buildings, over 50% of the total square footage of space, and almost 58% of the total building value. Densities in the New York and Long Island Region can reach up to 16,000 buildings per square mile.

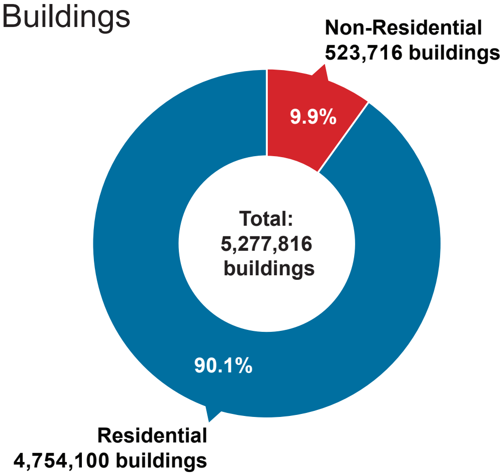
Outside the New York City and Long Island Region, buildings tend to be most densely distributed across cities along the two major transportation corridors— the New York State Thruway (U.S. Interstate Route 90) and U.S. Interstate Route 87. The regions along these corridors—Western New York/Great Lakes Plain, Tug Hill Plateau, and East Hudson and Mohawk River Valleys—account for another 42% of the State's buildings, 36% of the total square footage, and 31% of the total building value within the State.

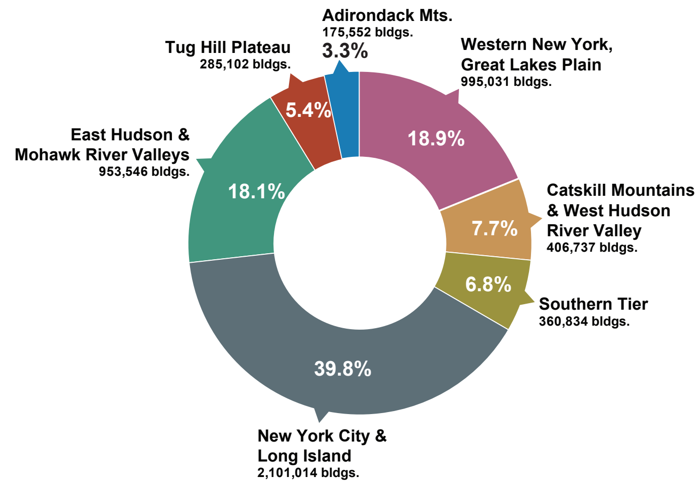
The rest of the building stock can be found in the remaining three regions—Catskill Mountains and West Hudson River Valley, Southern Tier, and Adirondack Mountains. These regions are characterized by large tracts of rural or natural lands and several smaller towns and cities. Although these regions have collectives of cities that act as the centers of commerce for the region, they lack a large dominant city. These regions account for 18% of the buildings, 13% of the total square footage, and 11% of the total building value within the State.

NEW YORK STATE'S BUILDING STOCK BY THE NUMBERS (2015)

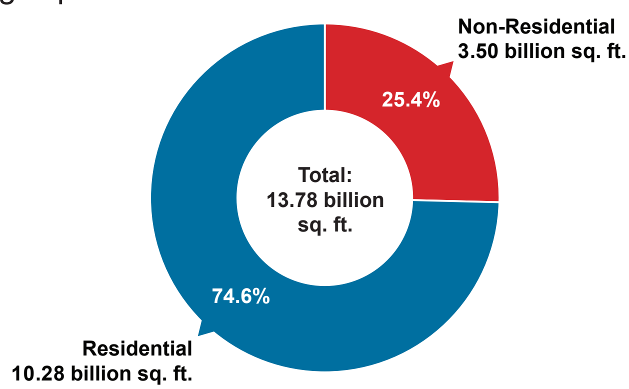
New York's Total Building Stock	Regional Distribution of Building Stock

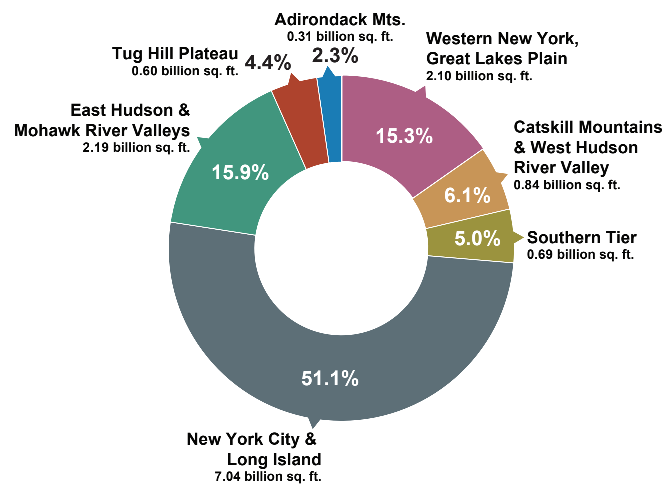
Number of Buildings



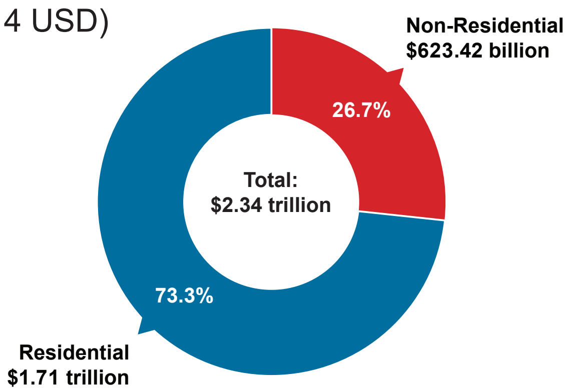


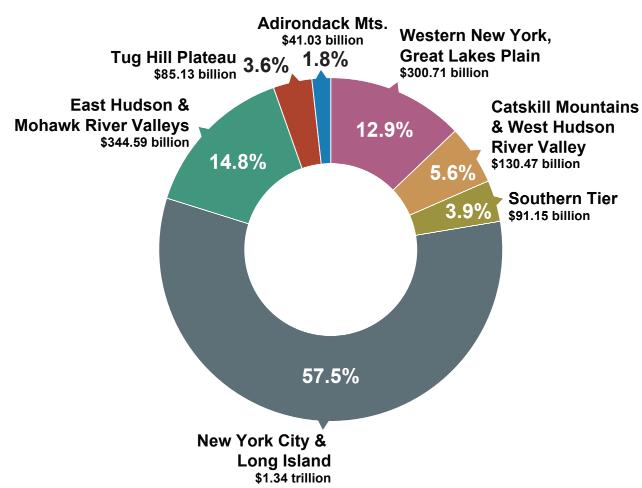
Building Square Feet





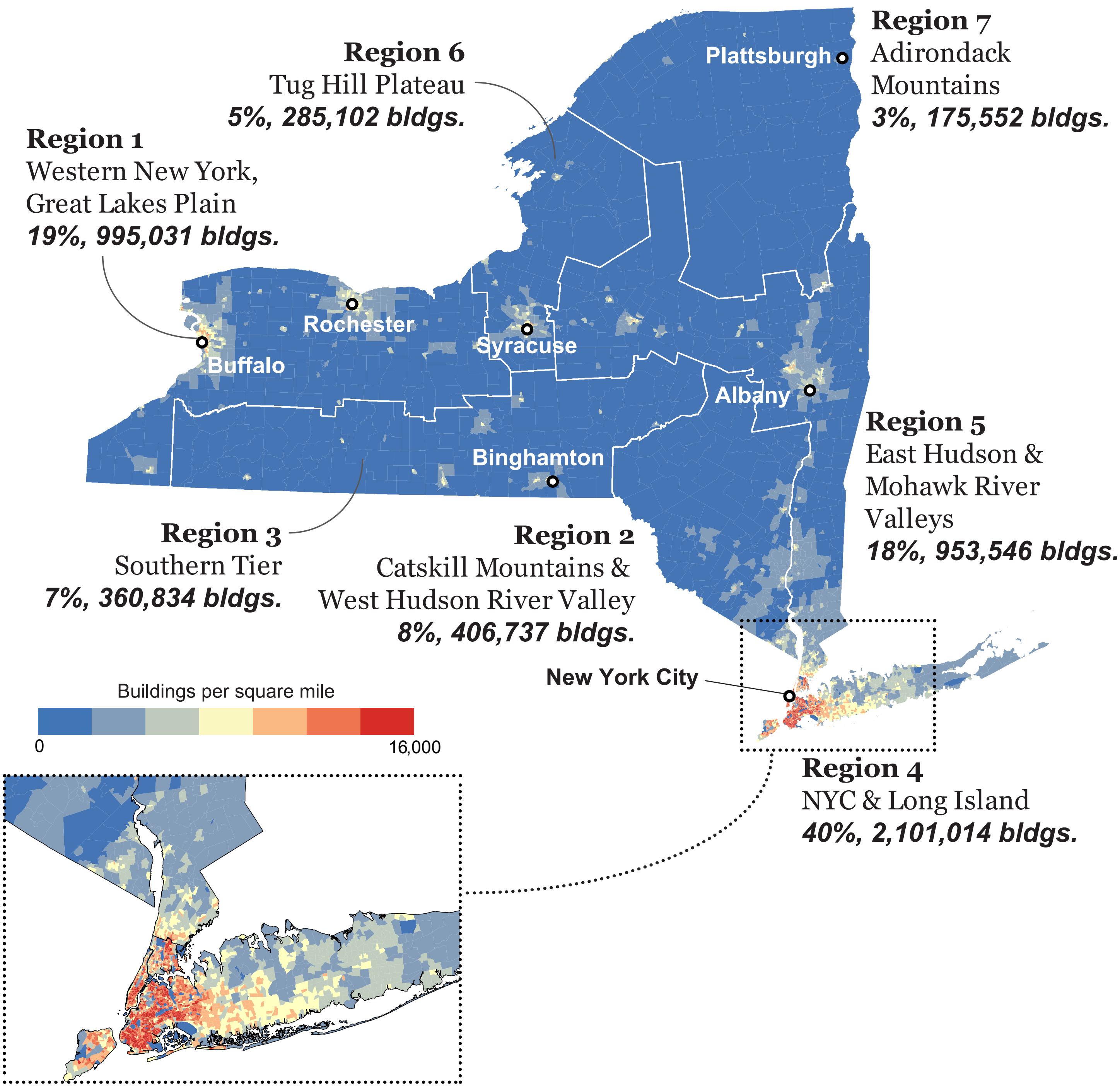
Assessed Building Value (2014 USD)





Data Source: FEMA-Hazus MH

REGIONAL DISTRIBUTION OF BUILDINGS ACROSS ClimAID REGIONS (2015)



Data Source: FEMA HAZUS MH

Climate Hazards Considered in This Report

Economic losses caused by the following climate hazards are considered in this report.

Hurricanes

HAZARD DESCRIPTION:
Hurricanes produce severe winds, intense precipitation, and storm surge. The entire Atlantic coast of the United States is susceptible to this hazard. ClimAID Region 4 (New York City and Long Island) is particularly vulnerable to hurricanes due to its coastal location, but several other inland ClimAID regions can be affected by hurricanes as well.

ANTICIPATED CHANGES:
The strength of hurricanes and tropical storms may increase due to a rise in ocean and atmospheric temperatures. In addition, as sea levels rise, the coastal flooding and storm surge that is associated with these storms may increase.[10]

Flooding

HAZARD DESCRIPTION:
Flooding is a regular event in New York State, occurring at least once every seven years in all 62 counties of the state.[10] The 2014 New York State Hazard Mitigation Plan identified nine types of flooding that cause damage to buildings: riverine overbank flooding, flash floods, alluvial fan floods, mudflows or debris floods, dam- and levee-break floods, local draining or high groundwater levels, fluctuating lake levels, ice jams, and coastal flooding.[2] Factors that increase flood risk include land elevation, proximity to a water body, and precipitation amount.[2]

ANTICIPATED CHANGES:
Flooding is often the result of extreme precipitation events. Downpours, defined as intense precipitation at sub-daily and often sub-hourly timescales are very likely to increase in frequency and intensity. The number of days with over two inches of rain is predicted to increase across the state by 2080. The greatest increase in extreme precipitation events will be in seen in ClimAID Region 3 (Southern Tier), Region 4 (New York and Long Island), and Region 7 (Adirondack Mountains).[2]

Severe Storms

HAZARD DESCRIPTION:
Severe storms include intense precipitation events (not including snow events) that occur over a short period of hours or even minutes. Often occurring in warmer months, these intense events are commonly associated with convective storms.[1]

ANTICIPATED CHANGES:
With temperatures projected to warm across New York State, the frequency and intensity of severe storms may increase.[1] Some research also suggests that lightning may increase in frequency with warmer temperatures and higher humidity; this can cause wildfire, building fire, or other types of damage.[1]

Winter Storms

HAZARD DESCRIPTION:
Winter storms can include cold temperatures, snow, ice, high winds, blizzard conditions, and other localized phenomena like lake effect snowstorms.[1] These storms can cause significant physical damage or property loss.

ANTICIPATED CHANGES:
The severity of a winter storm depends on several physical and climatological factors, including precipitation amounts and temperature.[1] Although seasonal projections are less certain than annual results, significant increases in regional precipitation amounts are expected to occur during winter months in New York State.[2] In addition, models suggest that the decrease in ice cover on the Great Lakes may lead to increased lake effect snow in the coming decades.[2] However, by mid-century these lake effect snow hazards may decrease as temperatures below freezing become less common.[2]

Climate Hazards Not Considered in This Report

The following climate hazards are not considered in the analysis presented in this report due to the lack of economic loss data. Although there is currently a lack of data to accurately assess the regional economic impacts caused by these hazards, the threat they pose to buildings is real. Increased exposure of buildings to these hazards could have serious financial implications for the ownership, operation, and maintenance of real property and should be considered when planning for future climate conditions. See *New York State Climate Hazards Profile* for detailed maps and additional data about climate hazards.

Pest Infestations

HAZARD DESCRIPTION
Rising temperatures may contribute to an increase in pests and invasive species. These pests and invasive species can cause disruptions to ecosystems and the agricultural sector, as well as increasing exposure to infectious diseases.[1]

ANTICIPATED CHANGES
By 2100, New York State's climate may resemble the one currently found in the Southeastern United States.[2] While changes in temperature and precipitation may allow some invasive species to overcome environmental and ecological constraints that prevented them from thriving in New York State in the past,[1] these conditions may also create a habitable environment for new types of insects and other pests not currently found in the Northeastern United States.[11]

ECONOMIC IMPACTS
Invasive species have profound economic implications for buildings and their grounds. Invasive pest insects are estimated to raise the management costs for lawns, gardens, and golf courses in the United States by $1.5 billion annually.[12] Additionally, termite management and repairs to termite-related damage is estimated to cost up to $11 billion annually in the United States.[13] If New York State's future climate more closely resembles that of Southeastern United States—where termites are most common[14]—termites will have a greater impact on the State's wood-framed buildings. In all, the presence of new species of pests in New York State will likely pose new management challenges and increase costs in the future.

Extreme Heat

HAZARD DESCRIPTION
Prolonged periods of hot weather are projected to become more frequent and intense in New York State. Excessive heat can create stresses on human populations, including heat-related illness and death. It also poses new challenges to energy systems, air quality, infrastructure, and buildings.[1] High temperatures can also contribute to other types of extreme events like drought or wildfire.[6]

ANTICIPATED CHANGES
The average annual temperatures across New York State are projected to increase by 2.0–3.4°F by the 2020s, 4.1–6.8°F by the 2050s, and 5.3–10.1°F by the 2080s.[2] Based on baseline data from 1971 to 2000, the greatest warming is projected to be in the northern parts of the State including ClimAID Region 7 (Adirondack Mountains) and parts of Region 6 (Tug Hill Plateau). The frequency of extreme heat events is likely to become more prevalent as well. The number of days over 90°F is projected to increase for every ClimAID region in the State, and the frequency and duration of heat waves (defined as three or more consecutive days with maximum temperatures at or above 90°F) are also expected to increase.[2]

ECONOMIC IMPACTS
Heat waves are more likely to affect buildings' occupants than the structures themselves. Most fatal heat-related illnesses occur in the indoor home environment. In New York City (NYC), more than 80% of heat strokes citywide have been attributed to exposure at home.[15] By 2050, the total number of heat-related premature deaths in NYC is projected to be between 204 and 268 per year, depending on the greenhouse gas emissions scenario used and the acclimatization of the local population.[16] Given EPA's current estimate for the value of a human life of $7.4 million,[17] by 2050, heat-related premature deaths could have an annual impact of between $1.51 to $1.98 billion in NYC alone. Most regions across the State are estimated to see significant increases in hospital admissions from heat-related illnesses, which will result in additional costs to the state's health care system.[18] Investing in strategies to reduce exposure to high temperatures indoors may have a significant impact on New York State's health care costs.

Rising Sea Levels

HAZARD DESCRIPTION
As glaciers and ice sheets melt, and warming ocean waters expand, the threat of rising sea levels escalates for coastal communities. Sea level rise can exacerbate risks from hurricanes and tropical storms; without adaptation, homes, businesses, and infrastructure are at risk of inundation.[1]

ANTICIPATED CHANGES
Estimates for ClimAID Regions 2 (Catskill Mountains and West Hudson River Valley) and 5 (East Hudson and Mohawk River Valleys) project a rise in sea levels of 1 to 4 inches by the 2020s, 5 to 9 inches by the 2050s, and 8 to 18 inches by the 2080s, while estimates for ClimAID Region 4 project a rise in sea levels of 2 to 5 inches by the 2020s, 7 to 12 inches by the 2050s, and 12 to 23 inches by the 2080s. In the long term, rising sea levels will worsen storm surges associated with hurricanes and severe storms and may cause permanent inundation of sites currently occupied by buildings, posing a significant challenge to existing buildings.[9]

ECONOMIC IMPACTS
Rising sea levels will lead to economic losses associated with the protection or abandonment of buildings in many coastal cities across the United States. ClimAID Region 4 (New York City and Long Island) will be particularly vulnerable given its miles of coastline and its high density of buildings. According to Climate Central, a sea level rise of six feet would expose 125,364 housing units, 104 schools, and a total property value of $44.8 billion. At nine feet of sea level rise, a total of $90.6 billion of property would be exposed.[19] These estimates do not include property on Long Island or along other coastal areas of the State. This additional property will significantly add to the overall exposure level of buildings in New York State.

Wildfires

HAZARD DESCRIPTION:
Wildfires are the unplanned and unwanted burning of vegetation, often in forested areas or other undeveloped places. Though they often begin unnoticed, they spread quickly and cause damage to thousands of acres annually in New York State.

ANTICIPATED CHANGES:

As extended droughts and heat waves are projected to increase in New York State, wildfire hazards are likely to increase as well. Wildfires may become more frequent and intense, and drier conditions in the warmer months can lead to a growing threat of wildfires. In addition, forested areas may become more susceptible to fire because of changes in the forest ecosystem.[9]

ECONOMIC IMPACTS:
Wildfires have had a relatively small economic impact on the State's building sector. Wildfires caused only $39 million in total damage from 1960 to 2014, but the likely increase in droughts, heat waves, and population could put more buildings at risk in the future.

Economic Losses and Building Stock Vulnerabilities

What is Vulnerability?

Vulnerability is the degree to which buildings are susceptible to and unable to cope with adverse impacts of climate change.

Vulnerability is a function of **exposure** and **sensitivity**.

Exposure is the degree to which buildings are in direct contact with climate variables and/or may be affected by long-term changes in climate conditions or by changes in climate variability, including the magnitude and frequency of extreme events.

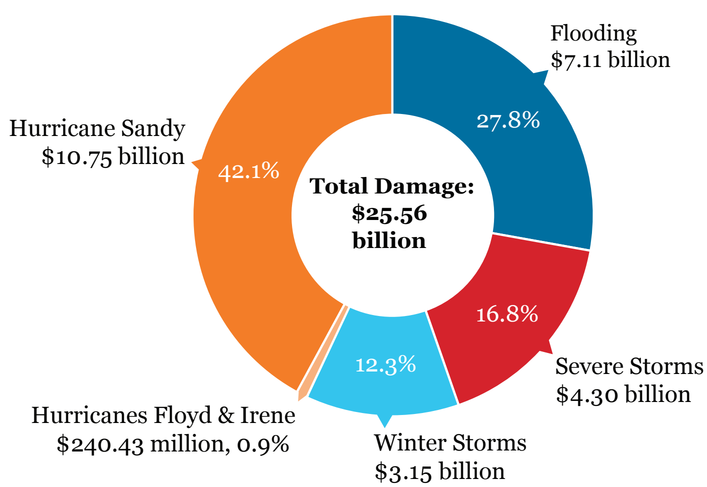
Sensitivity is the degree to which buildings will respond to a change in climate, either beneficially or detrimentally.[1]

STATE-WIDE IMPACTS

Assessing the potential future economic impacts from climate hazard events requires an accurate understanding of the present-day vulnerability of buildings. Historical property damage cost data from 1960 to 2014 were used to assess the inherent vulnerabilities of the state's building stock. Data availability limited the analysis to property damage losses caused by winter storms, severe storms, hurricanes, and flooding (see page 15 for an explanation of these hazard events).

Hurricanes were by far the most costly—yet rarest—events to hit the State, accounting for 43% of the total damage over the 54-year period. Since 1960, New York's buildings have sustained an estimated $25.7 billion (2014 USD) in damage; however, more than 42% of the total costs can be attributed Superstorm Sandy, which hit the State in 2012. Excluding the impacts of Superstorm Sandy, the total amounts to $14.9 billion. Conversely, severe storms were the most frequent and widespread events, but they accounted for only 16.8% of the total damage.

TOTAL STATE-WIDE ESTIMATED PROPERTY DAMAGE, 1960–2014 (2014 USD)



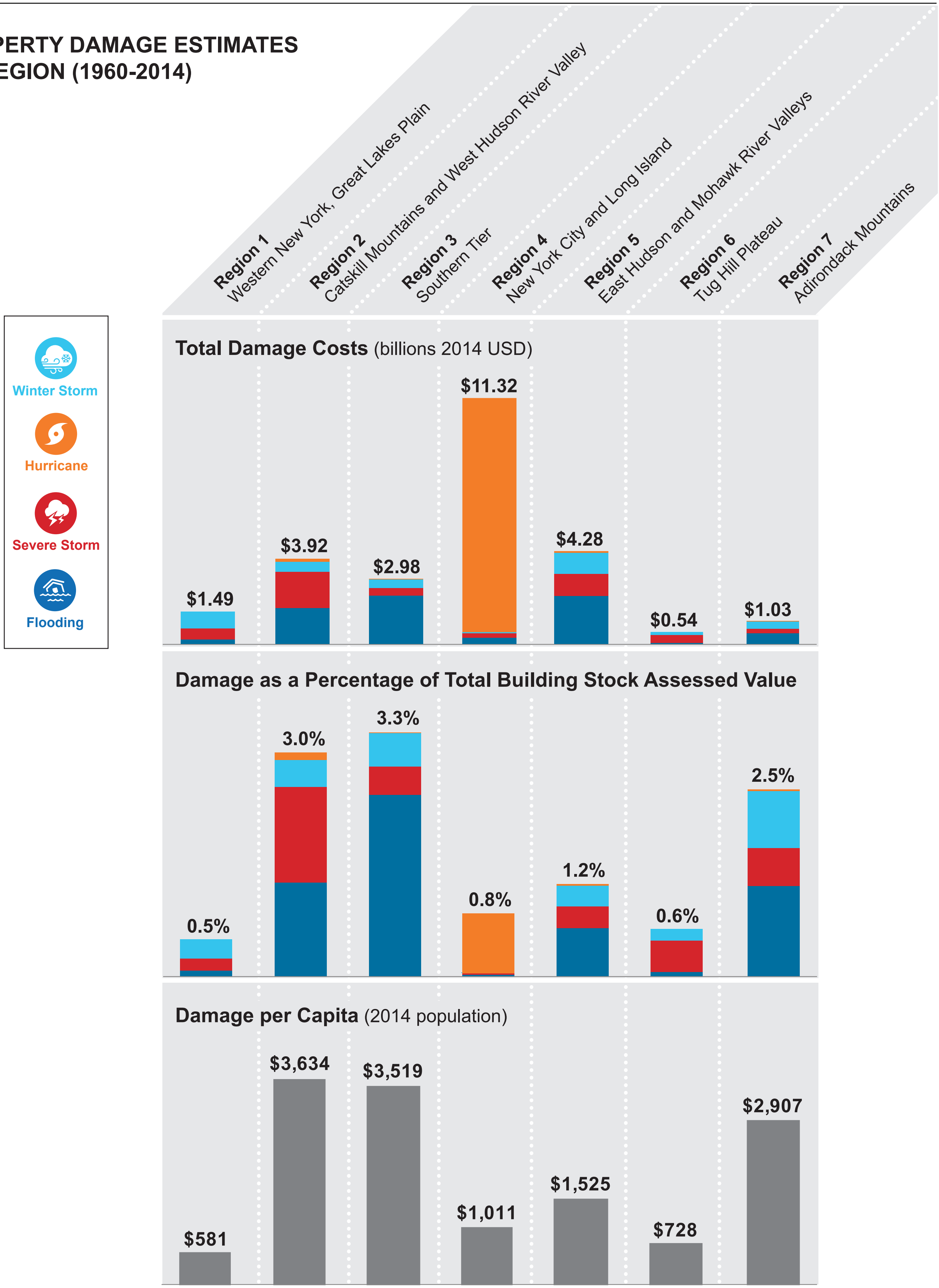
Data Source: SHELDUS, FEMA

A closer look at historical costs as a percentage of total building stock value reveals a more nuanced picture of the true impacts in each region. Since hurricanes have predominately affected Region 4 (New York City and Long Island), the impacts have occurred in the center of the highest concentration of building value in the State. While the localized impacts of all types of events can be devastating to individual property owners, the New York City region as a whole may be more economically resilient than other regions across the State. The total historical damage cost in the region was 0.8% of its total building stock value; for events other than hurricanes, it was a mere 0.04%. On the other hand, this underscores the focused attention given to preparing for future hurricanes in the region.

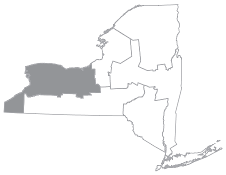
Hazard events outside the New York City and Long Island Region in other regions have had relatively greater impacts. For example, the total damage in the Southern Tier Region accounted for 3.3% of the region's total building value. The Catskill Mountains and West Hudson River Valleys and Adirondack Mountains Regions faced similar circumstances, exhibiting total damage shares of 3.0% and 2.5%, respectively, more than double the share exhibited by the New York City and Long Island Region.

The following pages provide summaries of region-specific property damage.

PROPERTY DAMAGE ESTIMATES BY REGION (1960-2014)



Data Source: SHELDUS, FEMA



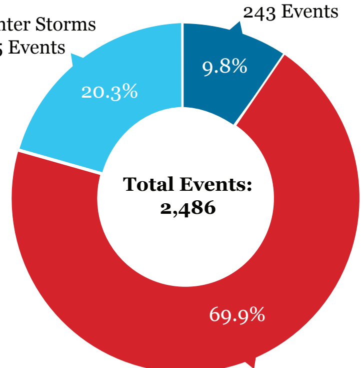
REGION 1 VULNERABILITY PROFILE

Western New York/Great Lakes Plain

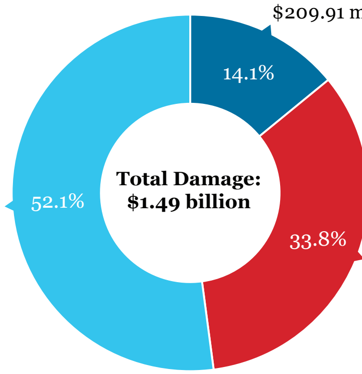
Since 1981, there has been a considerable increase in the number of events in the Western New York Region, and the area of developed land in the region grew by 3.6% between 2001 and 2011. Still, the total annual cost of damage has not increased over time (see Appendix B for more information).

Since 1960, the region has seen the third-lowest historical property damage total among ClimAID regions at just under $1.5 billion. Winter storms were the most significant hazard in the Western New York Region. Since 1960, winter storms have caused the most damage in the region, and while winter storm events accounted for only 20% of all events, they have been responsible for more than 52% of the damage. Furthermore, these events have had the greatest average cost in the region at $1.54 million per event, which exceeds the State's average cost for winter storm events by almost 33%. Flooding events in the region also had a relatively high average cost of $864,000 per event, although that figure is low compared to the statewide average cost of $5.09 million per flood event.

NUMBER OF EVENTS 1960–2014



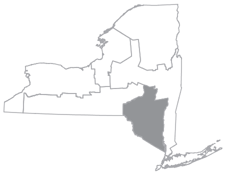
TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost Per Event	Average Cost per Event across All Regions
Hurricanes	Property damage was not recorded for this region.		
Flooding	$81.75	$0.86 million	$5.09 million
Severe Storms	$196.64	$0.29 million	$0.43 million
Winter Storms	$302.72	$1.54 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)

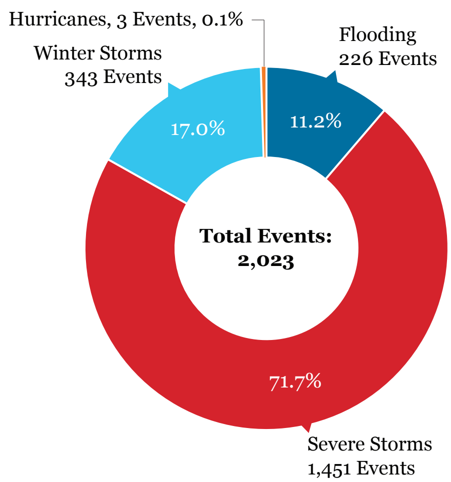


REGION 2 VULNERABILITY PROFILE

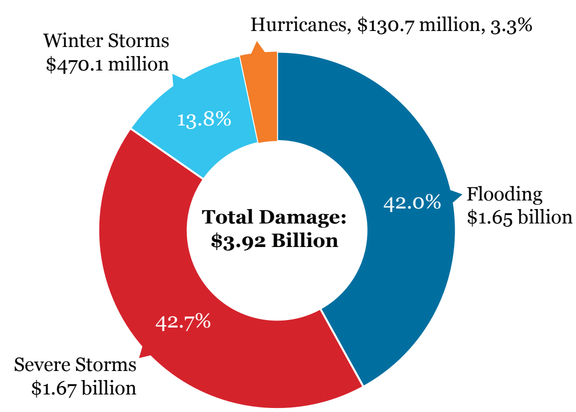
Catskill Mountains and West Hudson River Valley

While the total annual cost of damage has not increased over time in the Catskill Mountains and West Hudson River Valley Region, the area of developed land in the region grew by 5.4% between 2001 and 2011, potentially exposing more buildings to future climate hazards (see Appendix B for more information). Overall, the region has been relatively vulnerable, facing a mix of impacts from severe storms, flooding, and hurricanes—all of which have cost more, per event, than the State average for each hazard. In total, the region has seen more than $3.9 billion in building damage since 1960. As in most regions, severe storms have been the most frequent events, accounting for 71% of all events and causing more than 42% of the total damage in the region. Flooding and hurricanes have also played significant roles in the accumulation of damage over the years, but they have occurred in very different ways. Flooding accounted for only 11% of all events, but caused 42% of the total damage, costing an average of $7.28 million per event. In contrast, relatively few hurricane events (three) have been responsible for $130 million in damage, which makes them the most costly events in the region with an average cost of $43.57 million per event. Per capita damage costs reveal the inherent vulnerability of the region. Although the region's population is the fourth largest in the State (1,079,188 residents), per capita property damage costs for severe storms ($1,552 per person) and flooding ($1,525 per person) are the second and third highest in the State when we consider all hazard events.

NUMBER OF EVENTS 1960–2014



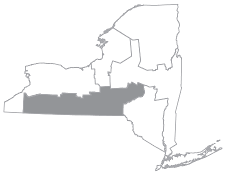
TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost Per Event	Average Cost per Event across All Regions
Hurricanes	$121.12	$43.57 million	$916.31 million
Flooding	$1,525.02	$7.28 million	$5.09 million
Severe Storms	$1,552.08	$1.15 million	$0.43 million
Winter Storms	$435.57	$1.37 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)



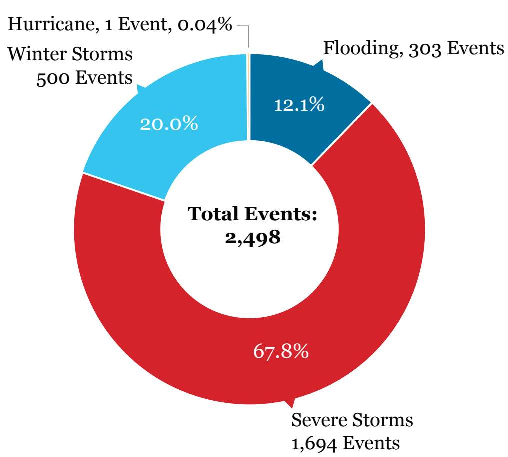
REGION 3 VULNERABILITY PROFILE

Southern Tier

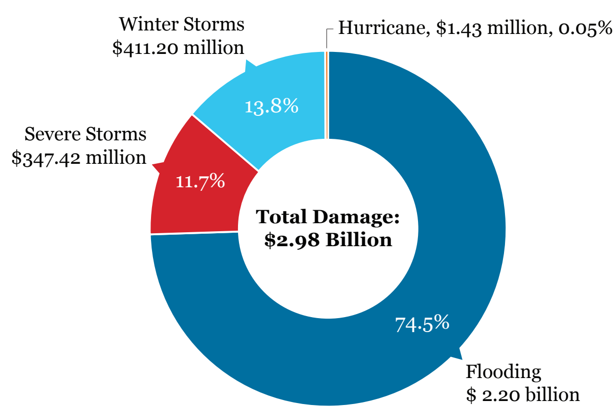
Since 2001 there has been a considerable increase in the number of events in the Southern Tier Region, but the area of developed land in the region grew by only 1.6% between 2001 and 2011—the lowest growth rate in the State—and total annual damage costs have remained constant (see Appendix B for more information).

Since 1960, the region has been particularly susceptible to flooding events, costing an average of $7.33 million per event, which is the second highest in the State, trailing the East Hudson and Mohawk River Valley. But unlike those of the East Hudson and Mohawk River Valley, the Southern Tier's flooding events accounted for more than 74% of its total damage costs and the highest per capita damage costs ($2,626 per person) across all regions and hazard events. Additionally, the Southern Tier Region has the third-lowest number of buildings in the State—7% of the State total—which suggests that Southern Tier floods have a disproportionate impact.

NUMBER OF EVENTS 1960–2014



TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost per Event	Average Cost per Event across All Regions
Hurricanes	$1.68	$1.43 million	$916.31 million
Flooding	$2,621.56	$7.33 million	$5.09 million
Severe Storms	$410.48	$0.21 million	$0.43 million
Winter Storms	$485.39	$0.82 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)

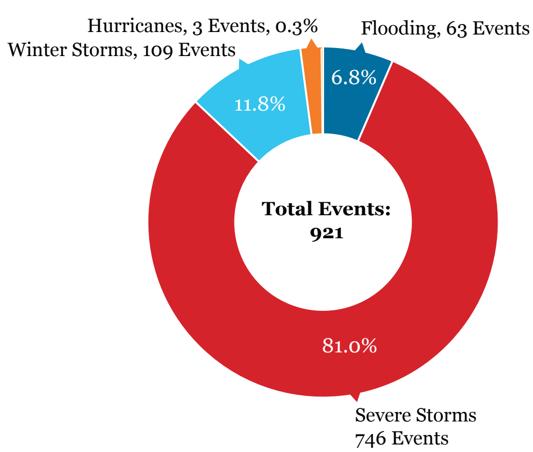
REGION 4 VULNERABILITY PROFILE

New York City and Long Island

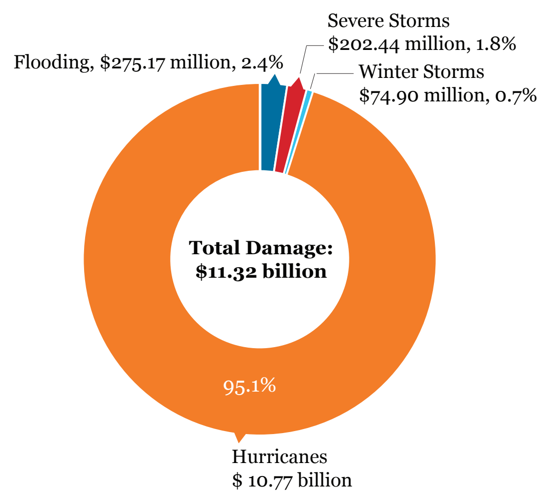
New York City and Long Island Region's location along the eastern seaboard makes it particularly vulnerable to hurricanes. The impacts from all other events in the region pale in comparison to those associated with the hurricanes that hit the region between 1960 and 2014. Three hurricanes caused more than $10 billion in damage and 99% of the damage costs can be attributed to Superstorm Sandy, which caused an estimated $10.69 billion of property damage. Alarmingly, these hurricanes hit the State's highest concentration of buildings and population. While the total hurricane-related property damage accounted for only 0.8% of the region's total building stock value, the per capita property damage cost ($961 per person) is relatively high—fifth overall among all regions and events—especially considering that the total population of the region was 11.2 million in 2014.

Flooding events not associated with hurricanes were the next most costly in the region, costing $4.37 million per event—still a relatively high figure when compared to that of other regions across the State.

NUMBER OF EVENTS 1960–2014



TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost per Event	Average Cost per Event across All Regions
Hurricanes	$961.32	$3.59 billion	$916.31 million
Flooding	$24.56	$4.37 million	$5.09 million
Severe Storms	$18.07	$0.27 million	$0.43 million
Winter Storms	$6.68	$0.69 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)

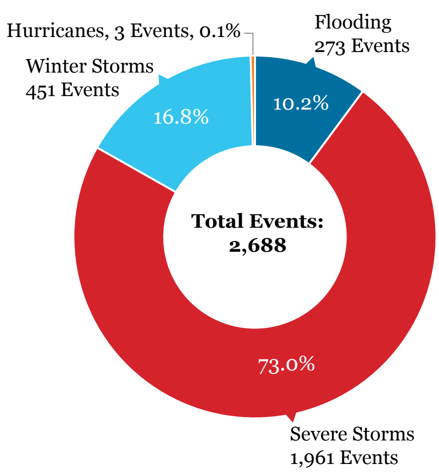
REGION 5 VULNERABILITY PROFILE

East Hudson and Mohawk River Valleys

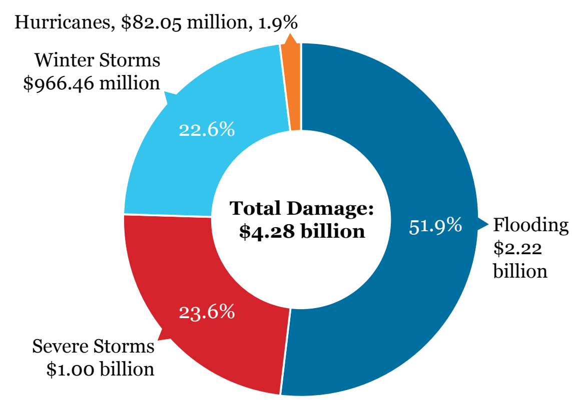
Over time, the East Hudson and Mohawk River Valleys Region has not seen a significant change in the number of events or a significant change in total annual damage costs, but the area of developed land in the region grew by 5.6%—the highest growth rate in the State—between 2001 and 2011, potentially exposing more buildings to future climate hazards (see Appendix B for more information).

The East Hudson and Mohawk River Valleys Region is unique among others across the State. Its geography covers a large portion of two river valleys and many densely populated urban areas. This combination made the region's buildings particularly vulnerable to flooding events. The region has the highest flood damage total and the highest per-event cost in the State at $2.22 billion and $8.12 million, respectively. Furthermore, these high levels of flood damage—accounting for almost 52% of the total property damage in the region—have come from 273 events, which accounts for only 10% of all events in the region. In addition to flooding, the region has also seen significant damage caused by winter storms. While there are a normal number of winter storm events relative to other regions, these events have cost, on average, more than twice as much as those across the State as a whole.

NUMBER OF EVENTS 1960–2014



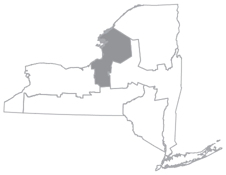
TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost per Event	Average Cost per Event across All Regions
Hurricanes	$29.26	$27.35 million	$916.31 million
Flooding	$791.01	$8.12 million	$5.09 million
Severe Storms	$359.80	$0.51 million	$0.43 million
Winter Storms	$344.66	$2.14 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)



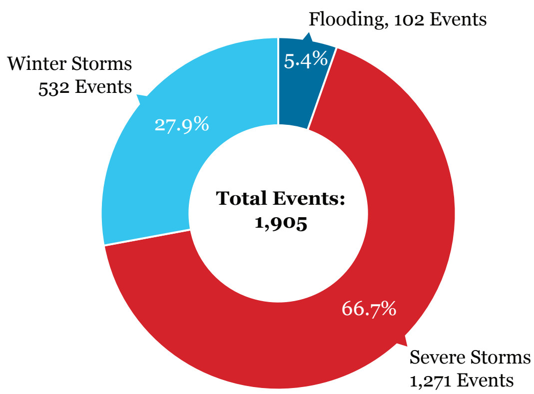
REGION 6 VULNERABILITY PROFILE

Tug Hill Plateau

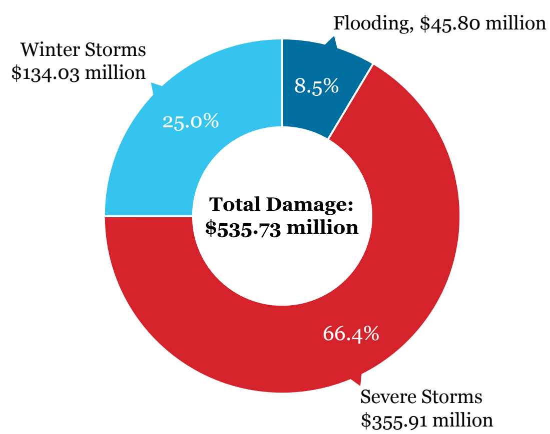
Since 1981, there has been a considerable increase in the number of events in the Tug Hill Plateau Region, and the area of developed land in the region grew by 5.1% between 2001 and 2011 (see Appendix B for more information).

The Tug Hill Plateau has had the most balanced damage profile of all regions in the State, in that each hazard's proportion of events is roughly proportional to the damage it caused. For example, severe storms accounted for 66% of all events in the region and accounted for 66% of the total damage. While the region has not faced the same level of impacts as other regions, it has still sustained 1,905 events. The region's location along the eastern banks of Lake Ontario has made it particularly susceptible to winter storm events, but not necessarily winter storm-related property damage. A total of 607 winter storm events hit the region from 1960 to 2014—the second highest count in the State, behind only the Adirondack Mountain Region—and caused only $134.03 million worth of property damage. This costs an average of $252,000 per event, a relatively low figure when compared to the State average of $1.03 million for winter storm events. Overall, the Tug Hill Plateau has been the most resilient region in the State in terms of property damage. This is likely due to its relatively low exposure to hurricane and flooding hazards—the most costly hazards statewide.

NUMBER OF EVENTS 1960–2014



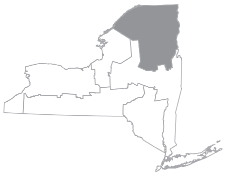
TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost per Event	Average Cost per Event across All Regions
Hurricanes	Property damage was not recorded for this region		
Flooding	$62.26	$0.45 million	$5.09 million
Severe Storms	$483.86	$0.28 million	$0.43 million
Winter Storms	$182.22	$0.25 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)



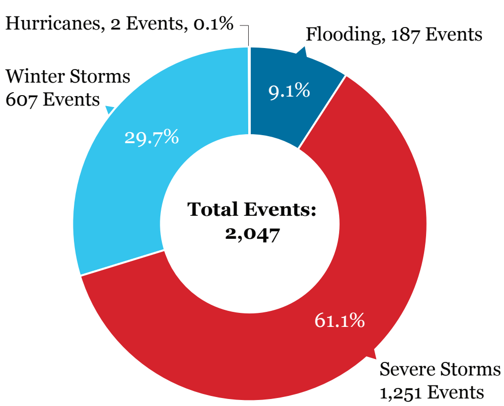
REGION 7 VULNERABILITY PROFILE

Adirondack Mountains

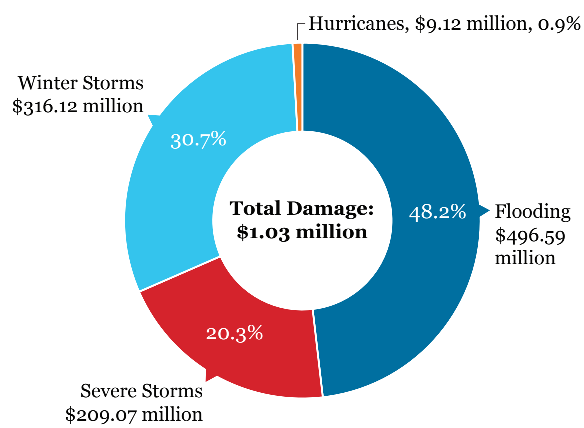
Since 1981, there has been a considerable increase in the number of events in the Adirondack Mountains Region, but the area of developed land in the region grew by only 1.9% between 2001 and 2011—the second-lowest growth rate in the State—and total annual damage costs have remained constant (see Appendix B for more information).

Hazard events in the region have caused the second-lowest regional total of property damage in the state at $1.03 billion, but flooding has had a disproportionate impact over the years. 187 flooding events in the region—accounting for 9% of all events—have caused 48% of the region's total property damage. And although flooding events in the region are less costly than flooding in other regions, they have still caused an average of $2.66 million worth of property damage per event. The region has also seen the greatest number of winter storm events in the state, but the average per-event damage cost caused by these events is well below the state average. Adirondack Mountain winter storm events have cost an average of $521,000 per event in property damage as compared to the statewide average of $1.03 million. This is likely a function of the relatively low population. The region is home to 354,595 residents—the smallest population in the state—and its per capita damage cost is the highest in the State for winter storms at $891 per person.

NUMBER OF EVENTS 1960–2014



TOTAL DAMAGE COSTS 1960–2014 (2014 USD)



REGIONAL AVERAGE COST PER EVENT (2014 USD)

Climate Hazard	Cost per Capita (2014 Population)	Regional Average Cost per Event	Average Cost per Event across All Regions
Hurricanes	$25.72	$4.56 million	$916.31 million
Flooding	$1,400.45	$2.66 million	$5.09 million
Severe Storms	$589.59	$0.17 million	$0.43 million
Winter Storms	$891.49	$0.52 million	$1.03 million

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)

ECONOMICALLY SIGNIFICANT CLIMATE HAZARD SUMMARY

	Highest Average Cost per Event		Climate Hazard Causing the Greatest Disproportionate Cost (Greatest Deviation from Expected Costs)	
Region	Climate Hazard	Average Cost (2014 USD)	Climate Hazard	Description
REGION 1: Western New York/Great Lakes Plain	Winter Storms	$1.54 million	Winter Storms	Winter storms accounted for 20% of all events in the Western New York/ Great Lakes Plain region but were responsible for 52% of the damage.
REGION 2: Catskill Mountains and West Hudson River Valley	Hurricanes	$43.69 million	Flooding	Flooding accounted for 11% of all events in the Catskill Mountains and West Hudson River Valley region but was responsible for 42% of the damage.
REGION 3: Southern Tier	Flooding	$7.33 million	Flooding	Flooding accounted for 12% of all events in the Southern Tier region but was responsible for 75% of the damage.
REGION 4: New York City and Long Island	Hurricanes	$3.60 billion	Hurricane	Hurricanes accounted for 0.3% of all events in the New York City and Long Island region but were responsible for 95% of the damage.
REGION 5: East Hudson and Mohawk River Valleys	Hurricanes	$27.35 million	Flooding	Flooding accounted for 10% of all events in the East Hudson and Mohawk River Valleys region but was responsible for 52% of the damage.
REGION 6: Tug Hill Plateau	Flooding	$0.45 million	Flooding	Flooding accounted for 5% of all events in the Tug Hill Plateau region but was responsible for 9% of the damage. Although flooding was a source of disproportionate damage, the average cost per event was $4.64 million less than the state-wide average.
REGION 7: Adirondack Mountains	Hurricanes	$4.56 million	Flooding	Flooding accounted for 9% of all events in the Adirondack Mountains region but was responsible for 48% of the damage. Although flooding was a source of disproportionate damage, the average cost per event was $2.43 million less than the state-wide average.

Data Source: SHELDUS, FEMA, U.S. Census Bureau, American Community Survey (ACS)

Regional Economies and Adaptive Capacity

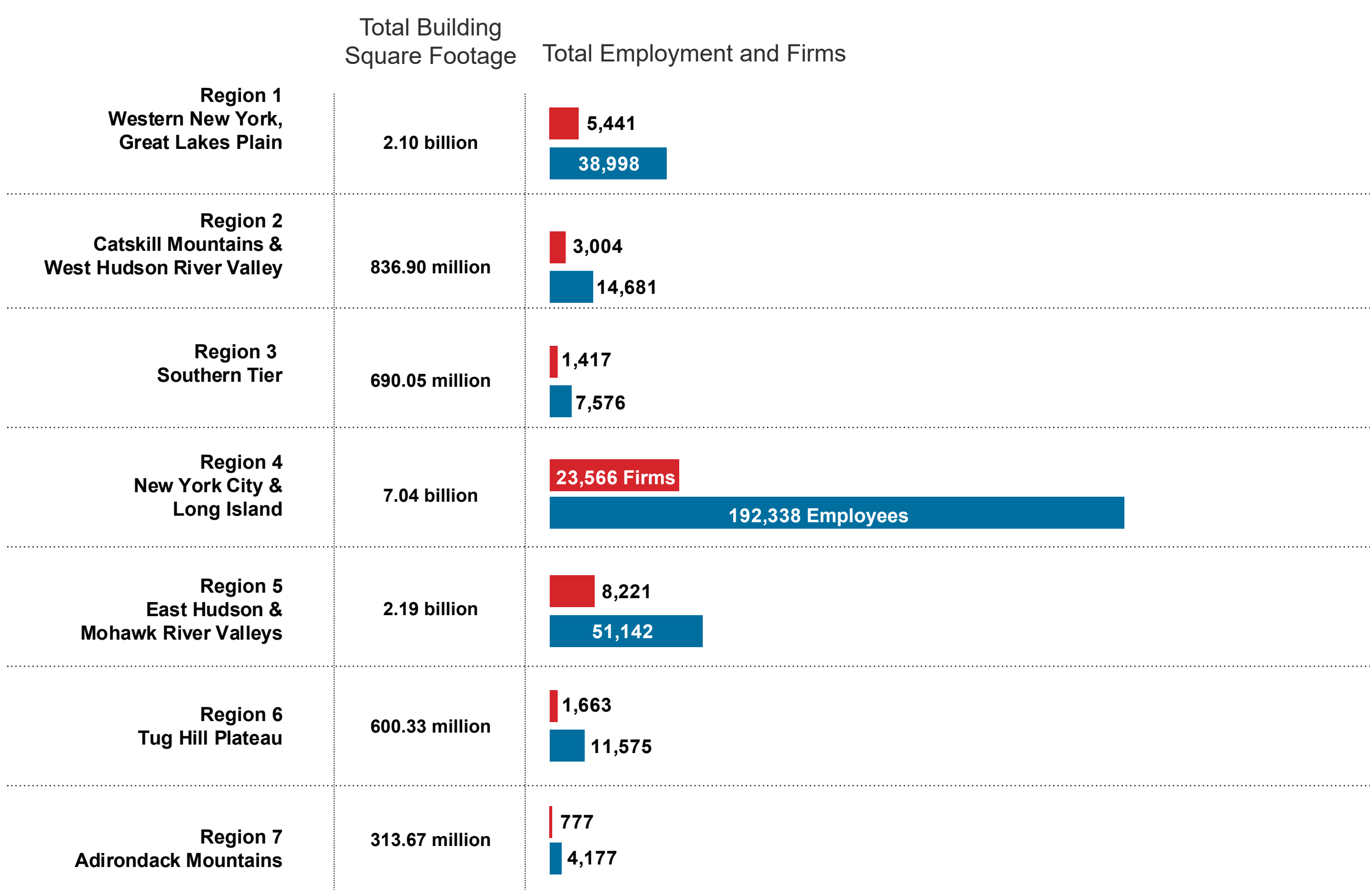
What is Adaptive Capacity?

The ability of a system to adjust to actual or expected climate stresses or cope with the consequences. Actions that build adaptive capacity aim to lessen the physical, social, or economic impacts of climate change or take advantage of new opportunities emerging from a changing climate.[1]

OVERALL CONSTRUCTION CAPACITY

A region's ability to adapt its building stock and building-related economy will greatly increase its ability to cope with climate hazard events in the future. Broadly speaking, each region in New York State has its own economy built on unique geographical features, varying capital and labor markets, and complex supply chain networks. In the building sector, the most prominent economic impacts from future climate impacts—aside from the direct impacts on the businesses occupying buildings—will likely be felt by the real estate, insurance, and construction industries. While it is hard to predict the impacts of highly volatile market-based industries like real estate and insurance, it is possible to estimate the ability of the construction industry to prepare buildings for future weather events or rebuild damaged buildings after an event. A scan of the existing construction employment and firms in each region (shown in the figure below) provides an overview of the construction capacity of each ClimAID region in New York State.

TOTAL CONSTRUCTION EMPLOYMENT AND FIRMS IN EACH ClimAID REGION (2015)



Data Source: DOL, FEMA

CAPACITY PER SQUARE FOOT

An analysis of regional construction capacity reveals differences from region to region. For this assessment, regional construction capacity is defined as the inherent supply of construction professionals—employees and firms—within each region. Construction capacity is measured by the number of square feet of building space that each employee or firm would theoretically be responsible for in a mass recovery campaign that affects all the buildings in a region. While this event is unlikely and outside help would likely be needed, it provides a means of comparing capacity across all regions in the State. A higher capacity—or a lower measure per square foot—is an indication of a higher level of regional adaptive capacity since there is a greater ability to quickly mobilize local labor and rebuild after an event.

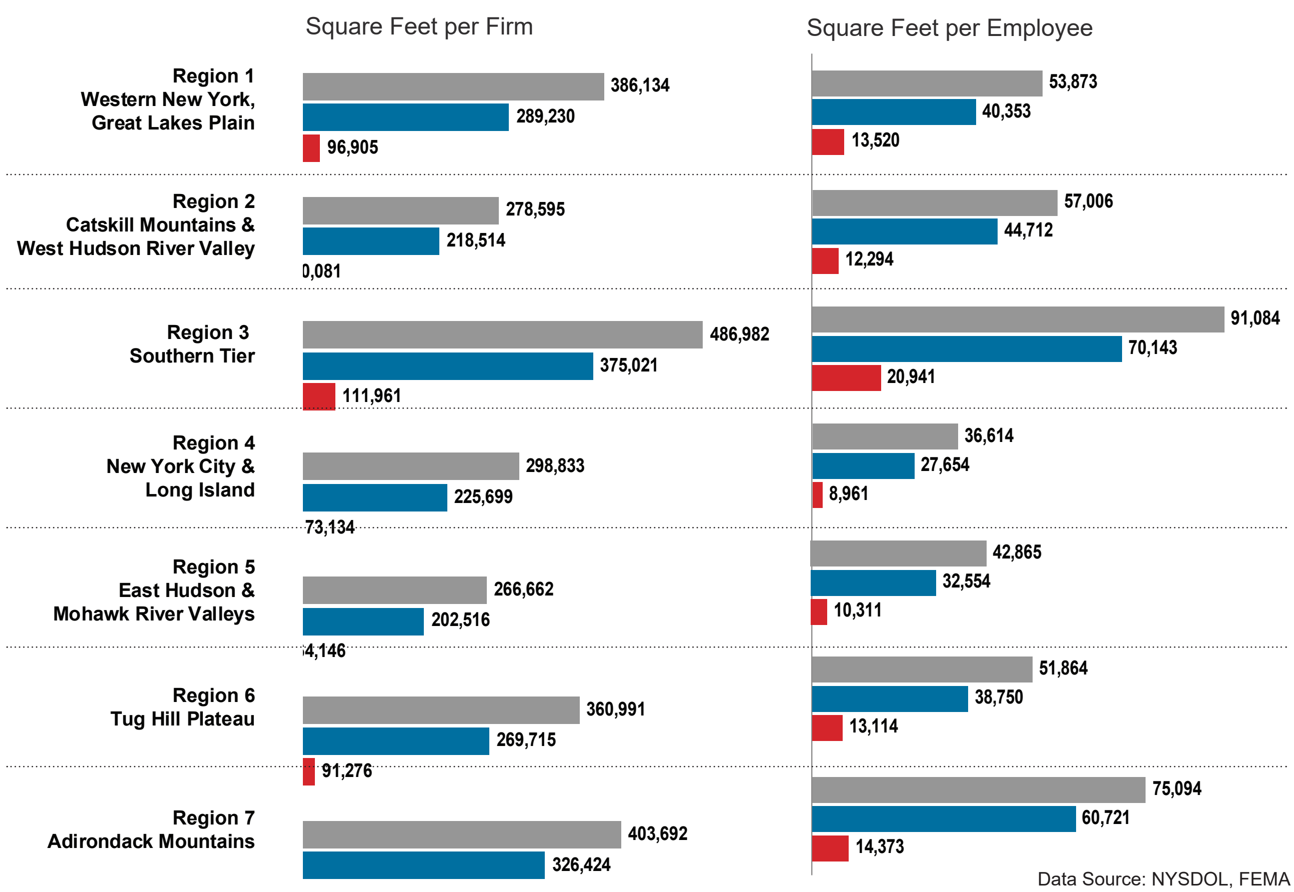
Not surprisingly, the New York City and Long Island Region is home to the highest concentration of construction employees and firms, while the Adirondack Mountains Region is home to the lowest number of construction employees and firms. However, taking into account the total square footage of building space in each region provides another perspective. The New York City and Long Island Region has 36,614 square feet of space per construction employee—the lowest of all the regions. This indicates a higher capacity to retrofit or rebuild the region's buildings with existing resources, since there are fewer square feet for each employee to work on.

Even more telling is the measure of a region's firms per square feet. While both labor and firms can move freely across regional borders, firms are less mobile than labor and retain valuable knowledge about local regulations and

SQUARE FEET PER CONSTRUCTION EMPLOYEE AND FIRM (2015)

The amount of building space that each firm/employee is responsible for, on average, in their region. The lower the figure, the higher the adaptive capacity.

Total
Non-residential
Residential



Data Source: NYSDOL, FEMA

market conditions. The region with the greatest capacity using this measure—or the lowest value of square feet per firm—is the East Hudson and Mohawk River Valleys Region, boasting 266,662 square feet per construction firm. This figure is most likely a function of the region's geographic extent, which covers north of New York City to Albany and beyond. Firms in this region can locate at a lower cost between larger cities while still accessing demand for work in the two largest markets in the State.

At the other end of the spectrum are the Southern Tier and Adirondack Mountain Regions. Both have a greater dispersion of buildings, lack a prominent metropolitan center, and have the lowest concentrations of private industry firms in the State. Both regions have almost twice the square footage of space per employee (90,084 and 75,094, respectively) as the New York City and Long Island Region and approximately 35% more square footage of space per firm (486,982 and 403,692, respectively) than the East Hudson and Mohawk River Valleys Region. This indicates these two regions may be at a disadvantage in capacity to recover relative to other ClimAID regions.

HOW DOES DIRECT SPENDING CREATE ADDITIONAL ECONOMIC ACTIVITY WITHIN REGIONAL ECONOMIES?

DIRECT EFFECT

An infusion of new money into the local economy to increase adaptive capacity. This might include payments to contractors and design professionals for building retrofits, new buildings, or post-disaster recovery activities.

INDIRECT EFFECT

Additional activity caused by direct-spending recipients as they perform their work. This might include spending on commodities and materials or additional services from subcontractors.

INDUCED EFFECT

Employees of the businesses that support the direct-spending recipients spend their wages within the local economy to create even more economic activity and employment.

SPIN-OFF ECONOMIC ACTIVITY

Climate hazard events can have devastating impacts on buildings and temporarily disrupt the function of local economies, especially if regions are not prepared to quickly recover from events. Preparing for such events can save lives, protect buildings, and ensure that impacts on local economies are minimized. In fact, implementing new building-specific resilience strategies can provide opportunities to spur additional economic activity while increasing the region's adaptive capacity, especially if new funding comes from outside of the region or is induced by new policies that do not shift local funding from existing sources.

New spending on preemptive resilience strategies and post-event recovery can provide work for local construction and design firms, but additional benefits can accrue to broader regional economies as well. Payments to contractors and design firms (known as direct spending) can create additional spin-off activity (known as indirect and induced spending) by stimulating the recirculation of money in the regional economy. Spin-off activity can be related to the operations of local firms or spending of households' income on local goods and services.

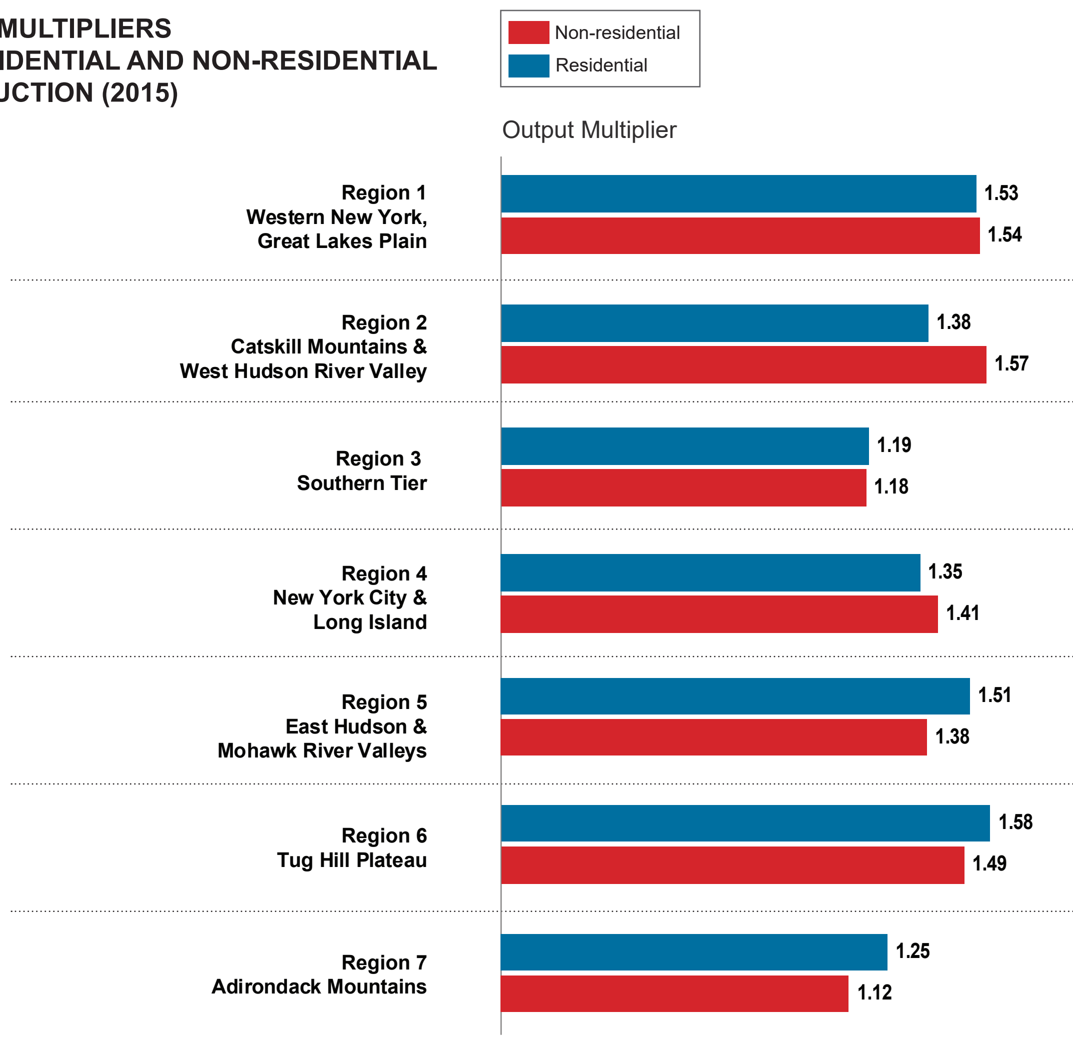
For example, consider a local contractor that has been hired to repair damaged roofs on a number of municipal buildings. This contractor then buys roofing materials from a local supply company, who in turn pays a local mechanic for repairs to the company's delivery fleet. Additionally, the contractor and material supply company pay their employees' wages, which they take home and spend on household items like food and clothing, further perpetuating the circulation of the money. Since regional economies are not entirely self-sufficient ecosystems, the money will eventually leak out to other regions. The measure of the collective impact of all this spin-off activity before the money completely leaves the regional economy is referred to as output.

Using IMPLAN—an industry-standard input-output modeling software—the potential for each region to generate new spin-off output is calculated and shown in the following table. This potential, measured as an "output economic multiplier," estimates the regional economy's ability to generate spin-off activity from an influx of new money to the region. A higher multiplier indicates a higher level of potential spin-off activity. For example, the non-residential construction output multiplier for the Catskill Mountains and West Hudson River Valley Region of 1.57 indicates that every dollar spent directly in the regional economy on construction in the non-residential building sector will create an additional 57 cents in spin-off activity. Typically, output multipliers range from 1.0 to 4.0.

Slight differences can be seen in the output multipliers across all NYS ClimAID regions. In four out of seven regions, investing in residential construction is estimated to have a higher return to the regional economy than investing in non-residential construction. The opposite is true for the New York City and Long Island Region and Catskill Mountains and West Hudson River Valleys Regions, while the Western New York/ Great Lakes Plain and Southern Tier Regions exhibit a more or less even return from investing in residential or non-residential construction.

The lowest estimated spin-off returns—in residential and non-residential construction—are seen in the Southern Tier and Adirondack Mountains Regions. This is likely due to two factors. First, both regions are characterized by a network of smaller cities and towns and lack a prominent major city that plays the critical role as a central hub for labor. Second, these two regions have the lowest concentrations of construction firms among all ClimAID regions. While these regions will still benefit from spending on preemptive resilience strategies and post-event recovery, lower output multipliers indicate that these two regions may generate lower levels of spin-off activity.

OUTPUT MULTIPLIERS FOR RESIDENTIAL AND NON-RESIDENTIAL CONSTRUCTION (2015)



Data Source: MIG, Inc. Impact Analysis for Planning (IMPLAN)

Discussion

EXPOSURE TO CLIMATE HAZARDS

In the future, exposure to many climate-related hazards for New York's buildings is likely to increase. A changing climate is extremely likely to bring higher temperatures to New York State, with slightly larger increases in the north of the state than along the coastal plain. Heat waves are very likely to become more frequent, intense, and longer in duration. Total annual precipitation is more likely than not to increase; brief, intense rainstorms are likely to increase as well. Additionally, rising sea levels are extremely likely, and coastal storm events are very likely to lead to more frequent and damaging flooding along the coastal plain and Hudson River.[1]

If recent trends hold, socioeconomic pressures will also lead to continued growth in developed land. According to USGS data from 2001 to 2011, the area of developed land in the State increased by 159 square miles, or a growth 3.6%.[14] While growth was not evenly distributed across regions, every region increased at least 1.6%. The greatest growth rates were seen in the East Hudson and Mohawk Valley River Valleys Region (+5.6%) and the Catskill Mountains and West Hudson River Valleys (+5.4%) Region. Both of these regions border the Hudson River, which is projected to see increased flooding in the future.

New York State's buildings have been exposed to the four climate hazards considered in this report in very different ways over the years. Severe storms and flooding have the most widespread impacts on the State. Thousands of events have inflicted property damage spread across every ClimAID region since 1960. But unlike severe storms, flooding events have caused disproportionately greater levels of damage per event in all regions except for Region 4 (NYC and Long Island). Additionally, Region 1 (Western New York/Great Lakes Plain) also faced significant exposure to more than 500 winter storms, which caused the majority of its property damage. On the other hand, the localized effects of one hurricane event (Superstorm Sandy) hitting the State's most densely populated region (Region 4, NYC and Long Island) was responsible for 42% ($10.75 billion) of the total property damage sustained across the whole State. New York's buildings will continue to face this dual threat of frequent events—flooding and winter storms—and one-time catastrophic disasters like hurricanes. Strategic investments and policies aimed at building local adaptive capacity will need to take into account the differences between each region's building stock, exposure to climate hazards, and the nature of this dual threat.

ADAPTIVE CAPACITY

Preparing the building sector for future climate hazards can have benefits beyond simply lowering the sensitivity of buildings to extreme hazards. Sustained preemptive actions can also build local capacity for recovery activities post-event, including events that occur under the current climate. Increased local capacity to recover after an event would reduce overall recovery times and minimize economic losses that take place in across each region.

The sources of funding are important as well. Hazard mitigation projects funded by sources from outside of the region—State and federal sources, for example—have the added bonus of creating new economic output while they build local capacity. This may be particularly crucial for less-wealthy regions where local governments and property owners may not have the funding or capacity to handle such projects. While some regional economies may be better at generating spin-off returns from construction spending, all regions will see some new spin-off returns on projects funded by external sources.

Just as building stock vulnerability differs across all ClimAID regions, so does adaptive capacity. Regions without prominent metropolitan areas have an overall lower concentration of construction firms and construction employees. These regions may have less capacity to repair buildings after extreme events, make modifications to existing buildings, or construct new buildings designed to resist future climate hazards. This is especially apparent when considering the square feet of space that each firm or employee might have to work on. Both the Southern Tier and Adirondack Mountain Regions have over 400,000 square feet per construction firm, which is 50% higher than what the firms in the East Hudson and Mohawk River Valleys Region—the region with the lowest value—would have to handle. Moreover, the regional economies of the Southern Tier and Adirondack Mountains

Regions are less able to generate extra spin-off activity from construction activity. These two regions' economies rank lowest in the State in terms of their ability to generate additional returns on construction spending.

DATA LIMITATIONS

The process of making strategic and fiscally prudent decisions must rely on good data. Unfortunately, there are several data gaps that make it difficult to accurately assess the level of exposure for buildings. There is limited access to site-level data on building attributes, historical loss data, and weather predictions and a lack of resources to assess the economic benefit of resilient strategies that can be used to lessen the impact of future climate hazard events.

While the research presented here relied on data that provide estimates of buildings by type (residential and non-residential) and value, a more comprehensive dataset with other variables– such as age, construction type and price—typically held by real estate industry organizations like the Multiple Listing Service (MLS) and insurance companies—would provide a better basis for assessing future vulnerabilities. These data sources are tightly held or shared in a limited capacity by the industry for proprietary purposes. Future large-scale building vulnerability assessments should rely on close partnerships with these organizations.

There are currently several sources of loss estimation data, including SHELDUS and FEMA, which were both used for this research, but these and other data sources have limitations. Most of the shortcomings associated with current data sources are related to accuracy (internal biases), availability (open source versus proprietary), and comparability.[15] Another limiting factor in assessing the vulnerability of buildings is a lack of comprehensive datasets that provide local-level loss estimations. Currently, these figures are available at the county level, but events like flooding may occur in floodplains that cross several counties or simply affect a small portion of one county. The ability to spatially match loss estimations and future projections with a detailed buildings database would provide a robust platform for addressing a wide range of policy decisions targeted at reducing future vulnerabilities.

Finally, the ability to confidently assess the cost and efficacy of adaptation strategies for buildings would allow for more fiscally sound policy or investment decisions. For example, the development of a set of comprehensive benefit-cost ratios (BCRs) for adaptation strategies would provide a basis for comparing and evaluating potential projects that can better prepare new or existing buildings. FEMA defines a BCR as the method by which the future benefits of a mitigation project are estimated and compared to its cost. The measure is derived from a project's total net benefits divided by its total project cost. A project is considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs. The Multihazard Mitigation Council's report "Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities" was an important first step in laying out a methodology for calculating BCRs for mitigation strategies and providing some baseline results for reference.[20] The Council's analysis draws on data from FEMA grant programs and in-depth studies of eight communities to calculate BCR ranges for several mitigation strategies. Unfortunately, the study does not assess the performance of resilience strategies that can be applied directly to buildings. One exception is the retrofitting of buildings with shutters in Horry County, South Carolina. This strategy was found to have a BCR range of 1.9-17.2 (NIBS 2005). The cost estimates provided in the *Climate Resilience Strategies for Buildings in New York State* report are meant to provide a foundation for further work on calculating BCRs for resilient strategies for building.

Conclusions

New York State's buildings sustained more than $25.56 billion worth of damage from hurricanes, flooding, winter storms, and severe storms from 1960 to 2014. Exposure to these climate hazards—along with several others such as sea level rise and wildfire—is projected to increase in the future as our climate changes and the state's physical infrastructure expands to support a growing population. Policy-makers, property owners, facility managers and researchers should consider the following conclusions from this research as they prepare for the future.

CONCLUSIONS FROM THE DATA

- **Climate hazards are not distributed evenly across the State.** The four hazards considered in this research did not affect each region equally. Buildings in Region 4 (New York City and Long Island) were impacted the most by hurricanes. Buildings in other regions—Region 3 (Southern Tier) and 7 (Adirondack Mountains)—were impacted the most by flooding, while Region 1 (Western New York/Great Lakes Plain) was impacted the most by winter storms.
- **Hurricanes and flooding have the greatest impact on buildings, but in different ways.** The State was exposed to only three hurricanes between 1960 and 2014, but they caused the most total damage to buildings ($11 billion, 43% of all damage statewide),which was primarily sustained in Region 4 (New York City and Long Island). Conversely, the State was also exposed to hundreds of flooding events spread across all regions and all years that caused $7.11 billion in damage.
- **Capacity to adapt to climate hazards is different in each ClimAID region.** Regions that have a strong metropolitan center may have greater capacity to prepare for and recover from the adverse impacts of climate hazards. Regions that do not—Region 3 (Southern Tier) and Region 7 (Adirondack Mountains)—may need more support than other regions from State and federal agencies to prepare for future hazards.
- **Data gaps need to be filled to more accurately assess the vulnerability of the State's building sector.** This research relied on estimates of building location and function. A more detailed dataset of buildings' locations, functions, and other attributes—such as construction type and floor area—is needed to accurately inform future policies aimed at bolstering adaptive capacity. Moreover, there is a strong need for research into the economics of deploying resilience strategies for buildings to determine which strategies have the greatest economic return.

ACTIONS FOR POLICY-MAKERS AND RESEARCHERS

- **Create a statewide building stock database.** Such a database would support consistent study of building vulnerabilities and the modeling of impacts. The development of a database could build on existing datasets—such as the State's property parcel database—by adding critical data from the private sector such as the insurance industry (loss estimations and risk analysis) and real estate industry (building attributes such as building type, floor area and value). This database could also be used to cross reference with other databases such as SHELDUS (historical loss estimations), flood plain maps (likely flooding exposure), and predictive climate models (future hazard exposure) to better inform statewide policies.

- **Take advantage of the tools we currently have.** A statewide building stock database would further refine the use of current modeling tools such as FEMA's HAZUS-MH model. HAZUS-MH could be used for scenario modeling to determine the potential impacts from hurricanes and floods in every town, city or village across the State. Strategic partnerships needed to implement such tools might include NYSERDA, NYS Division of Homeland Security & Emergency Services, NYS Office of General Services (OGS), FEMA, General Services Administration (GSA), research universities, construction firms, and design firms.
- **Uncover loss estimations for more climate hazards.** Currently available data cover property damage estimates for several hazards, but more damage estimates are needed to understand the complete set of hazards that may affect the State's buildings in the future. The set of climate hazards to be researched should include sea level rise, pest infestations, extreme heat, and wildfires.
- **Create a comprehensive set of Benefit Cost Ratios (BCRs) for building resilience strategies.** The costs of implementing the resilience strategies presented in *Climate Resilience Strategies for Buildings in New York State* are readily available, but the long-term economic benefits of implementing these strategies is not well known at this point in time. This lack of knowledge hampers the ability of building owners and policymakers to accurately compare strategies and make strategic decisions that could reduce future vulnerability of buildings.

Bibliography

1. Rosenzweig, C., W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, and P. Grabhorn (Eds.). 2011. Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation. Albany, NY: New York State Energy Research and Development Authority (NYSERDA). Accessed September 8, 2016. http://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Environmental- Research-and-Development-Technical-Reports/Response-to-Climate-Change-in-New-York.

2. Horton, R., D. Bader, C. Rozenzweig, A. T. DeGaetano, and W. Solecki. 2014. Climate Change in New York State: Updating the 2011 ClimAID Climate Risk Information. Albany, NY: New York State Energy Research and Development Authority (NYSERDA).

3. Changnon, S. A., D. Changnon, E. R. Fosse, D. C. Hoganson, R. J. Roth Sr., and J. M. Totsch. 1997. Effects of Recent Weather Extremes on the Insurance Industry: Major Implications for the Atmospheric Sciences. *Bulletin of the American Meteorological Society*, 78(3), 425-435.

4. Kunkel, K. E., R. A. Pielke Jr., R.A. and S. A. Changnon. 1999. Temporal Fluctuations in Weather and Climate Extremes That Cause Economic and Human Health Impacts: A Review. *Bulletin of the American Meteorological Society*, 80(6), 1077-1098.

5. Lott, N. and T. Ross. 2015. Tracking and Evaluating US Billion Dollar Weather Disasters, 1980-2005. Asheville, NC: National Oceanic and Atmospheric Administration's National Climatic Data Center (NOAA NCDC).

6. National Academies of Sciences, Engineering, and Medicine, 2016. Attribution of Extreme Weather Events in the Context of Climate Change. National Academies Press. Accessed March 30, 2017. https://www.ncdc.noaa.gov/billions/mapping.

7. Financial Stability Board. 2017. Recommendations of the Task Force on Climate-related Financial Disclosures. Accessed June 23, 2017. https://www.fsb-tcfd.org/publications/final-recommendations-report.

8. University of South Carolina. 2016. Spatial Hazard Events and Losses Database for the United States (SHELDUS). Hazards and Vulnerability Research Institute. Accessed December 14, 2016. http://hvri.geog.sc.edu/SHELDUS/.

9. New York State Division of Homeland Security and Emergency Services. 2014. NYS Standard Multi-Hazard Mitigation Plan (State Mitigation Plan). NYSDHSES.

10. Federal Emergency Management Agency. 2016. Data Visualization: Disaster Declarations for States and Counties. FEMA. Accessed December 14. 2016. https://www.fema.gov/data-visualization-disaster-declarations-states-and-counties.

11. Leichenko, R., D. Major, K. Johnson, L. Patrick, and M. O'Grady. 2011. An Economic Analysis of Climate Change Impacts and Adaptations in New York State. In Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaption. eds. C. Rosenzweig, W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, and P. Grabhorn. Albany, NY: New York State Energy Research and Development Authority (NYSERDA), 501-649.

12. Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the Environmental and Economic Costs Associated with Alien-invasive Species in the United States. *Ecological Economics*, 52(3), 273-288.

13. Su, N. Y. 2002. Novel Technologies for Subterranean Termite Control. *Sociobiology*, 40(1), 95-102.

14. U.S. Forest Service. 2006. Subterranean Termites—Their Prevention and Control in Buildings. Accessed June 23, 2017. https://www.fs.usda.gov/treesearch/pubs/26674.

15. Quinn, A., J. D. Tamerius, M. Perzanowski, J. S. Jacobson, I. Goldstein, L. Acosta, and J. Shaman. 2014. Predicting Indoor Heat Exposure Risk during Extreme Heat Events. *Science of the Total Environment*, 490, 686-693.

16. Knowlton, K., B. Lynn, R. A. Goldberg, C. Rosenzweig, C. Hogrefe, J. K. Rosenthal, and P. L. Kinney. 2007. Projecting Heat-related Mortality Impacts under a Changing Climate in the New York City Region. *American Journal of Public Health*, 97(11), 2028-2034.

17. United States Environmental Protection Agency. 2000. Guidelines for Preparing Economic Analyses. EPA 240-R-00-003. Washington, DC, US Environmental Protection Agency.

18. Lin, S., W. H. Hsu, A. R. Van Zutphen, S. Saha, G. Luber, and S. A. Hwang. 2012. Excessive Heat and Respiratory Hospitalizations in New York State: Estimating Current and Future Public Health Burden Related to Climate Change. *Environmental Health Perspectives*, 120(11), 1571.

19. Climate Central. 2014. Sea Level Rise and Coastal Flood Risk: Summary for New York, NY. Accessed June 23, 2017. http://ssrf.climatecentral.org.s3-website-us-east-1.amazonaws.com/Buffer2/states/NY/downloads/pdf_reports/Town/NY_New_York-report.pdf.

20. Council, M. M., 2005. Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities. Washington, DC: National Institute of Building Sciences, 68.

Appendix A: Data Sources and Tools

AMERICAN COMMUNITY SURVEY

The American Community Survey (ACS) is an ongoing survey (administered by the U.S. Census Bureau) that provides vital information on a yearly basis about our nation and its people. Information from the survey generates data that help determine how more than $400 billion in federal and State funds are distributed each year. ACS data were used to estimate regional population figures. Data are available at https://www.census.gov/programs-surveys/acs/.

HAZUS-MH

Data from FEMA's loss and risk management software Hazus-MH were used to quantify the building types and the total replacement value of the building stock in New York State. More information on the FEMA Hazus-MH risk management software is available at https://www.fema.gov/Hazus.

IMPLAN

IMPLAN is an industry-standard input-output software package that models economic systems and can be used to determine the effects of direct spending inputs. IMPLAN is used in this analysis to model the interactions between all goods producers and service providers within the economies of each ClimAID Region in New York State. More information is available at http://Implan.com.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

Information accessible from FEMA's online Presidential Disaster Declaration data visualizer was used to quantify losses due to hurricanes in each region. More information is available at https://www.fema.gov/data-feeds.

NEW YORK STATE DEPARTMENT OF LABOR

New York State Department of Labor's Quarterly Census of Employment and Wages reports data on annual employment, number of firms, and wages for every industry in New York State. Industries are defined by the North American Industry Classification System (NAICS). For the purposes of this report, the numbers of construction firms and employees present in each region to work on building mitigation or recovery are estimated using NAICS industry codes 236 (Construction of Buildings) and 238 (Specialty Trade Contractors). More information is available at https://labor.ny.gov/stats/LSQCEW.shtm.

SHELDUS

The University of South Carolina's Spatial Hazard Events and Losses Database for the United States (SHELDUS) data for New York State are used to identify the location, cost, and frequency of climate hazard events. More information is available at http://hvri.geog.sc.edu/SHELDUS/.

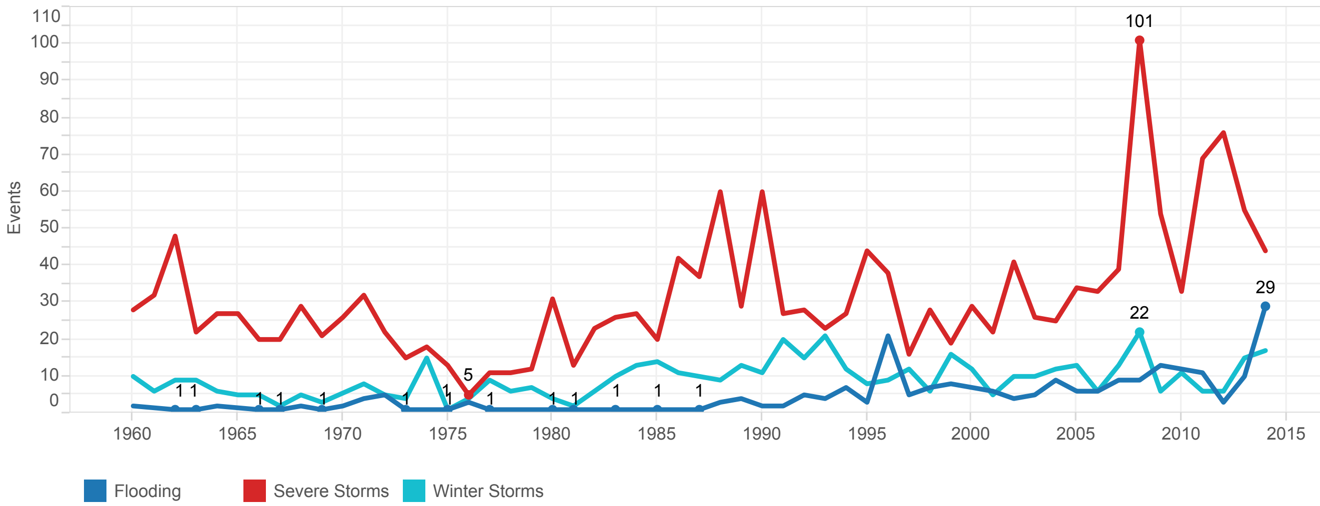
U.S. GEOLOGICAL SURVEY

USGS land cover raster data files from the Landsat satellite were used to determine the extent of growth in developed lands in each region. The USGS acquires, processes, archives, and distributes Landsat and other satellite and airborne remotely sensed data products to scientists, policy makers, and educators worldwide. These data are acquired by both civilian satellites and aircraft and are used to study a wide range of natural hazards, global environmental change, economic development, and conservation issues: https://landcover.usgs.gov/landcoverdata.php.

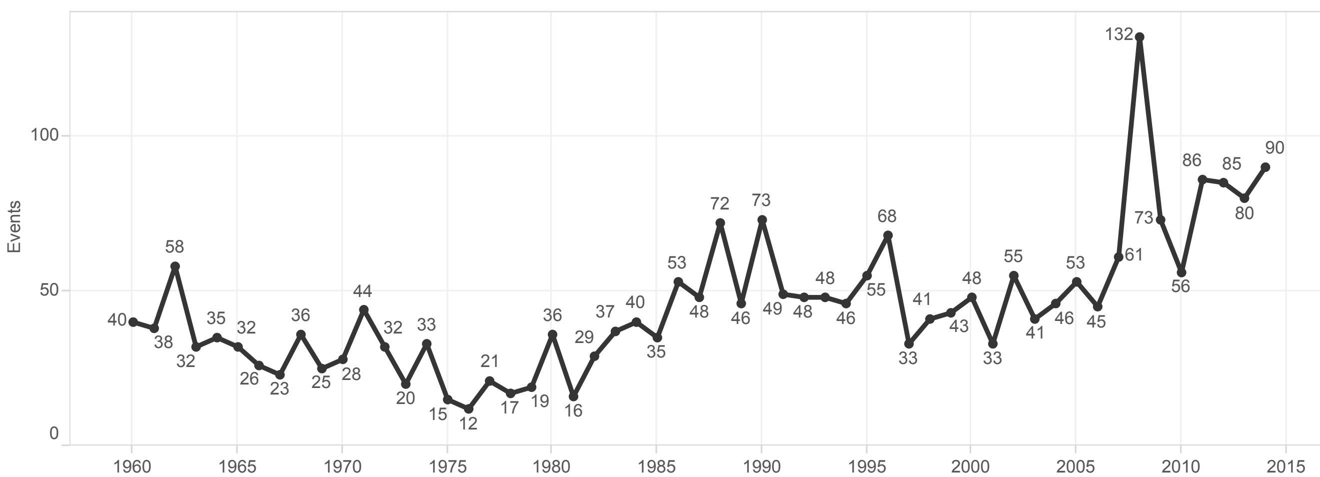
Appendix B: Annual Hazard Events and Property Damage (1960–2014)

REGION 1: WESTERN NEW YORK/GREAT LAKES PLAIN

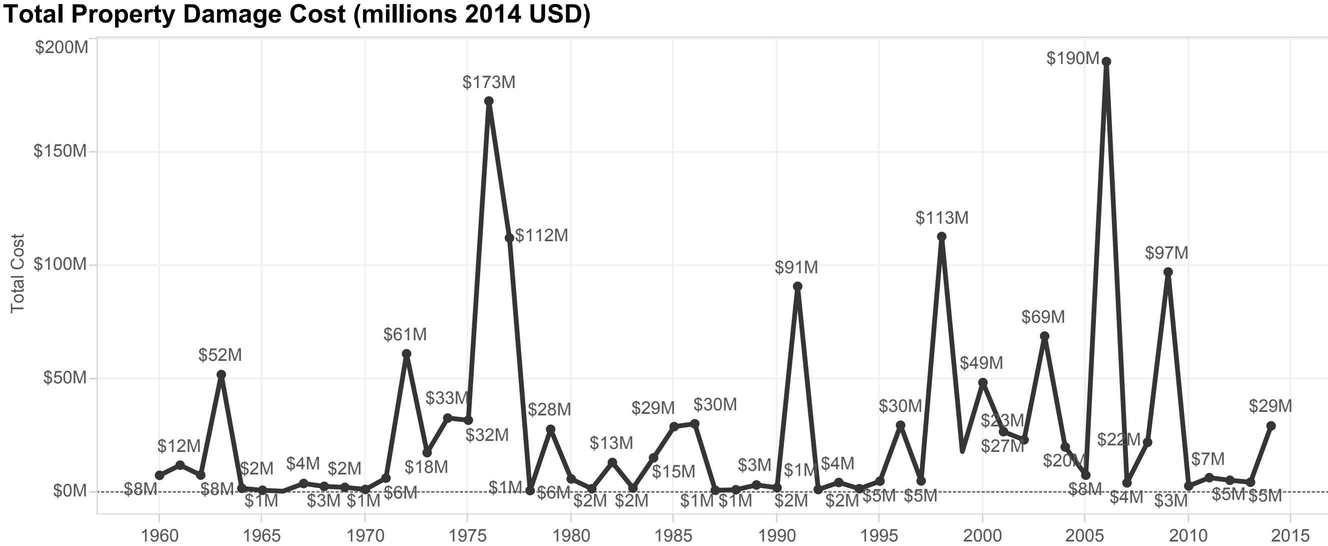
Annual Events by Hazard Type



Total Annual Events

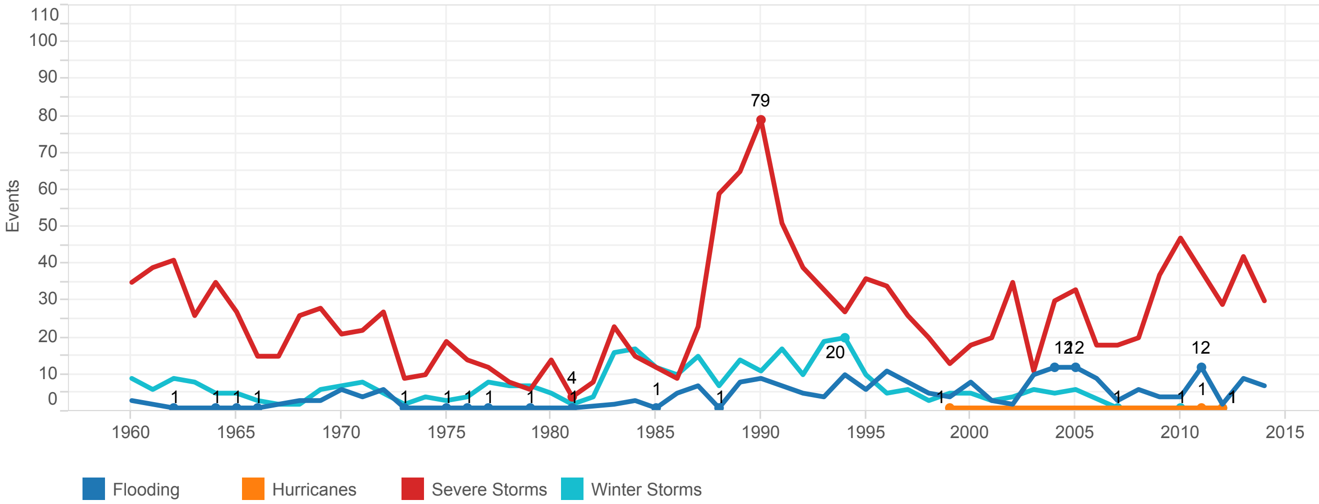


Total Property Damage Cost (millions 2014 USD)

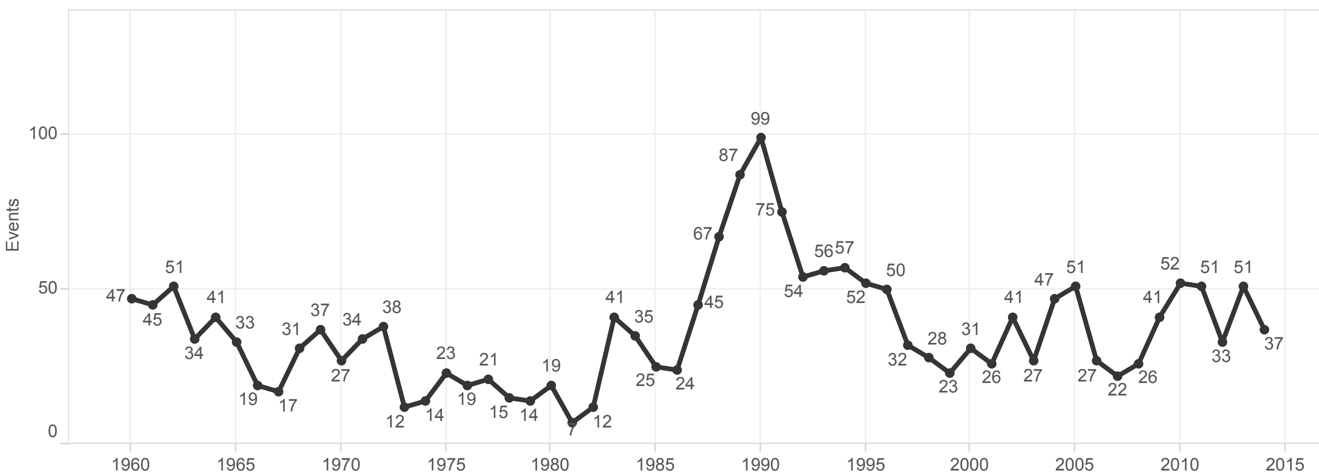


REGION 2: CATSKILL MOUNTAINS AND WEST HUDSON RIVER VALLEY

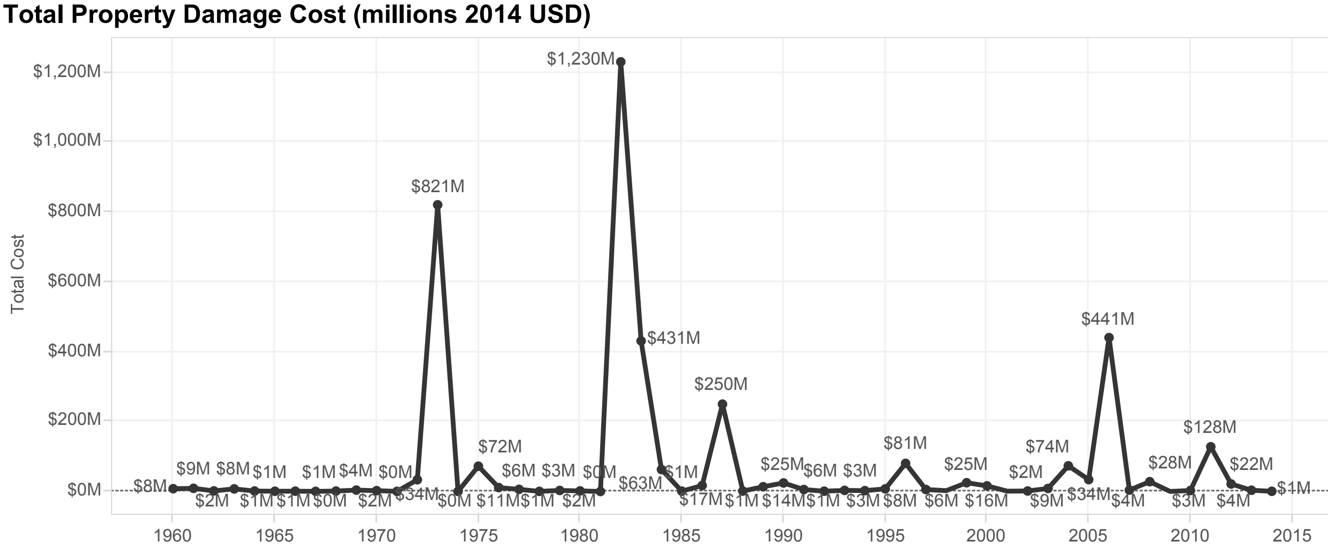
Annual Events by Hazard Type



Total Annual Events

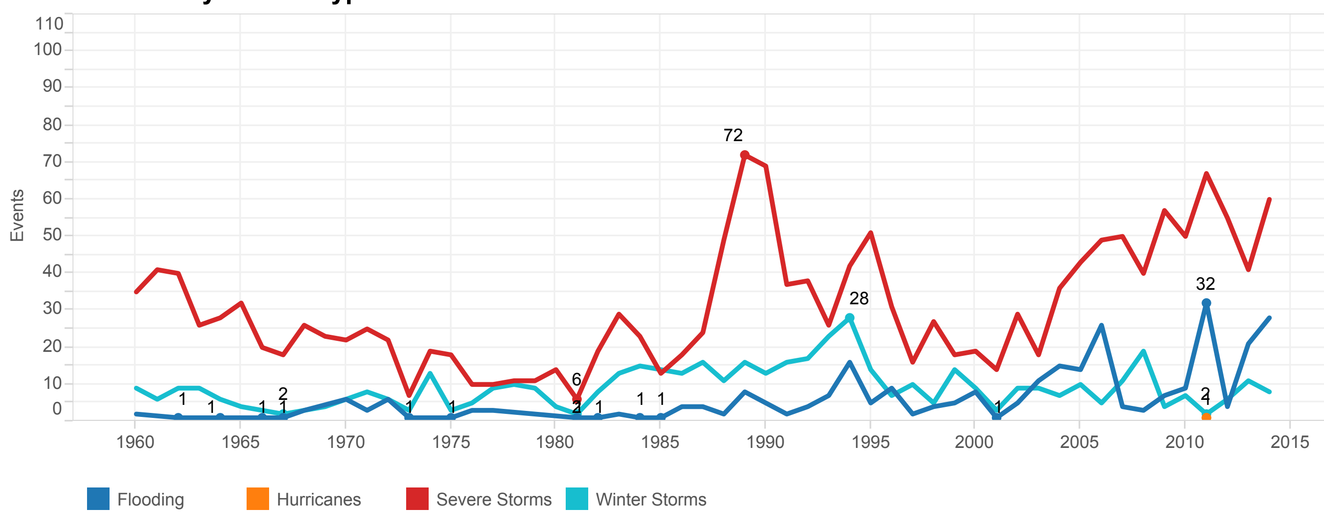


Total Property Damage Cost (millions 2014 USD)

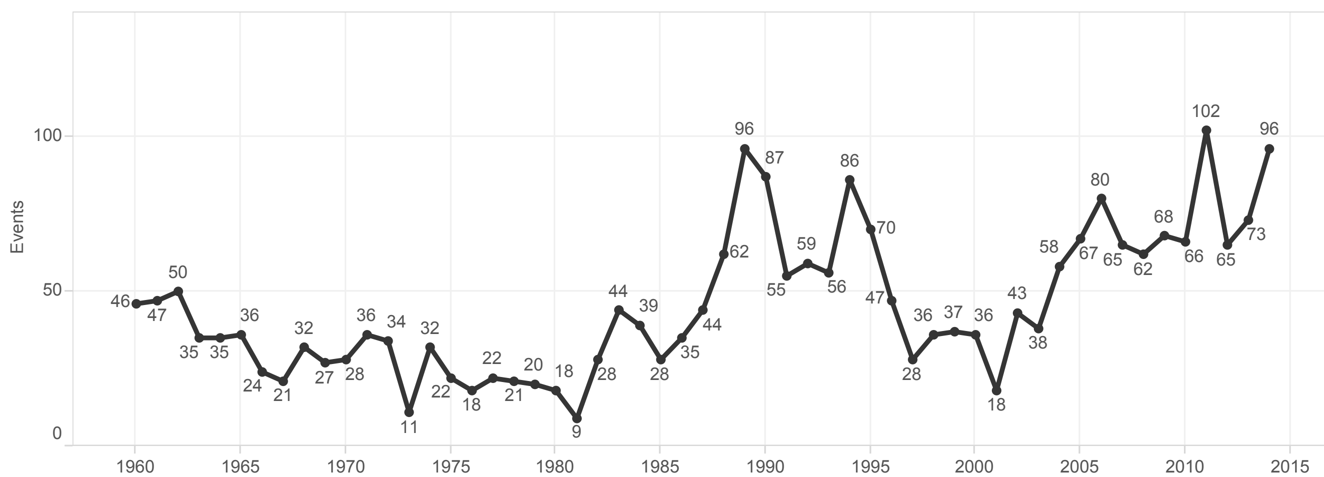


REGION 3: SOUTHERN TIER

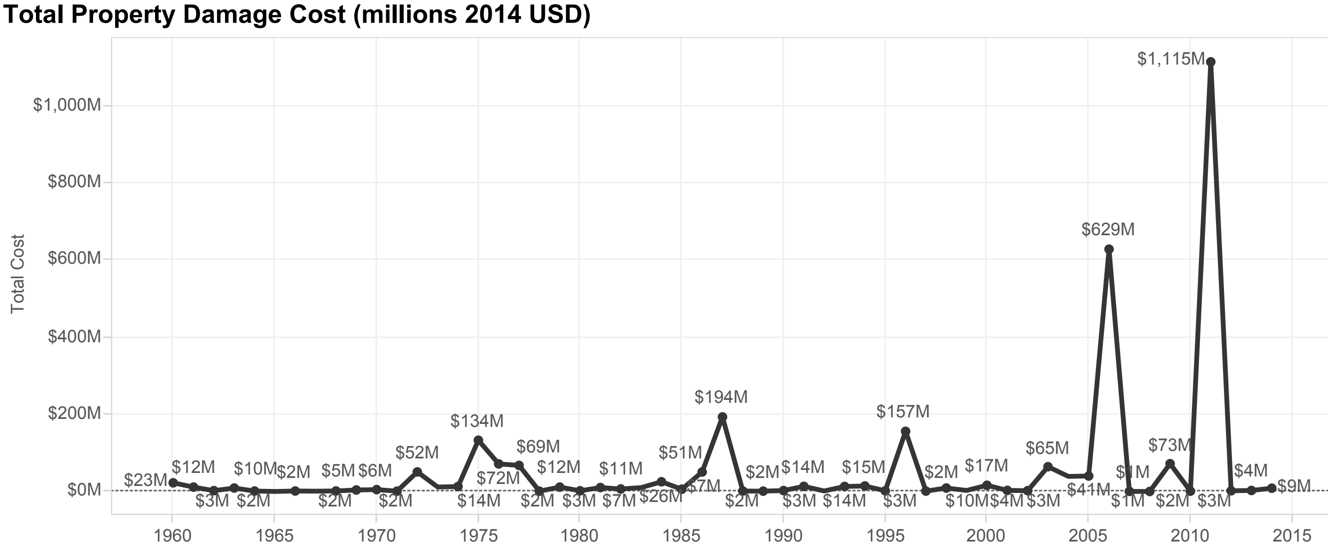
Annual Events by Hazard Type



Total Annual Events

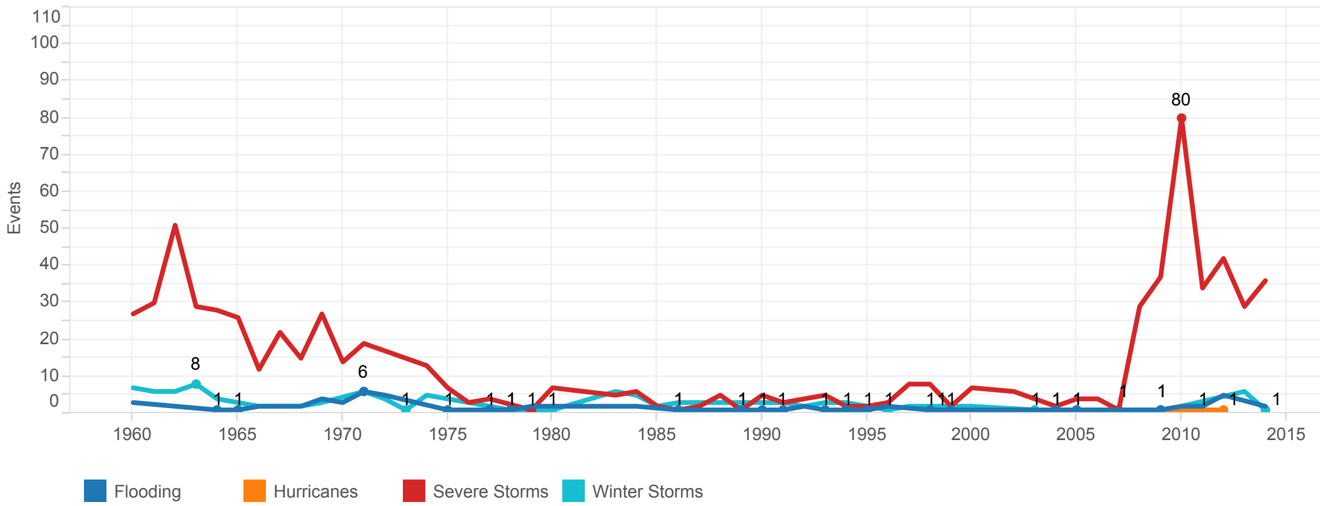


Total Property Damage Cost (millions 2014 USD)

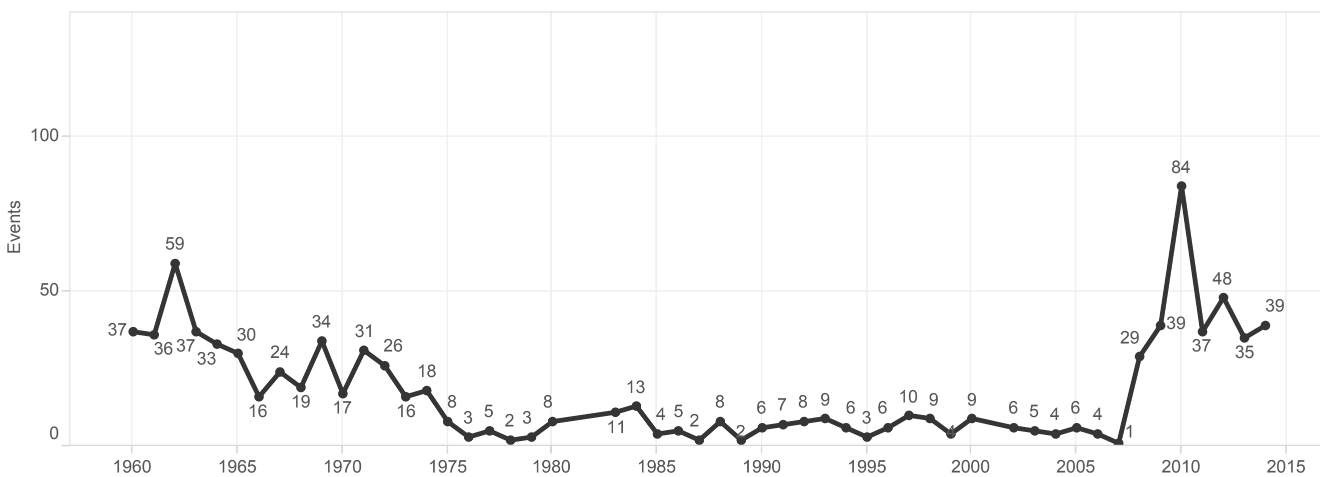


REGION 4: NEW YORK CITY AND LONG ISLAND

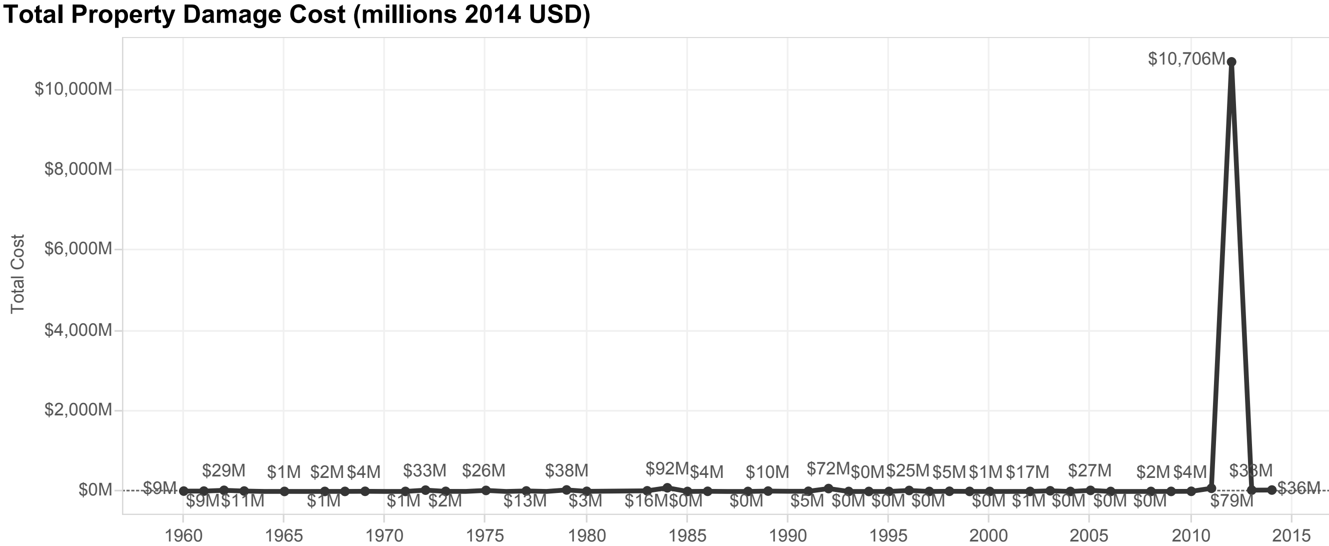
Annual Events by Hazard Type



Total Annual Events

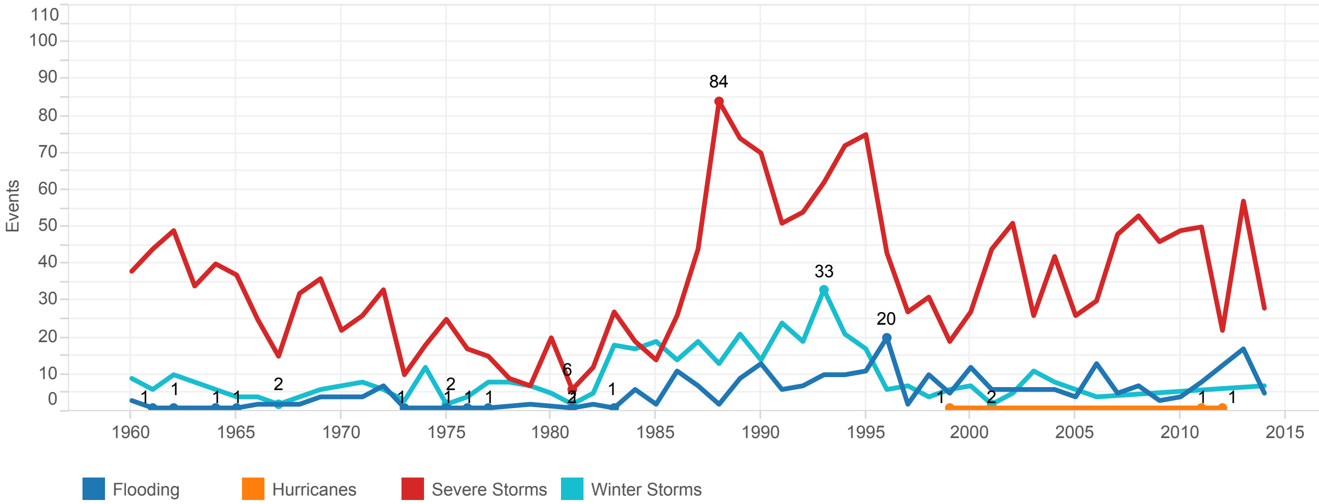


Total Property Damage Cost (millions 2014 USD)

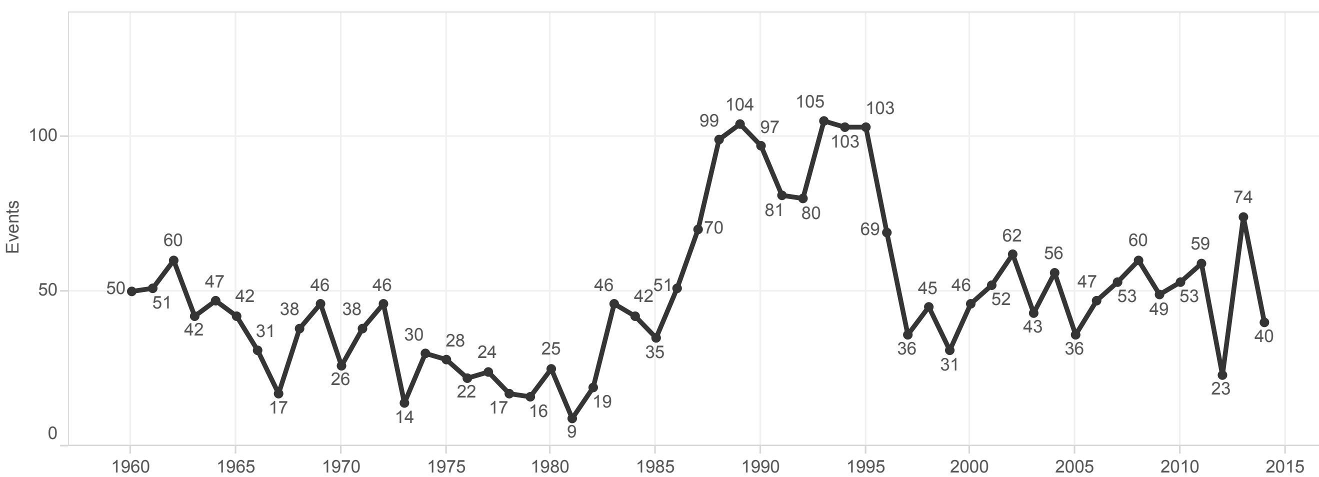


REGION 5: EAST HUDSON AND MOHAWK RIVER VALLEYS

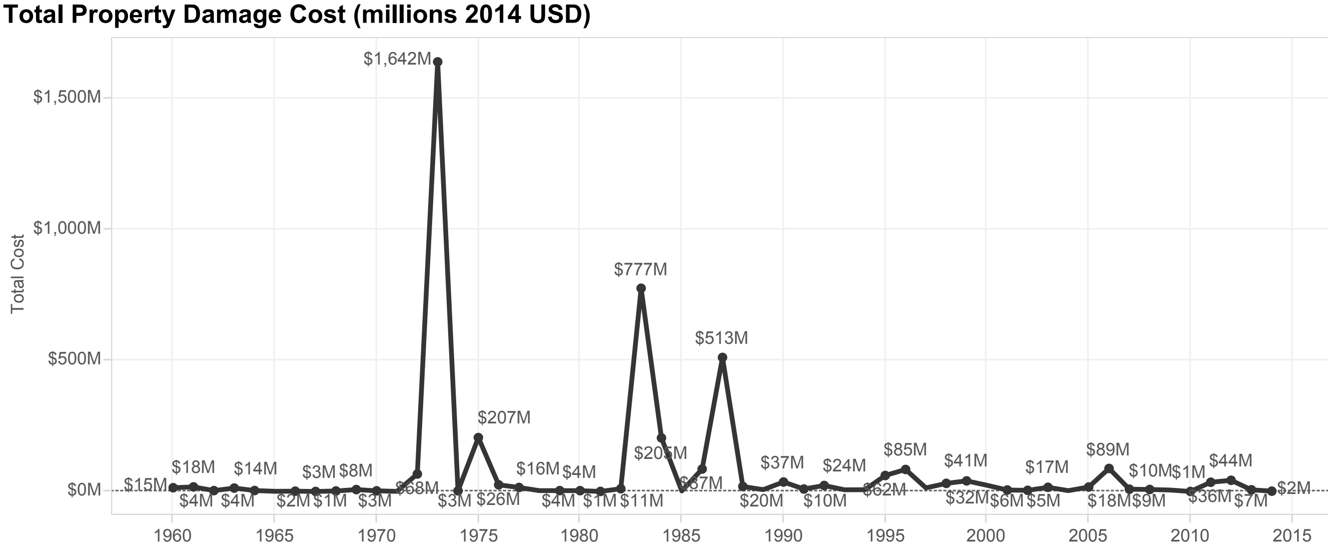
Annual Events by Hazard Type



Total Annual Events

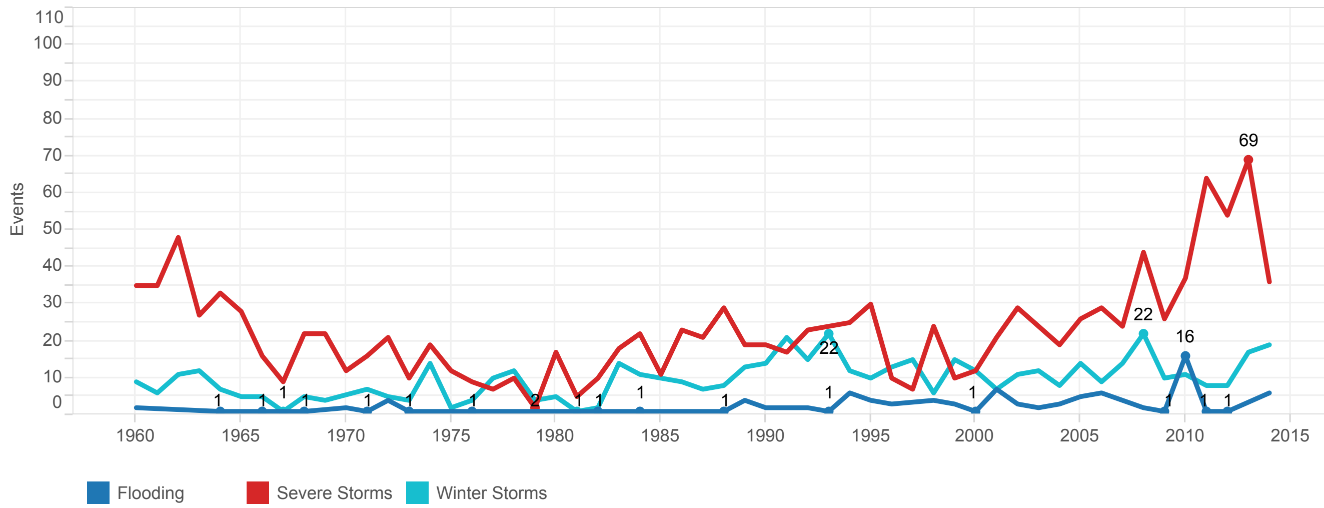


Total Property Damage Cost (millions 2014 USD)

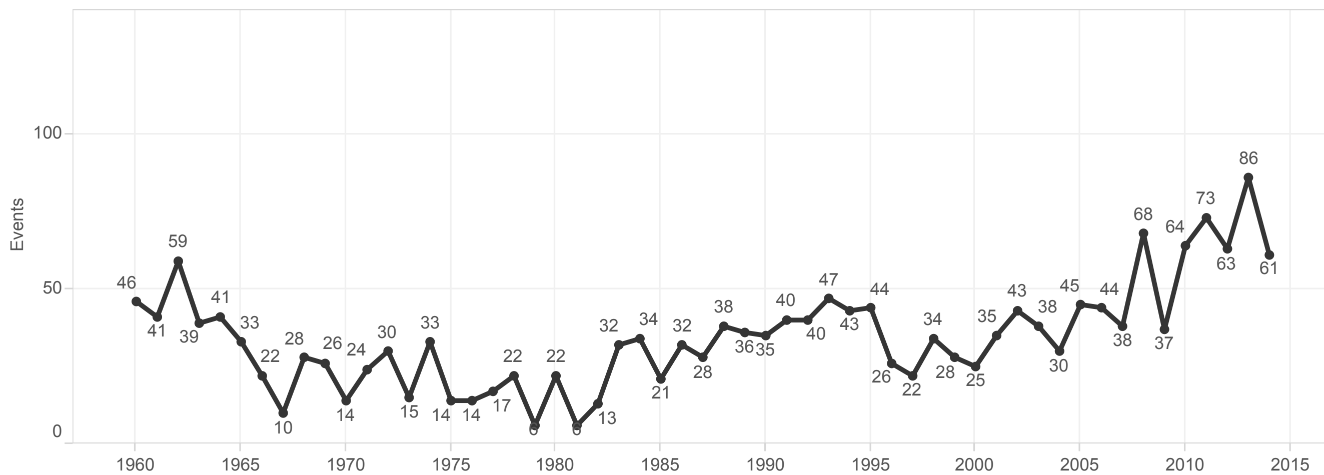


REGION 6: TUG HILL PLATEAU

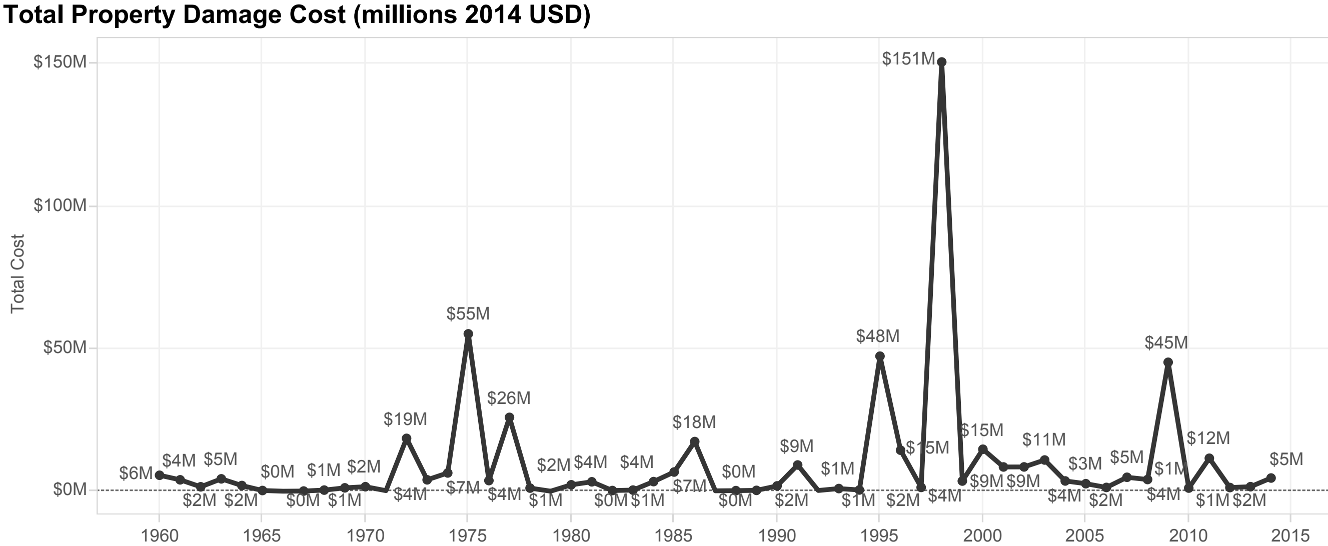
Annual Events by Hazard Type



Total Annual Events

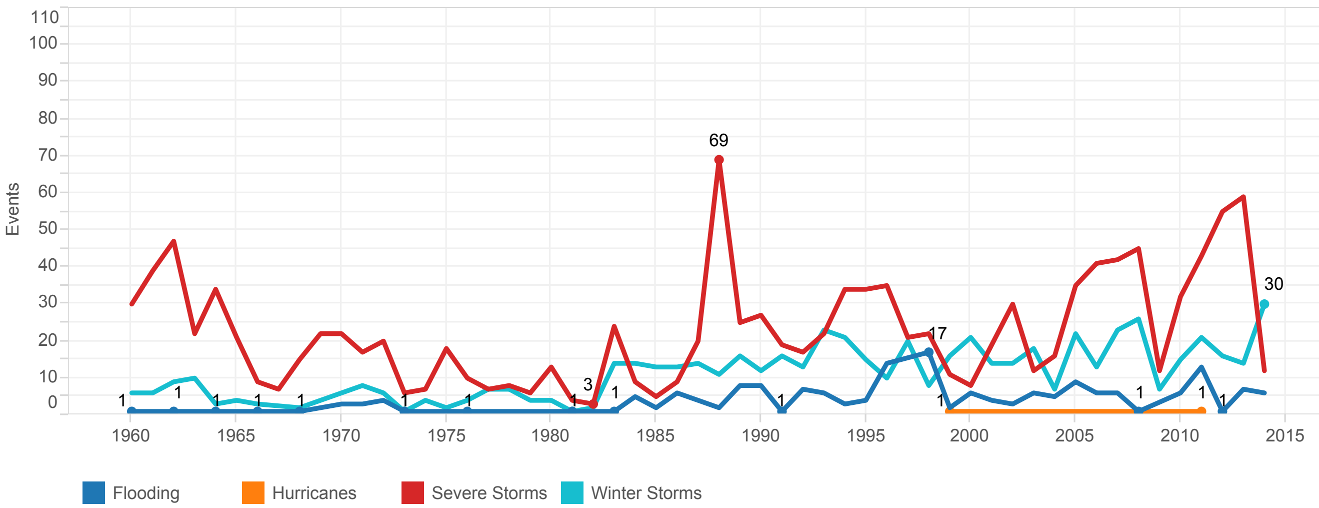


Total Property Damage Cost (millions 2014 USD)

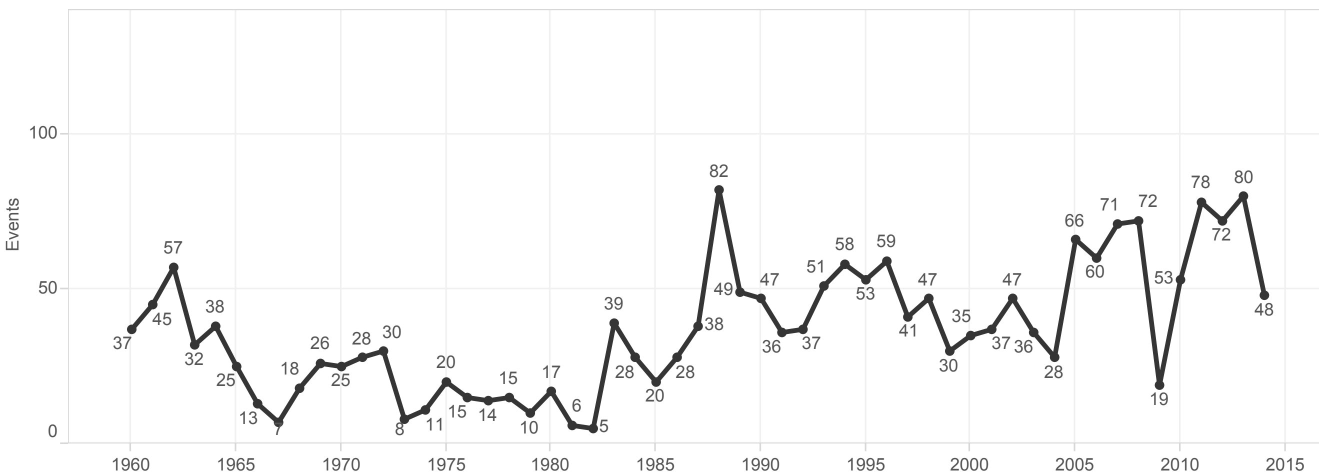


REGION 7: ADIRONDACK MOUNTAINS

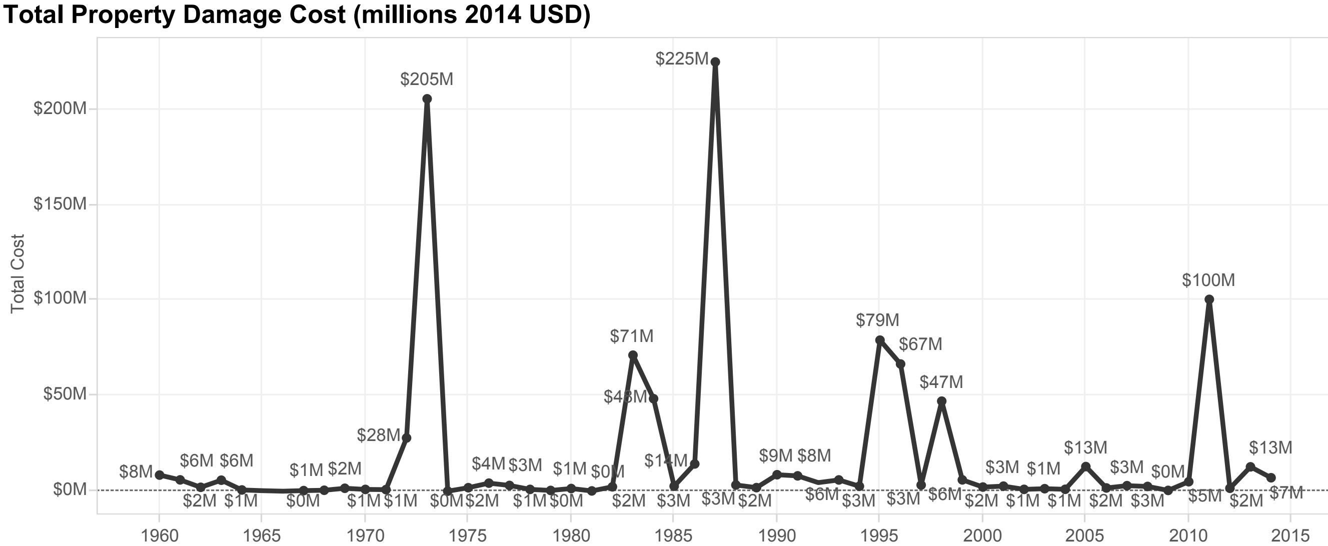
Annual Events by Hazard Type



Total Annual Events



Total Property Damage Cost (millions 2014 USD)



Appendix C: Economically Significant Climate Hazards by Region

The tables provide an assessment of the relative impacts that climate hazards have had on each ClimAID region. This assessment uses measures of cost per event and deviation from expected costs to allow comparison across all regions and identify economically significant climate hazards. Average cost per event is calculated by dividing the total cost associated with each hazard by the number of hazard events. Deviation is calculated as the difference between actual and expected total costs for each hazard. Expected costs are calculated by reallocating total costs—for all hazards—based on the distribution of the number of events. For example, the total cost from all hazards in Region 1 was $1.49 billion, and winter storm events accounted for 20.3% of all events. Therefore, the expected costs are $303 million ($1.49 billion x 20.3%). The actual cost of winter storm events was $777 million, $474 million greater than the expected value.

REGION 1: Western New York/Great Lakes Plain

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	20.3%	$303 million	$777 million	$474 million
Severe Storms	69.9%	$1 billion	$505 million	-$538 million
Flooding	9.8%	$146 million	$210 million	$64 million

REGION 2: Catskill Mountains and West Hudson River Valley

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	17.0%	$664.9 million	$470.06 million	-$194.84 million
Hurricanes	0.1%	$5.82 million	$130.71 million	$124.89 million
Severe Storms	71.7%	$2.81 billion	$1.67 billion	-$1.14 billion
Flooding	11.2%	$438.09 million	$1.65 billion	$1.21 billion

REGION 3: Southern Tier

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	20.0%	$596.73 million	$411.2 million	-$185.53 million
Hurricanes	0.0%	$1.19 million	$1.43 million	$233.97 thousand
Severe Storms	67.8%	$2.02 billion	$347.74 million	-$1.67 billion
Flooding	12.1%	$361.62 million	$2.22 billion	$1.86 billion

REGION 4: New York City and Long Island

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	11.8%	$1.34 billion	$74.9 million	-$1.27 billion
Hurricanes	0.3%	$36.89 million	$10.77 billion	$10.74 billion
Severe Storms	81.0%	$9.17 billion	$202.44 million	-$8.97 billion
Flooding	6.8%	$774.67 million	$275.18 million	-$499.49 million

REGION 5: East Hudson and Mohawk River Valleys

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	16.8%	$717.35 million	$966.46 million	$249.11 million
Hurricanes	0.1%	$4.77 million	$82.05 million	$77.28 million
Severe Storms	73.0%	$3.12 billion	$1.01 billion	-$2.11 billion
Flooding	10.2%	$434.23 million	$2.22 billion	$1.78 billion

REGION 6:Tug Hill Plateau

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	27.9%	$149.61 million	$134.03 million	-$15.58 million
Severe Storms	66.7%	$357.43 million	$355.91 million	-$1.53 million
Flooding	5.4%	$28.68 million	$45.79 million	$17.11 million

REGION 7: Adirondack Mountains

Climate Hazard	Distribution of Events	Expected Costs Based on Distribution of Events	Actual Cost	Difference (Actual-Expected)
Winter Storms	29.7%	$305.69 million	$316.12 million	$10.42 million
Hurricanes	0.1%	$1.01 million	$9.12 million	$8.11 million
Severe Storms	61.1%	$630.02 million	$209.07 million	-$420.96 million
Flooding	9.1%	$94.18 million	$496.59 million	$402.42 million

Appendix D: New York State Building Stock Profile

INTRODUCTION

Approximately 14 billion square feet of building stock, valued at more than $2.3 trillion, will be impacted by climate change in New York State. The impact, however, will not be the same in all regions. According to the Federal Emergency Management Agency (FEMA), each region of New York State has a unique composition of building types (residential, commercial, industrial, etc.) and construction types (wood, steel, concrete, etc.), which could lead to an uneven distribution of damage if an extreme hazard event were to occur.

For example, older, wooden, single-family, residential buildings were more susceptible to damage from high winds and flooding than steel or concrete structures during Superstorm Sandy.[1] This appendix provides an overview of the building stock in New York State in order to identify areas, such as those with high concentrations of a particular building type, that may benefit most from the implementation of climate resilience policies or strategies.

The FEMA Hazus-MH 2.2 loss-estimation software provides data used to describe the building stock in New York State. Data that describe the conditions of the building stock are provided for each census tract within the State and are used to identify differences among each of the seven ClimAID Regions. More information on the FEMA Hazus 2.2 risk management software is available at https://www.fema.gov/hazus.

DATA DEFINITIONS

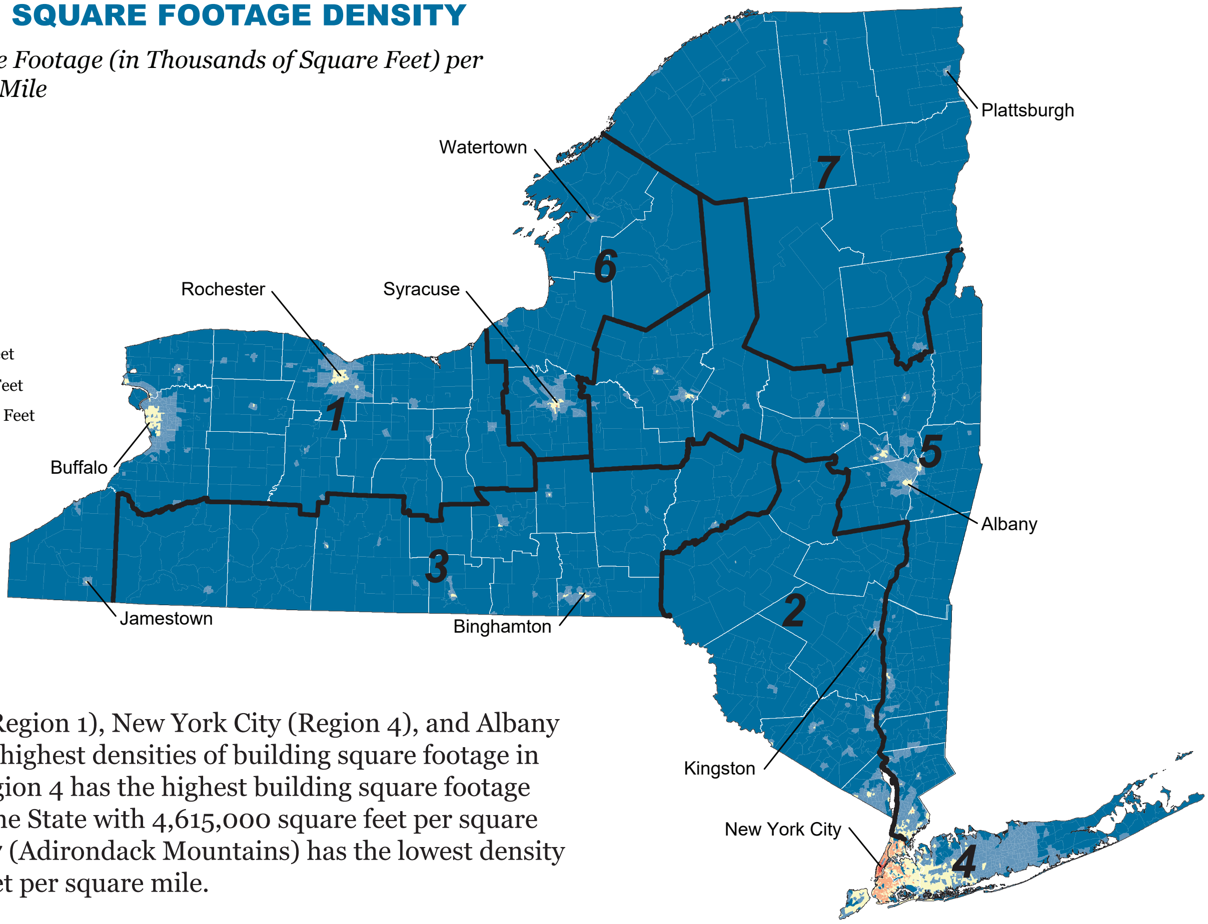
Building Type	Hazus Name	Description
Single-Family Residential	RES1	Single-Family Dwellings
	RES2	Manufactured Homes
Multi-Family Residential	RES3 A	Duplex - 1 to 2 units
	RES3 B	Duplex - 3 to 4 units
	RES3 C	Duplex - 5 to 9 units
	RES3 D	Duplex - 10 to 19 units
	RES3 E	Duplex - 20 to 49 units
	RES3 F	Duplex - more than 50 units
Other Residential	RES4	Temporary Lodging
	RES5	Institutional Dormatories
	RES6	Nursing Homes
Commercial	COM1	Retail Trade
	COM2	Wholesale Trade
	COM3	Personal and Repair Services
	COM4	Professional and Tech. Services
	COM5	Banks
	COM8	Entertainment and Recreation
Commercial (Cont'd)	COM9	Theaters
	COM10	Parking Garages
Medical	COM6	Hospitals
	COM7	Medical Offices and Clinics
Industrial	IND1	Heavy Industrial
	IND2	Light Industrial
	IND3	Food/Drugs/Chemicals
	IND4	Metal/Minerals Processing
	IND5	High Technology
	IND6	Construction Facilities and Offices
Agricultural	AGR1	Agriculture Facilities and Offices
Religious	REL1	Churches and Non-Profit Organizations
Government	GOV1	Government - General Services
	GOV2	Government - Emergency Response
Education	EDU1	Grade Schools and Admin. Offices
	EDU2	Colleges and Universities

NYS BUILDING SQUARE FOOTAGE DENSITY

Total Building Square Footage (in Thousands of Square Feet) per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 900 Square Feet
- 901 - 4,600 Square Feet
- 4,601 - 19,500 Square Feet
- 19,501 - 79,800 Square Feet
- 79,801 - 322,300 Square Feet



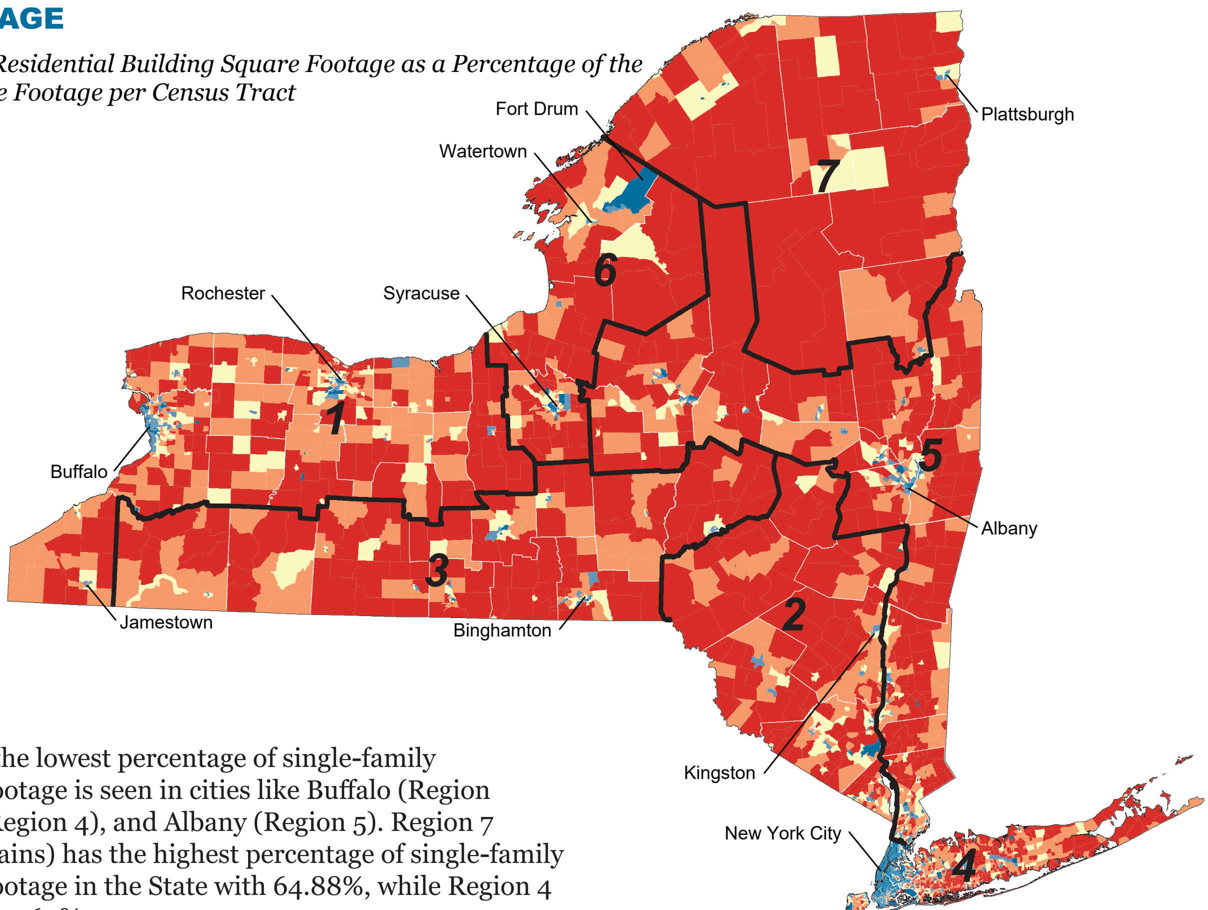
Cities like Buffalo (Region 1), New York City (Region 4), and Albany (Region 5) have the highest densities of building square footage in New York State. Region 4 has the highest building square footage per square mile in the State with 4,615,000 square feet per square mile, while Region 7 (Adirondack Mountains) has the lowest density at 28,580 square feet per square mile.

NYS SINGLE-FAMILY RESIDENTIAL BUILDING SQUARE FOOTAGE

Total Single-Family Residential Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 14.4 Percent
- 14.5 - 34 Percent
- 34.1 - 54 Percent
- 54.1 - 72 Percent
- 72.1 - 100 Percent



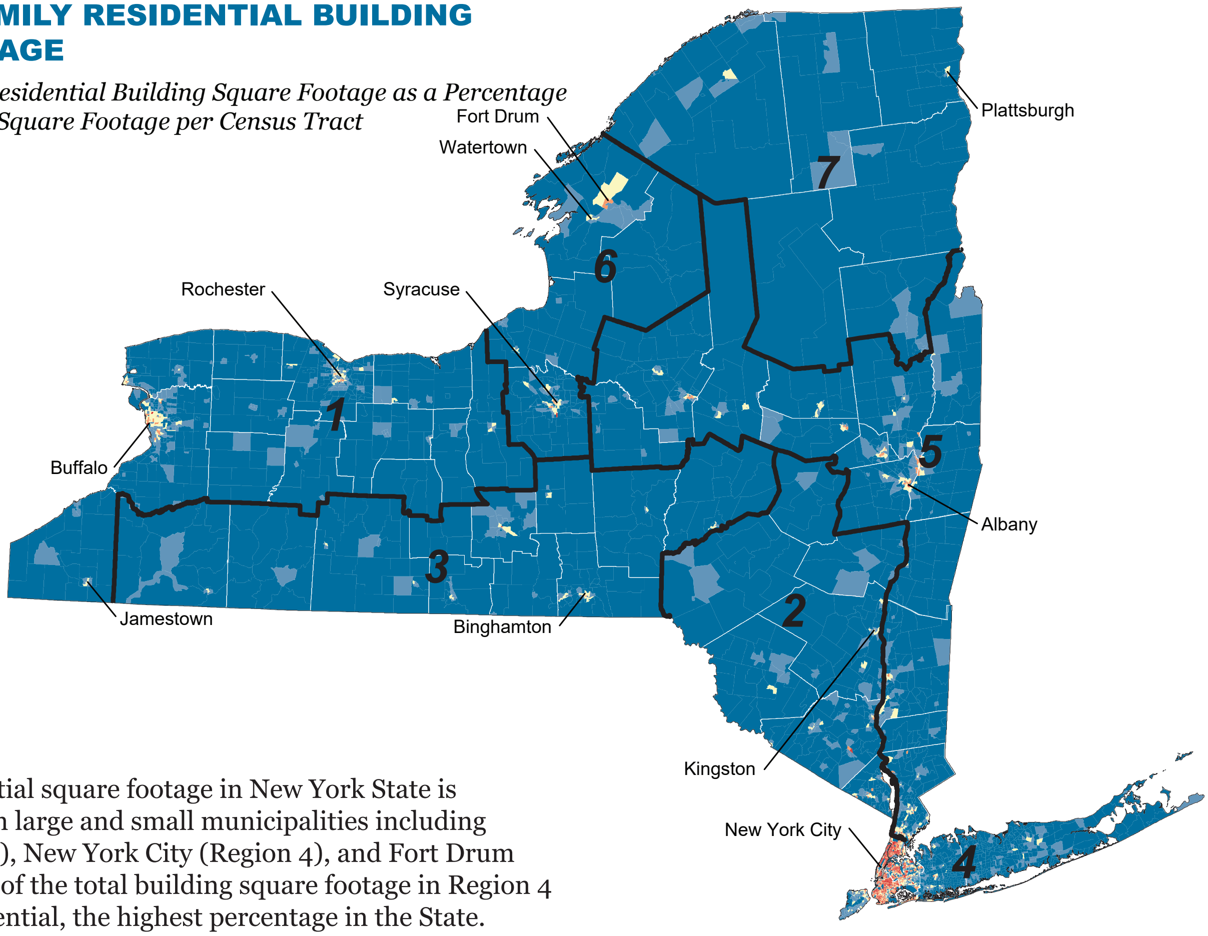
In New York State, the lowest percentage of single-family residential square footage is seen in cities like Buffalo (Region 1), New York City (Region 4), and Albany (Region 5). Region 7 (Adirondack Mountains) has the highest percentage of single-family residential square footage in the State with 64.88%, while Region 4 has the lowest with 31.62%.

NYS MULTI-FAMILY RESIDENTIAL BUILDING SQUARE FOOTAGE

Total Multi-Family Residential Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 13 Percent
- 13.1 - 30 Percent
- 30.1 - 50 Percent
- 50.1 - 70 Percent
- 70.1 - 100 Percent



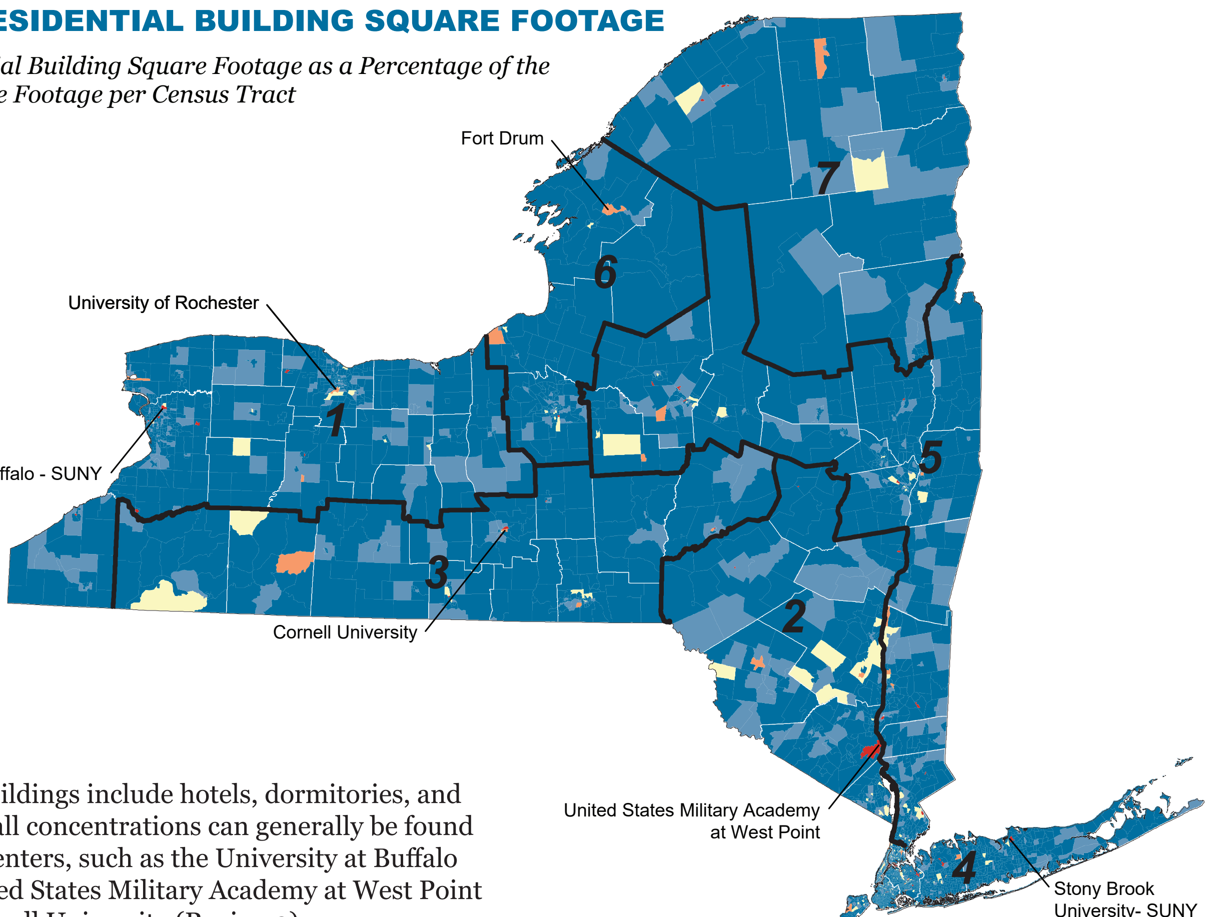
Multifamily residential square footage in New York State is concentrated in both large and small municipalities including Rochester (Region 1), New York City (Region 4), and Fort Drum (Region 6). 40.04% of the total building square footage in Region 4 is multifamily residential, the highest percentage in the State.

NYS OTHER RESIDENTIAL BUILDING SQUARE FOOTAGE

Total Other Residential Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 3 Percent
- 3.1 - 10 Percent
- 10.1 - 25 Percent
- 25.1 - 55 Percent
- 55.1 - 100 Percent



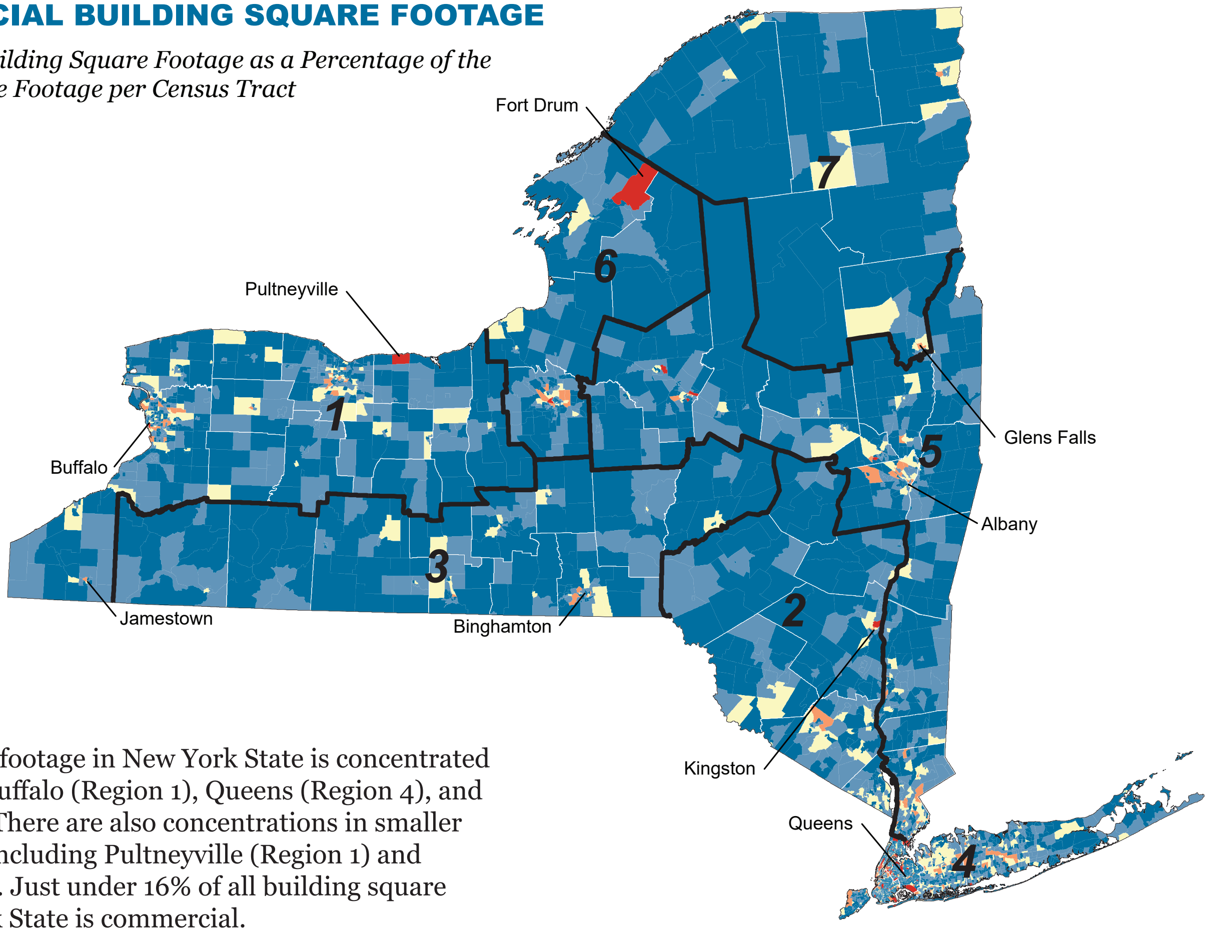
Other residential buildings include hotels, dormitories, and nursing homes. Small concentrations can generally be found around university centers, such as the University at Buffalo (Region 1), the United States Military Academy at West Point (Region 2), and Cornell University (Region 3).

NYS COMMERCIAL BUILDING SQUARE FOOTAGE

Total Commercial Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 10 Percent
- 10.1 - 18 Percent
- 18.1 - 32 Percent
- 32.1 - 57 Percent
- 57.1 - 100 Percent



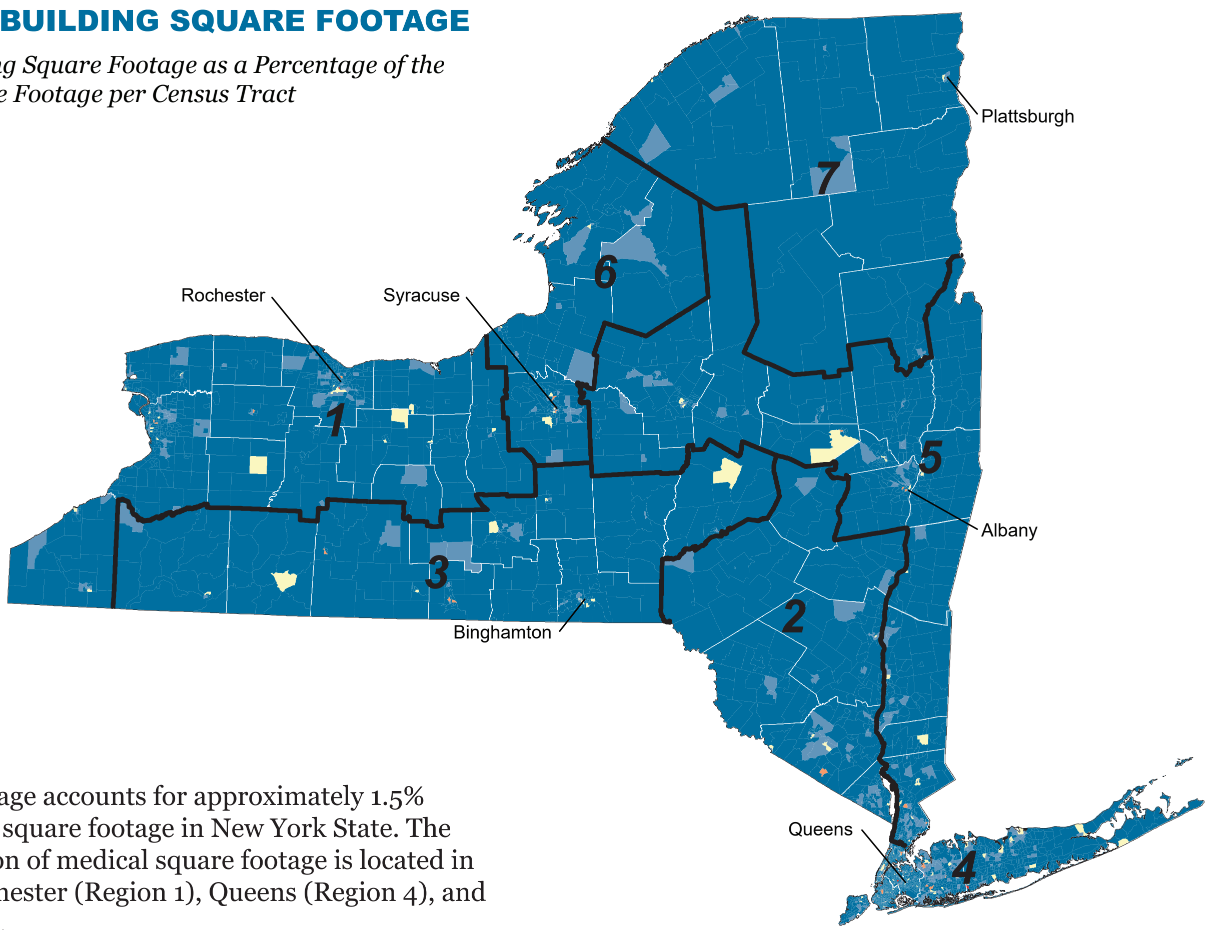
Commercial square footage in New York State is concentrated in cities including Buffalo (Region 1), Queens (Region 4), and Albany (Region 5). There are also concentrations in smaller towns and villages including Pultneyville (Region 1) and Antwerp (Region 6). Just under 16% of all building square footage in New York State is commercial.

NYS MEDICAL BUILDING SQUARE FOOTAGE

Total Medical Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 1.5 Percent
- 1.6 - 5.7 Percent
- 5.8 - 14 Percent
- 14.1 - 29 Percent
- 29.1 - 72 Percent



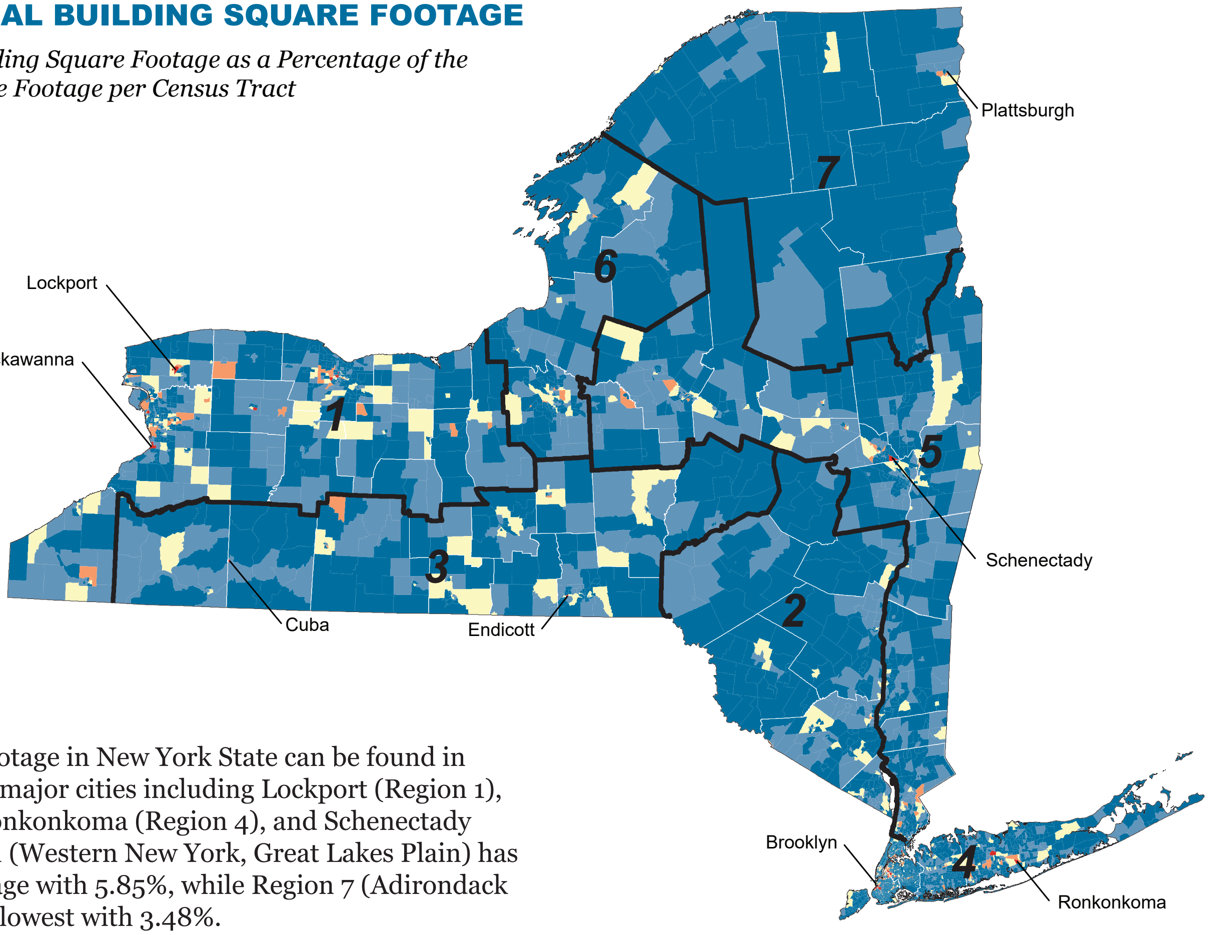
Medical square footage accounts for approximately 1.5% of the total building square footage in New York State. The highest concentration of medical square footage is located in cities including Rochester (Region 1), Queens (Region 4), and Syracuse (Region 6).

NYS INDUSTRIAL BUILDING SQUARE FOOTAGE

Total Industrial Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 3.0 Percent
- 3.1 - 8 Percent
- 8.1 - 17 Percent
- 17.1 - 32 Percent
- 32.1 - 68 Percent



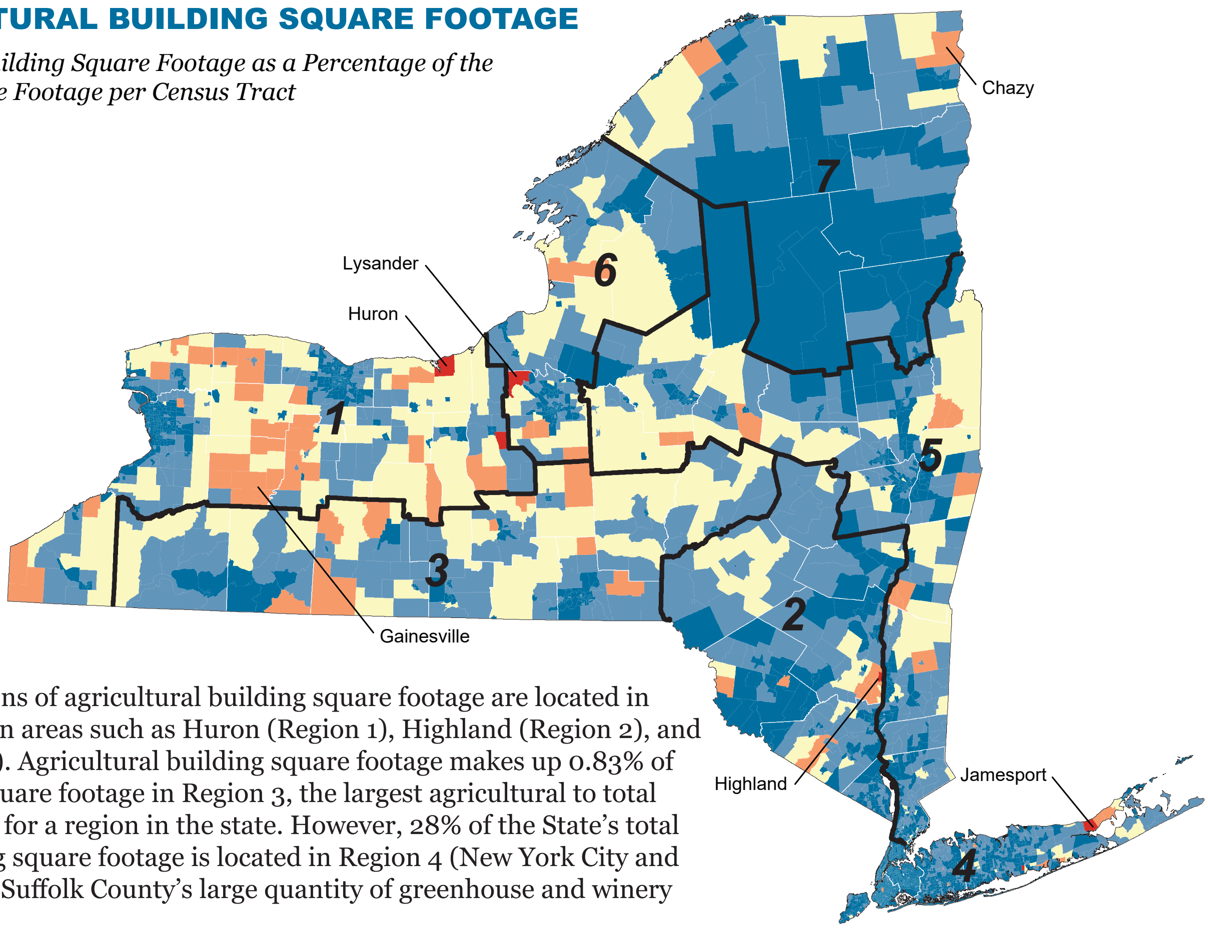
Industrial square footage in New York State can be found in areas outside of the major cities including Lockport (Region 1), Cuba (Region 3), Ronkonkoma (Region 4), and Schenectady (Region 5). Region 1 (Western New York, Great Lakes Plain) has the highest percentage with 5.85%, while Region 7 (Adirondack Mountains) has the lowest with 3.48%.

NYS AGRICULTURAL BUILDING SQUARE FOOTAGE

Total Agricultural Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 0.35 Percent
- 0.36 - 1 Percent
- 1.1 - 2.7 Percent
- 2.8 - 7.4 Percent
- 7.5 - 23 Percent



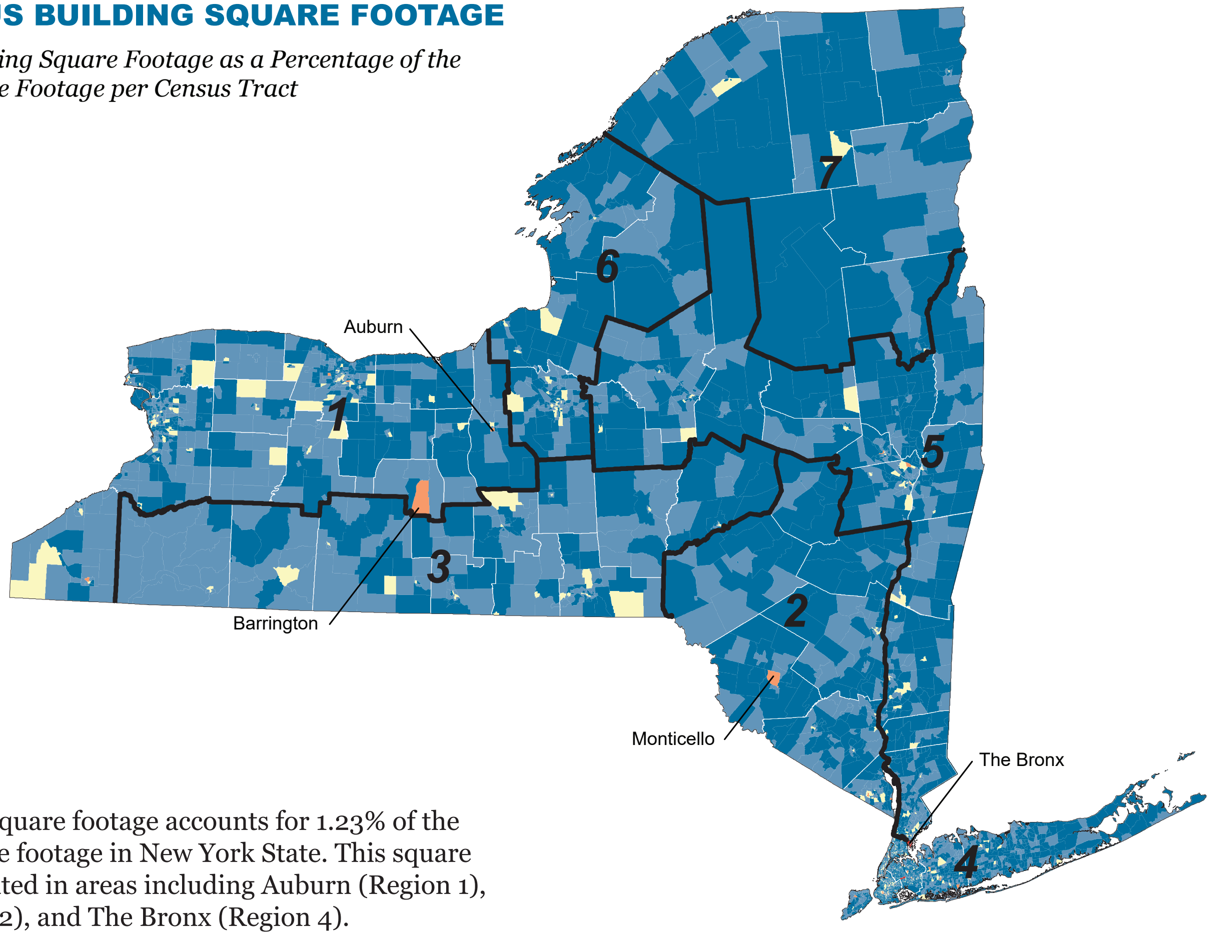
Higher concentrations of agricultural building square footage are located in Upstate New York, in areas such as Huron (Region 1), Highland (Region 2), and Lysander (Region 6). Agricultural building square footage makes up 0.83% of the total building square footage in Region 3, the largest agricultural to total building percentage for a region in the state. However, 28% of the State's total agricultural building square footage is located in Region 4 (New York City and Long Island) due to Suffolk County's large quantity of greenhouse and winery facilities.

NYS RELIGIOUS BUILDING SQUARE FOOTAGE

Total Religious Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 1 Percent
- 1.1 - 2.3 Percent
- 2.4 - 5.3 Percent
- 5.4 - 14.6 Percent
- 14.7 - 63 Percent



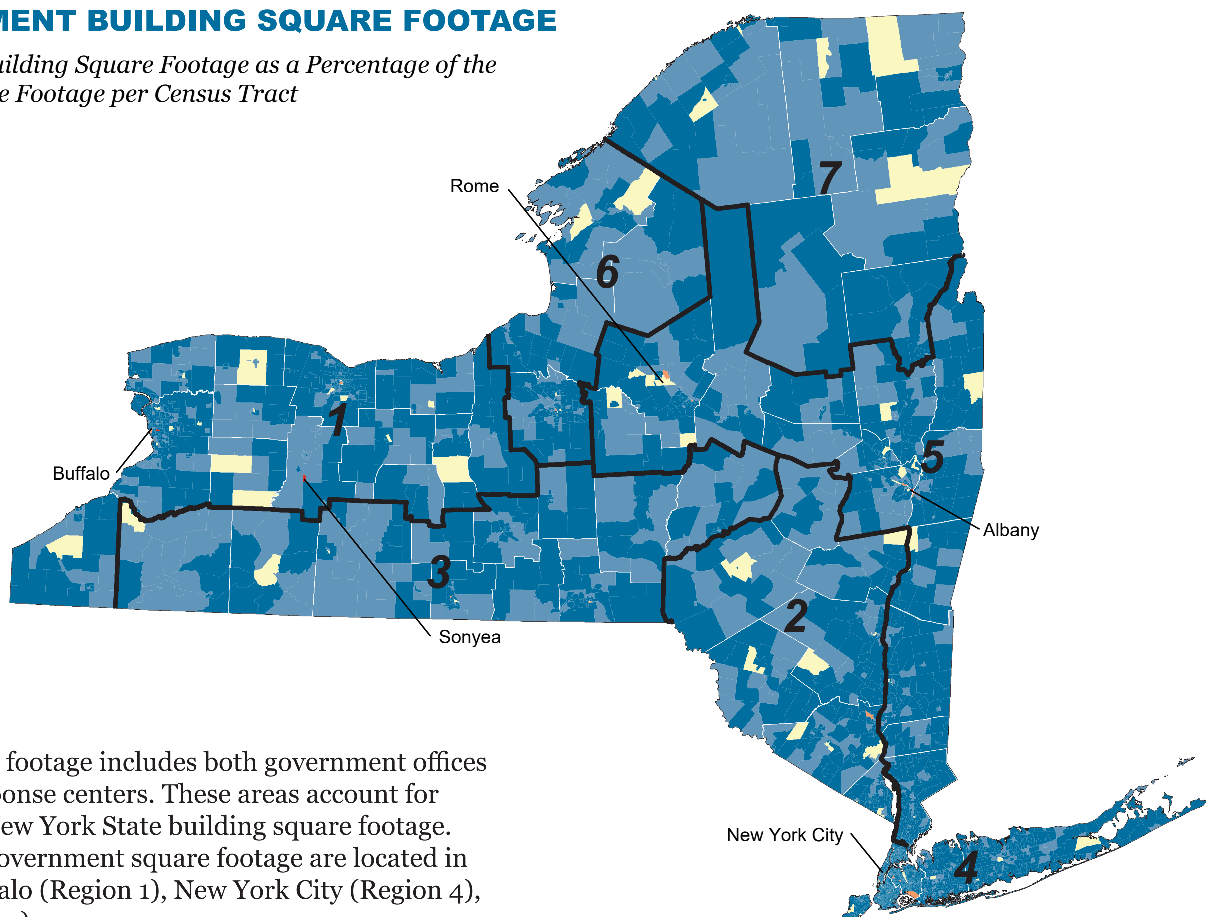
Religious building square footage accounts for 1.23% of the total building square footage in New York State. This square footage is concentrated in areas including Auburn (Region 1), Monticello (Region 2), and The Bronx (Region 4).

NYS GOVERNMENT BUILDING SQUARE FOOTAGE

Total Government Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

Legend:
- 0 - 0.8 Percent
- 0.9 - 3.3 Percent
- 3.4 - 1 Percent
- 1.1 - 25.5 Percent
- 25.6 - 60 Percent

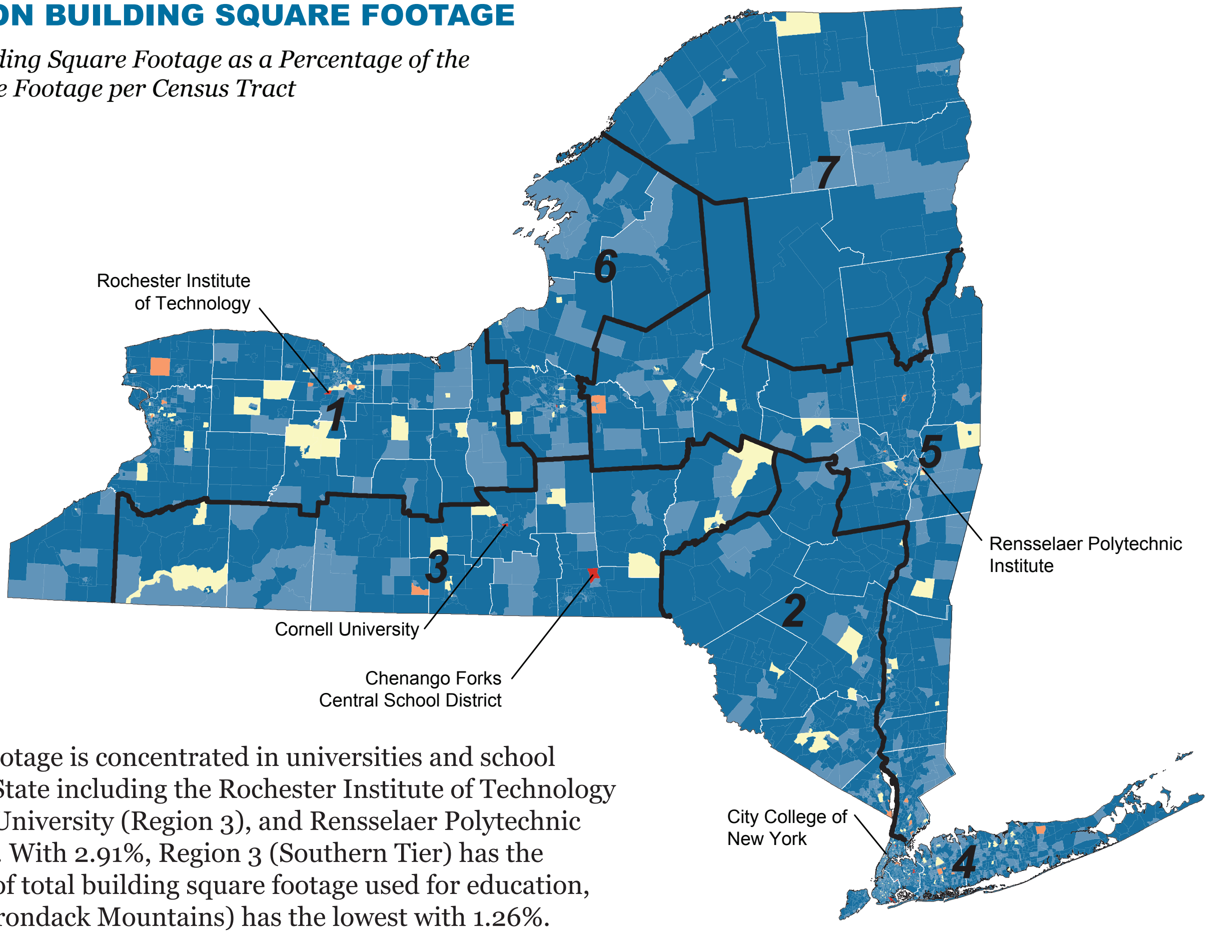


Government square footage includes both government offices and emergency response centers. These areas account for 0.72% of the total New York State building square footage. Concentrations of government square footage are located in large cities like Buffalo (Region 1), New York City (Region 4), and Albany (Region 5).

NYS EDUCATION BUILDING SQUARE FOOTAGE

Total Education Building Square Footage as a Percentage of the Total Building Square Footage per Census Tract

Data Source:
FEMA Hazus-MH Dataset

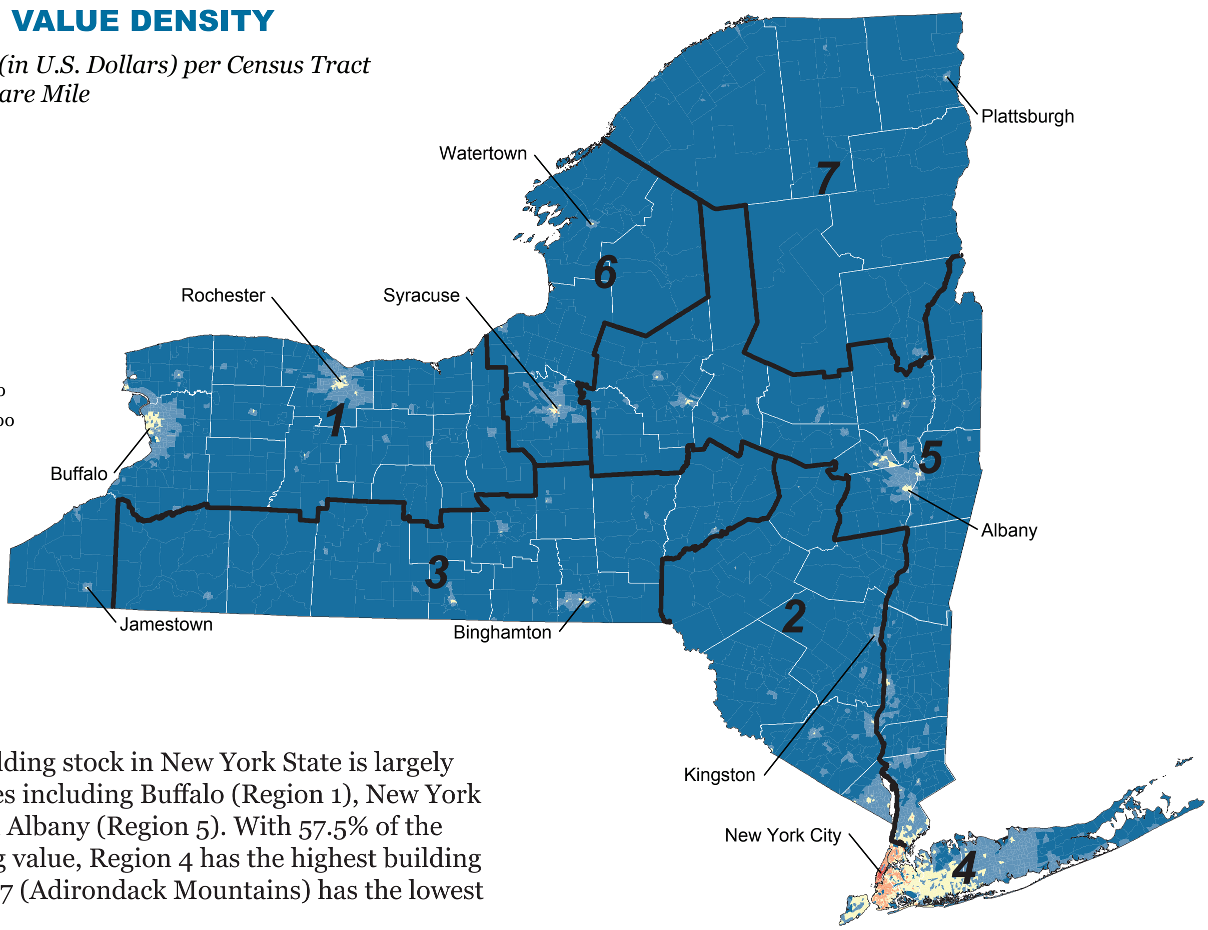


Education square footage is concentrated in universities and school districts across the State including the Rochester Institute of Technology (Region 1), Cornell University (Region 3), and Rensselaer Polytechnic Institute (Region 5). With 2.91%, Region 3 (Southern Tier) has the highest percentage of total building square footage used for education, while Region 7 (Adirondack Mountains) has the lowest with 1.26%.

NYS BUILDING VALUE DENSITY

Total Building Value (in U.S. Dollars) per Census Tract per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset



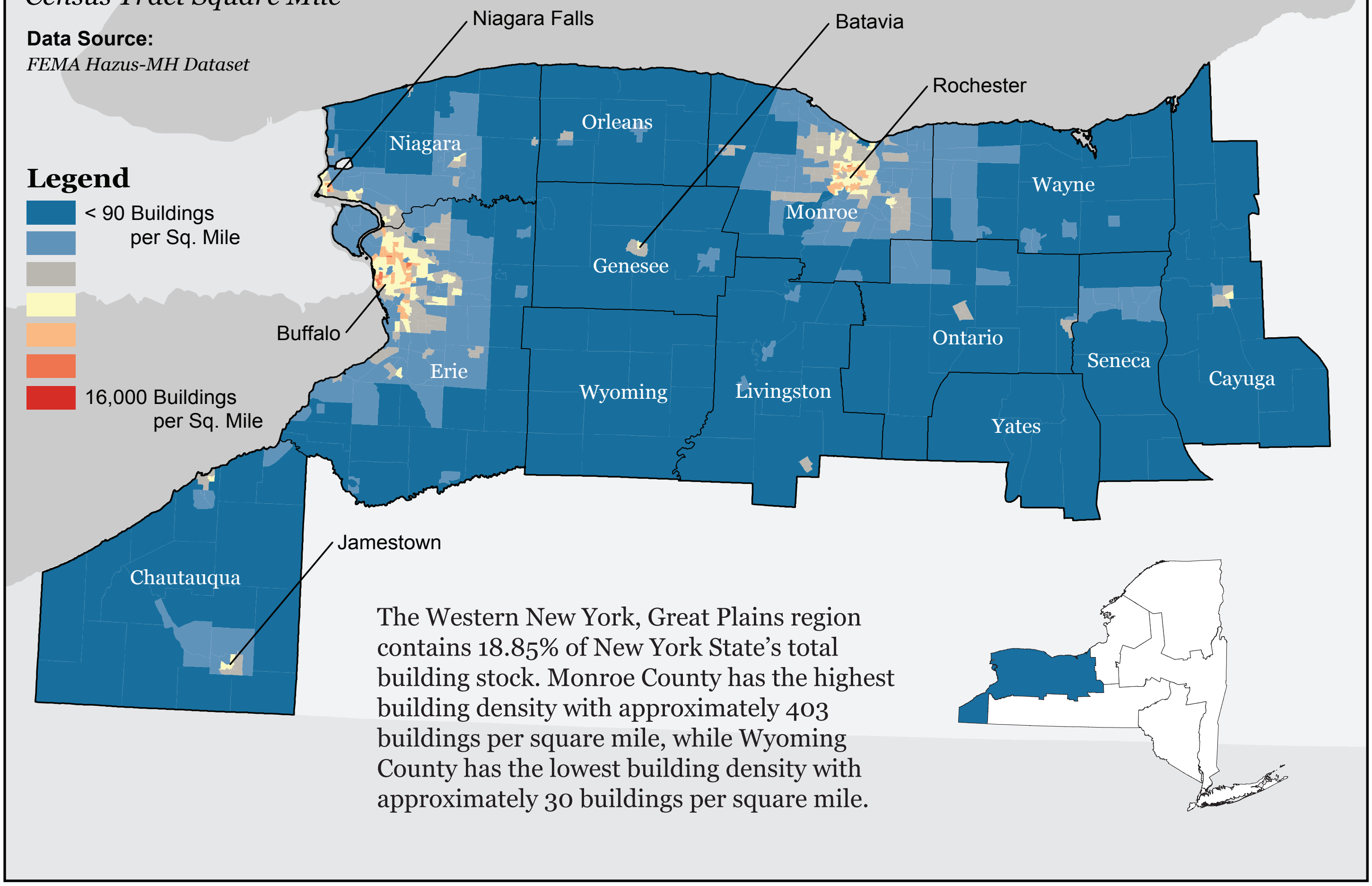
The value of the building stock in New York State is largely concentrated in cities including Buffalo (Region 1), New York City (Region 4), and Albany (Region 5). With 57.5% of the State's total building value, Region 4 has the highest building value, while Region 7 (Adirondack Mountains) has the lowest with 1.8%.

Region 1

BUILDING DENSITY

Total Number of Buildings per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset

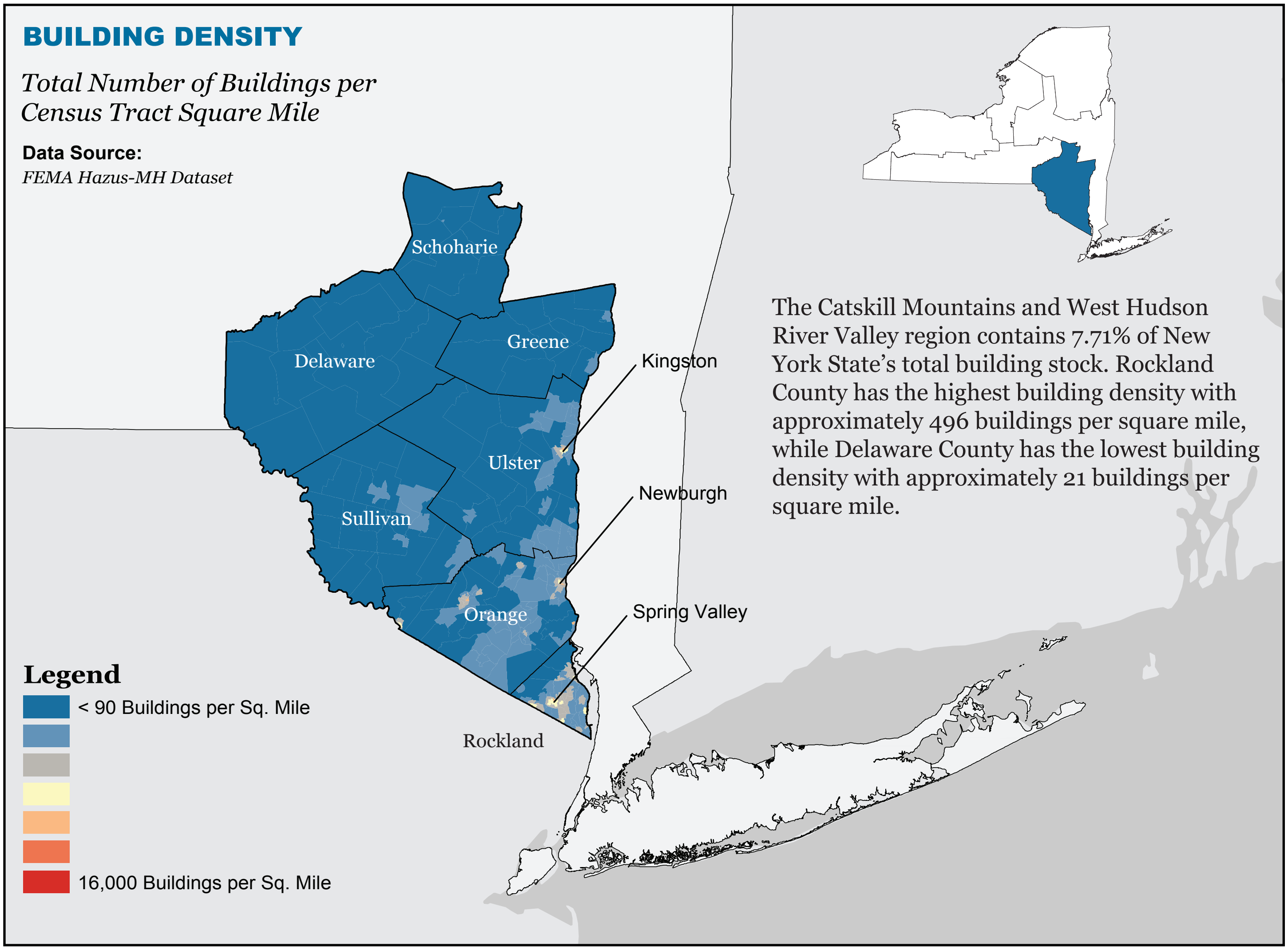


The Western New York, Great Plains region contains 18.85% of New York State's total building stock. Monroe County has the highest building density with approximately 403 buildings per square mile, while Wyoming County has the lowest building density with approximately 30 buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	808,383	81.24%	1,128,744	53.73%	923,595	10,866	-	152,122	42,161
Multi-Family Residential	97,739	9.82%	358,409	17.06%	222,214	14,336	10,752	111,107	-
Other Residential	4,041	0.41%	56,732	2.70%	8,938	19,090	10,852	17,852	-
Commercial	50,545	5.08%	311,666	14.83%	57,696	23,946	141,812	88,212	-
Medical	4,530	0.46%	25,202	1.20%	4,330	3,344	11,253	6,275	-
Industrial	15,814	1.59%	122,884	5.85%	9,389	15,864	71,507	26,124	-
Agricultural	4,559	0.46%	13,510	0.64%	6,485	270	4,458	2,297	-
Religious	5,141	0.52%	29,814	1.42%	10,732	1,789	3,280	14,013	-
Government	2,337	0.23%	17,882	0.85%	1,318	2,682	9,881	4,001	-
Education	1,942	0.20%	36,115	1.72%	3,745	5,178	15,740	11,452	-
Region 1 Total	**995,031**	**100.00%**	**2,100,958**	**100.00%**	**1,248,442**	**97,365**	**279,535**	**433,455**	**42,161**

* All square footage figures represent thousands of square feet.

Region 2

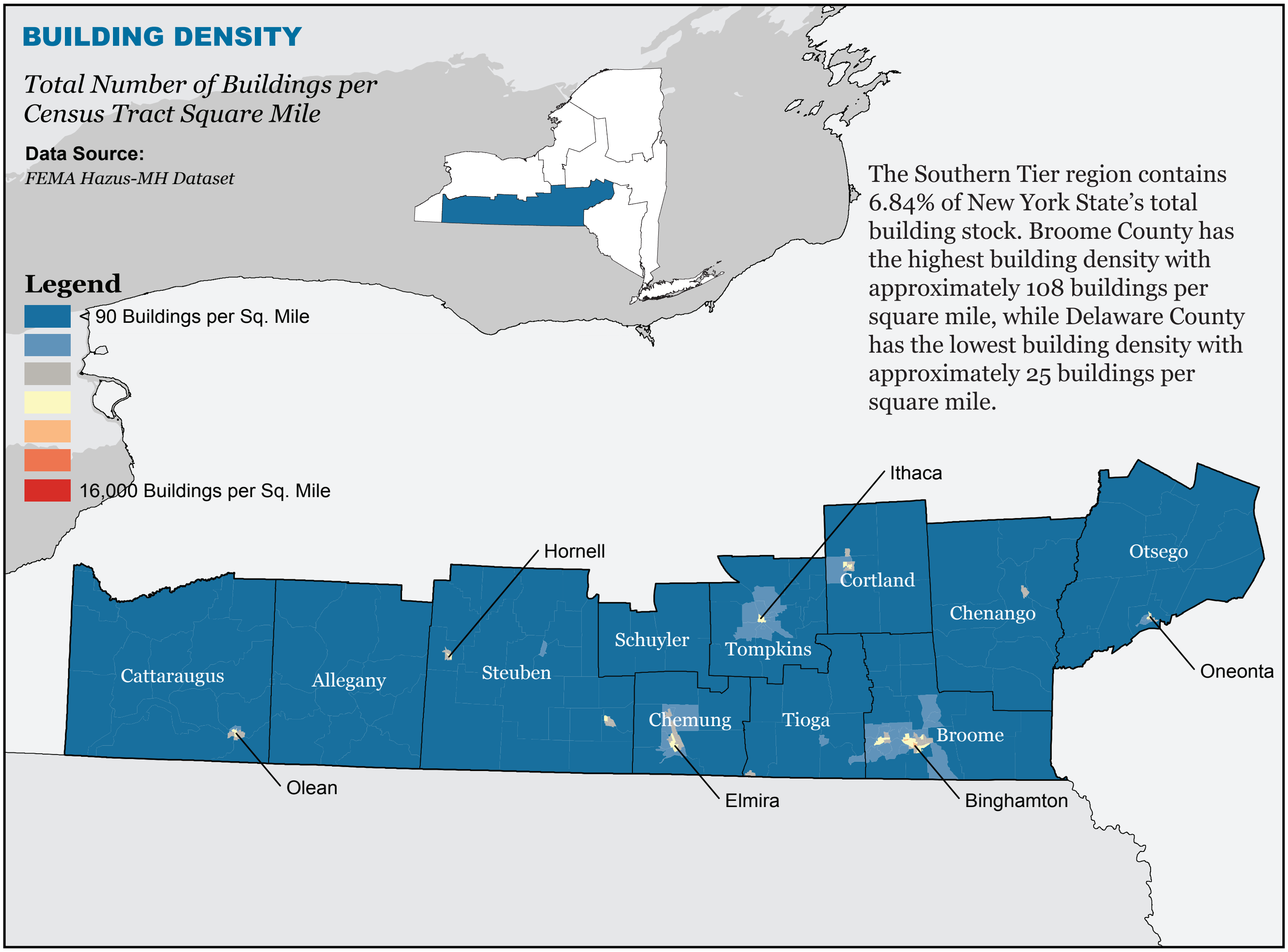


The Catskill Mountains and West Hudson River Valley region contains 7.71% of New York State's total building stock. Rockland County has the highest building density with approximately 496 buildings per square mile, while Delaware County has the lowest building density with approximately 21 buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	341,714	84.01%	502,166	60.00%	405,228	4,767	-	66,743	25,428
Multi-Family Residential	26,416	6.49%	111,464	13.32%	69,108	4,458	3,344	34,554	-
Other Residential	2,303	0.57%	32,497	3.88%	6,229	10,513	5,906	9,849	-
Commercial	22,053	5.42%	112,868	13.49%	21,180	8,679	51,055	31,954	-
Medical	2,034	0.50%	9,850	1.18%	1,639	1,348	4,434	2,429	-
Industrial	6,524	1.60%	33,643	4.02%	2,769	4,158	19,551	7,165	-
Agricultural	1,735	0.43%	5,379	0.64%	2,582	108	1,775	914	-
Religious	2,024	0.50%	10,289	1.23%	3,704	617	1,132	4,836	-
Government	1,046	0.26%	7,414	0.89%	542	1,078	4,173	1,621	-
Education	888	0.22%	11,330	1.35%	1,277	1,534	4,915	3,604	-
Region 2 Total	**406,737**	**100.00%**	**836,900**	**100.00%**	**514,258**	**37,260**	**96,285**	**163,669**	**25,428**

* All square footage figures represent thousands of square feet.

Region 3



The Southern Tier region contains 6.84% of New York State's total building stock. Broome County has the highest building density with approximately 108 buildings per square mile, while Delaware County has the lowest building density with approximately 25 buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	304,639	84.43%	399,646	57.92%	300,243	3,532	-	49,452	46,419
Multi-Family Residential	24,636	6.83%	93,879	13.60%	58,205	3,756	2,816	29,102	-
Other Residential	1,929	0.53%	27,990	4.06%	4,356	9,658	5,182	8,794	-
Commercial	17,400	4.82%	85,747	12.43%	15,693	6,508	39,616	23,930	-
Medical	1,432	0.40%	9,205	1.33%	1,264	1,466	4,327	2,148	-
Industrial	5,007	1.39%	35,098	5.09%	2,694	4,559	20,373	7,472	-
Agricultural	2,017	0.56%	5,703	0.83%	2,737	114	1,882	970	
Religious	1,955	0.54%	9,890	1.43%	3,560	594	1,088	4,648	-
Government	1,010	0.28%	6,898	1.00%	506	1,014	3,859	1,519	-
Education	809	0.22%	15,996	2.32%	1,800	2,168	6,940	5,088	-
Region 3 Total	**360,834**	**100.00%**	**690,052**	**100.00%**	**391,058**	**33,369**	**86,083**	**133,123**	**46,419**

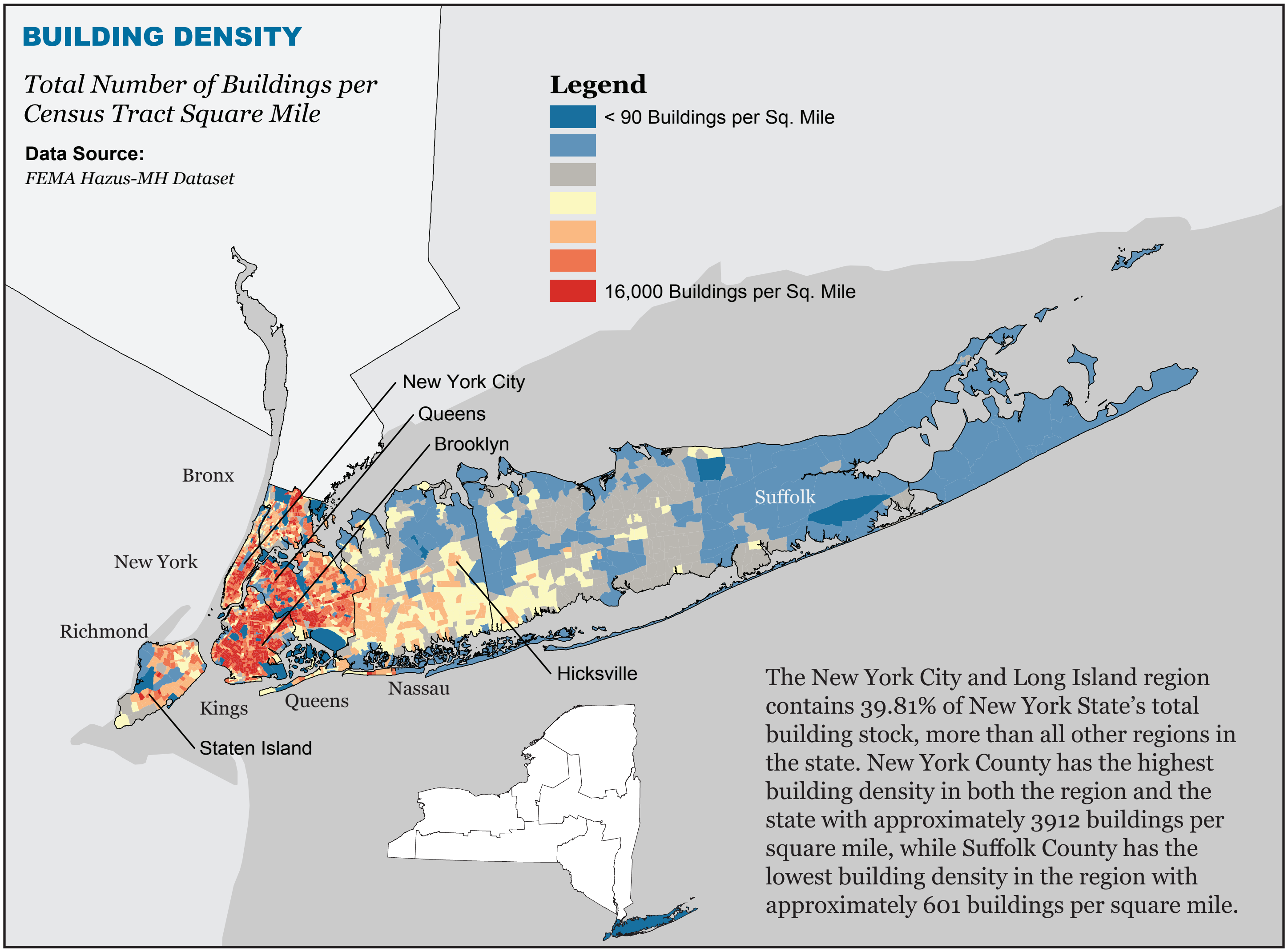
* All square footage figures represent thousands of square feet.

Region 4

BUILDING DENSITY

Total Number of Buildings per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset



The New York City and Long Island region contains 39.81% of New York State's total building stock, more than all other regions in the state. New York County has the highest building density in both the region and the state with approximately 3912 buildings per square mile, while Suffolk County has the lowest building density in the region with approximately 601 buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	1,415,076	67.35%	2,226,435	31.62%	1,883,605	22,160	-	310,241	10,429
Multi-Family Residential	430,464	20.49%	2,819,709	40.04%	1,748,220	112,788	84,591	874,110	-
Other Residential	10,481	0.50%	190,412	2.70%	32,370	63,330	35,624	59,088	-
Commercial	155,742	7.41%	1,203,108	17.08%	238,695	95,479	518,814	350,120	-
Medical	18,575	0.88%	108,749	1.54%	18,291	14,734	48,824	26,900	-
Industrial	40,789	1.94%	268,427	3.81%	22,708	33,324	152,903	59,492	-
Agricultural	5,919	0.28%	16,135	0.23%	7,745	323	5,325	2,742	-
Religious	13,147	0.63%	82,276	1.17%	29,619	4,937	9,050	38,670	-
Government	4,091	0.19%	34,543	0.49%	2,465	4,518	20,577	6,983	-
Education	6,730	0.32%	92,516	1.31%	10,382	12,564	40,148	29,422	-
Region 4 Total	**2,101,014**	**100.00%**	**7,042,310**	**100.00%**	**3,994,100**	**364,157**	**915,856**	**1,757,768**	**10,429**

* All square footage figures represent thousands of square feet.

Region 5

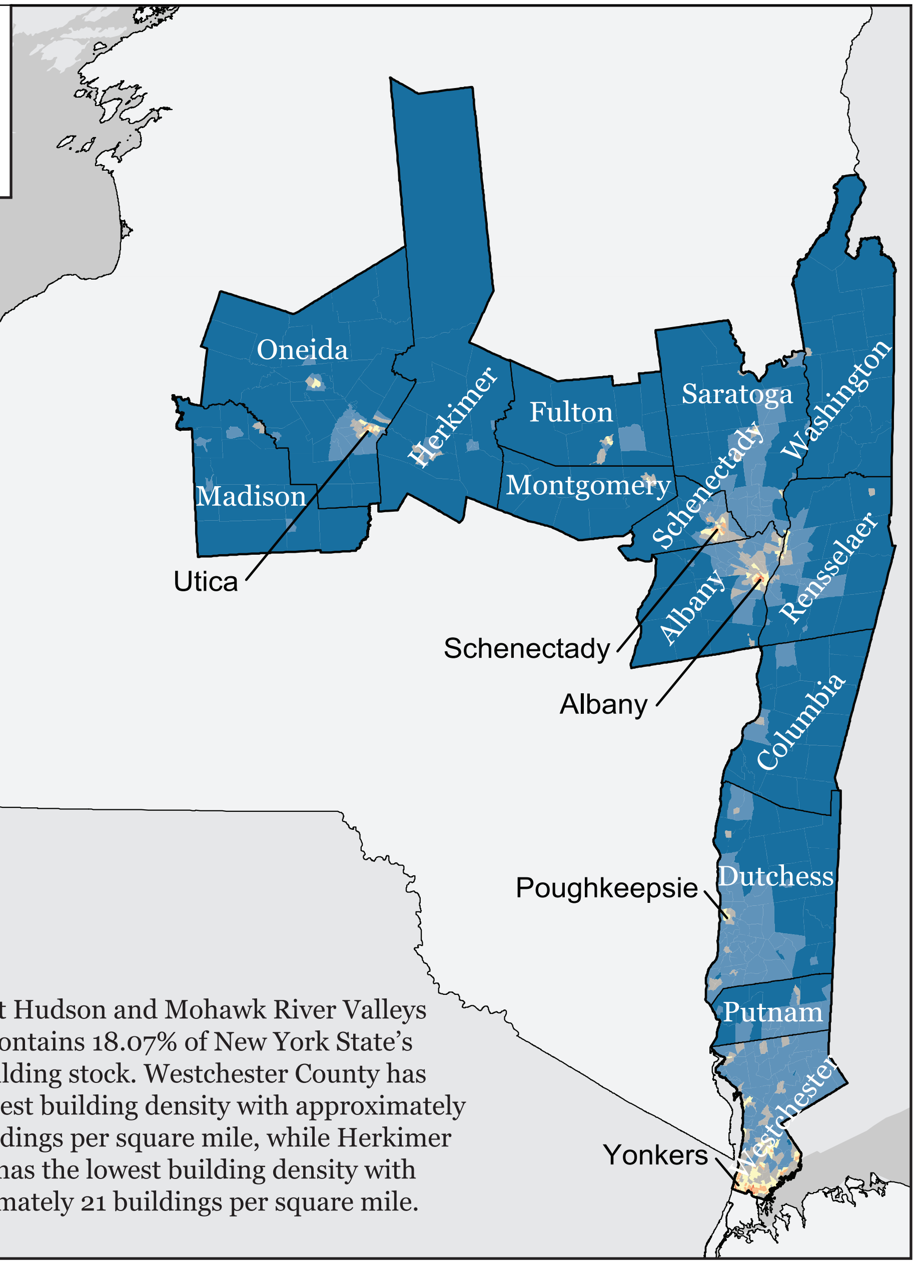
BUILDING DENSITY

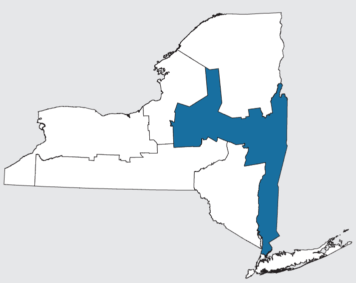
Total Number of Buildings per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset

Legend

- < 90 Buildings per Sq. Mile
- 16,000 Buildings per Sq. Mile





The East Hudson and Mohawk River Valleys region contains 18.07% of New York State's total building stock. Westchester County has the highest building density with approximately 558 buildings per square mile, while Herkimer County has the lowest building density with approximately 21 buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	762,295	79.94%	1,148,375	52.38%	939,547	11,053	-	154,749	43,026
Multi-Family Residential	96,002	10.07%	426,813	19.47%	264,624	17,073	12,804	132,312	-
Other Residential	4,508	0.47%	63,614	2.90%	8,899	22,221	12,152	20,342	-
Commercial	54,496	5.72%	321,317	14.66%	62,703	25,079	140,826	92,709	-
Medical	5,503	0.58%	29,594	1.35%	4,874	4,089	13,357	7,274	-
Industrial	16,129	1.69%	103,330	4.71%	8,428	12,535	60,670	21,697	-
Agricultural	4,234	0.44%	11,127	0.51%	5,341	222	3,672	1,892	-
Religious	4,908	0.51%	26,080	1.19%	9,389	1,565	2,869	12,257	-
Government	2,987	0.31%	23,573	1.08%	1,699	3,220	13,735	4,919	-
Education	2,484	0.26%	38,404	1.75%	4,018	5,475	16,730	12,181	-
Region 5 Total	**953,546**	**100.00%**	**2,192,227**	**100.00%**	**1,309,522**	**102,532**	**276,815**	**460,332**	**43,026**

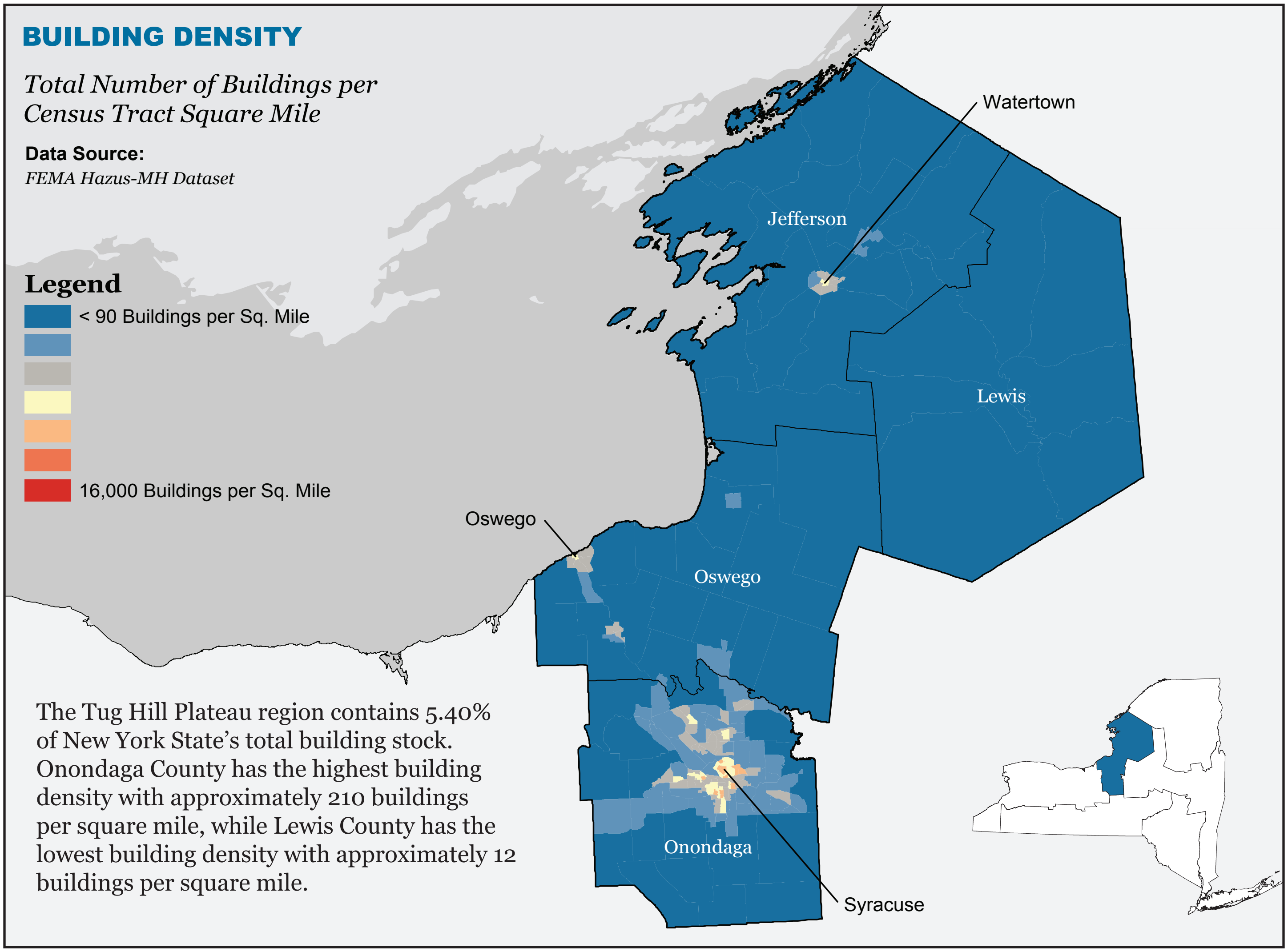
* All square footage figures represent thousands of square feet.

Region 6

BUILDING DENSITY

Total Number of Buildings per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset



The Tug Hill Plateau region contains 5.40% of New York State's total building stock. Onondaga County has the highest building density with approximately 210 buildings per square mile, while Lewis County has the lowest building density with approximately 12 buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	237,260	83.22%	328,081	54.65%	260,726	3,067	-	42,943	21,345
Multi-Family Residential	21,706	7.61%	91,780	15.29%	56,904	3,671	2,753	28,452	-
Other Residential	1,300	0.46%	20,409	3.40%	3,361	6,856	3,826	6,366	-
Commercial	14,938	5.24%	89,687	14.94%	16,889	6,929	40,402	25,467	-
Medical	1,264	0.44%	8,167	1.36%	1,212	1,231	3,776	1,948	-
Industrial	4,292	1.51%	26,701	4.45%	2,115	3,386	15,554	5,646	-
Agricultural	1,315	0.46%	4,080	0.68%	1,958	82	1,346	694	-
Religious	1,493	0.52%	8,266	1.38%	2,976	496	909	3,885	-
Government	782	0.27%	5,672	0.94%	412	805	3,238	1,217	-
Education	752	0.26%	17,485	2.91%	1,376	2,896	7,718	5,495	-
Region 6 Total	**285,102**	**100.00%**	**600,328**	**100.00%**	**347,929**	**29,419**	**79,522**	**122,113**	**21,345**

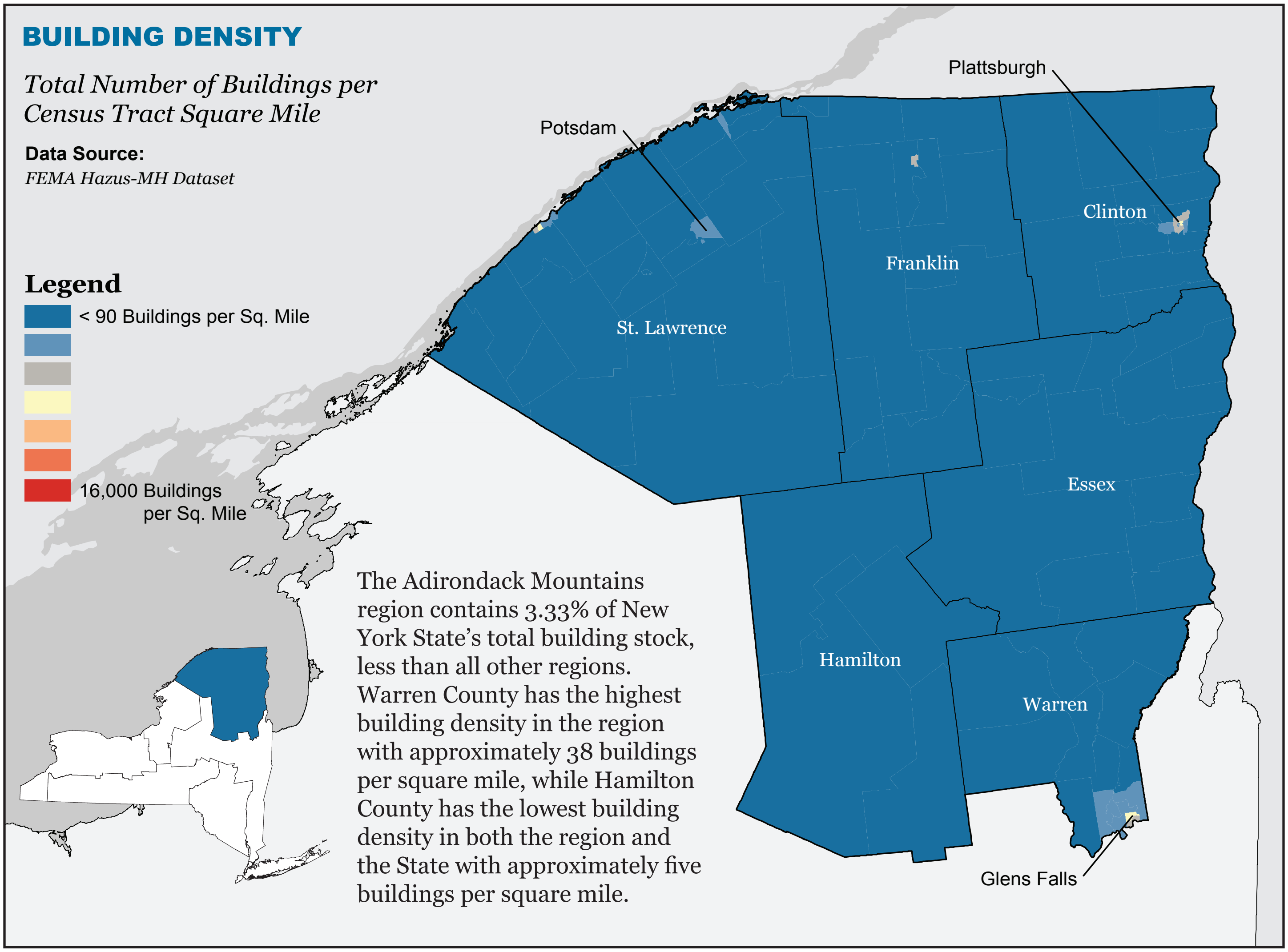
* All square footage figures represent thousands of square feet.

Region 7

BUILDING DENSITY

Total Number of Buildings per Census Tract Square Mile

Data Source:
FEMA Hazus-MH Dataset



The Adirondack Mountains region contains 3.33% of New York State's total building stock, less than all other regions. Warren County has the highest building density in the region with approximately 38 buildings per square mile, while Hamilton County has the lowest building density in both the region and the State with approximately five buildings per square mile.

Building Type	Buildings				Construction Type				
	Total Count		Total SF*		Wood SF*	Concrete SF*	Steel SF*	Masonry SF*	Pre-Fab. SF*
Single-Family Residential	153,863	87.65%	203,506	64.88%	155,268	1,827	-	25,574	20,837
Multi-Family Residential	8,299	4.73%	33,036	10.53%	20,483	1,321	991	10,241	-
Other Residential	1,046	0.60%	13,651	4.35%	2,806	4,327	2,443	4,075	-
Commercial	7,375	4.20%	35,590	11.35%	6,547	2,703	16,459	9,881	-
Medical	663	0.38%	3,652	1.16%	571	528	1,669	884	-
Industrial	1,989	1.13%	10,916	3.48%	911	1,363	6,257	2,385	-
Agricultural	706	0.40%	2,093	0.67%	1,004	42	691	356	-
Religious	715	0.41%	3,437	1.10%	1,237	206	378	1,616	-
Government	557	0.32%	3,839	1.22%	280	553	2,173	833	-
Education	339	0.19%	3,948	1.26%	456	525	1,711	1,256	-
Region 7 Total	**175,552**	**100.00%**	**313,668**	**100.00%**	**189,563**	**13,395**	**32,772**	**57,101**	**20,837**

* All square footage figures represent thousands of square feet.

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

To learn more about NYSERDA's programs and funding opportunities, visit nyserda.ny.gov or follow us on Twitter, Facebook, YouTube, or Instagram.

The University at Buffalo School of Architecture and Planning is guided by a culture of experimentation, a core belief in learning by doing, and a spirit of public service and inclusion. The school has shown that design and planning are agents of change for community, place, culture, social justice and the natural world since 1969.

University of Buffalo
School of Architecture and Planning

121 Hayes Hall
Buffalo, NY 14214-8030

local: 716-829-5900
fax: 716-829-2297

ap-info@buffalo.edu
ap.buffalo.edu

New York State
Energy Research and
Development Authority

17 Columbia Circle
Albany, NY 12203-6399

toll free: 866-NYSERDA
local: 518-862-1090
fax: 518-862-1091

info@nyserda.ny.gov
nyserda.ny.gov