Climate Change in Orange County, NY:

Natural Resource Inventory, Vulnerability Assessment and Adaptation Strategies

Orange County Planning Department

Benjamin Center at SUNY New Paltz

May 2020

Steven M. Neuhaus
County Executive

Acknowledgements

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Content in this report was informed through outreach to various stakeholders and groups as well as by the reference documents that are listed as citations. The following groups were consulted as this Report was being developed:

- Wallkill River Watershed Alliance
- Quassaick Creek Watershed Alliance
- Moodna Creek Watershed Intermunicipal Council
- Hudson River Watershed Alliance
- Orange County Planning Board
- Orange County Legislature's Green Committee
- Orange County Emergency Services
- Various municipal officials

This project was funded, in part, by the New York State Department of Environmental Conservation's Climate Smart Communities Program.

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Introduction

The impact of human activities on the global climate has become a significant area of focus within the scientific community in recent decades. Much work has gone into studying and discussing the causes and effects of climate change in order to determine how to reduce and mitigate these impacts, as well as how to adapt to the wide-ranging and unpredictable changes the Earth will be undergoing in the future. An abundance of scientific evidence strongly suggests that the health and continuance of many ecosystems are being compromised due to various impacts from human activities, and that these systems will continue to be in peril for decades to come due to impacts from climate change, among other factors (e.g. habitat destruction, pollution, etc.). Additionally, studies have evidenced that many aspects of infrastructure are currently and will continue to be affected by climate change. Such impacts are detailed in the Vulnerability Assessment section of this report. This report is meant to help Orange County, its municipalities, its residents, and other stakeholders understand which assets could be affected by climate change, and what actions can be taken to minimize climate-related impacts. To address both County and municipal resources, this report includes an inventory of resources, as well as an assessment of the vulnerabilities those resources have to future climate conditions.

The overall goal of this report is to provide information and recommend strategies specific to Orange County in order to guide local policies and plans that, when executed, will reduce vulnerabilities, conserve natural resources, and make communities more resilient to the changing climate. This document takes the approach of analyzing climate impacts and adaptation strategies based on the County's major watersheds due to the unique characteristics, threats, and needs of each area. The eight watershed areas include:

1. Upper Hudson River
2. Lower Hudson River
3. Quassaick Creek
4. Moodna Creek
5. Ramapo River
6. North Wallkill River
7. South Wallkill River
8. Delaware River

This report also completes three Climate Smart Communities actions, giving priority to the following tasks specified in the *Climate Smart Certification Manual*:

- Compiling a countywide **Natural Resource Inventory,**
- Creating a **Vulnerability Assessment,** and

- Developing **Climate Adaptation Strategies** to protect communities and their natural resources and infrastructure for the impacts of climate change. The adaptation strategies are organized into seven action areas:

1. land use
2. water systems
3. infrastructure
4. public health
5. public engagement
6. assistance to residents during emergencies
7. assistance to local governments

Following the table of strategies is a section that includes suggestions for actions that New York State could take to alleviate climate change impacts. The final section then outlines a methodology for implementation of all of the recommendations presented, along with suggestions for tracking implementation progress.

Natural Resources Inventory

Background

Orange County, New York has completed a Natural Resources Inventory (NRI) covering the entire geography of the County. Initiated and completed in 2019 by County Department of Planning staff, with assistance from members of the Orange County Planning Board and from faculty of the State University of New York at New Paltz. This NRI is important background information and serves as foundational research for the recent (adopted in 2019) updates to the County Comprehensive Plan, as well as meeting the current requirements for a complete and adopted NRI through the New York State Climate Smart Communities certification program. Note should be made that this NRI intentionally emphasizes a watershed and water supply focus as an essential management goal for Orange County.

In addition to supporting the 2019 updates to the County Comprehensive Plan, the nineteen (19) maps with narrative of this NRI are an essential component of the recently completed Countywide Climate Vulnerability Assessment and Climate Adaptation Strategy.

This work was funded in part by a grant from the New York State Department of Environmental Conservation, Climate Smart Communities Program (Contract No. DEC01-C00344GG-3350000). The NRI was reviewed and adopted by the Orange County Planning Board. Additional support was provided by the Orange County Water Authority, the Orange County Planning Board, and the Orange County Planning Department.

Orange County also credits important direction from “Creating a Natural Resources Inventory, A guide for communities in the Hudson River Estuary Watershed” published in 2014 by Cornell University Department of Natural Resources for New York State Department of Environmental Conservation’s Hudson River Estuary Program. We also note original guidance and inspiration from “Design with Nature” by Ian L, McHarg (1969).

Introduction

The Orange County Natural Resources Inventory (NRI) was researched and prepared as noted in the background section above. More specifically, County Planning Department staff, in consultation with faculty at The Benjamin Center at SUNY New Paltz, collaborated to produce this NRI through a series of public meetings with the County Planning Board, as well as a set of introductory and follow up discussions or meetings with representatives from each of active watershed organizations and alliances within Orange County. The NRI, as support

for the Climate Adaptation Strategy, was also discussed and presented to the Green Committee of the Orange County Legislature.

Several existing documents were used to support this NRI. Notable are the inventories, maps, and research completed for the 2004 Orange County Open Space Plan, the 2010 County Water Master Plan, the 2013 County Greenway Compact, and the 2015 County Agriculture and Farmland Protection Plan – all can be found online at orangecountygov.com/planning.

The County Planning Department is also a member of the NYS GIS Data Clearinghouse, and the Department is a data affiliate of the NYS Data Center and the US Census. With trained, experienced staff researchers and cartographers, this ready access to a full range of data and sources allowed for internal staffing of NRI analysis and production.

As the primary goal, this NRI serves as primary reference for County comprehensive planning, capital project, and related land use decisions consistent with NYS General Municipal Law. Additionally, the NRI informs reviews of municipal land use, planning and zoning permits as per referrals to the County Planning Commissioner under NYS General Municipal Law § 239 (m) & (n). While the County does not have zoning authority, under this NYS statute County staff have a mandatory review of a significant range of municipal land use permits – including master plans and plan updates, zoning changes, site plans, land subdivisions, special permits, and certain variances applications. The NRI is used to highlight sensitive and important features related to the locations of these referrals and land use impacts.

This Natural Resources Inventory (NRI) can also serve as guidance to municipal leaders, and to property owners, citizens, and private sector interests looking to make informed land management or to monitor and make smart land use decisions.

Maps

A set of nineteen (19) maps compile and describe important, naturally occurring resources within Orange County as well as priority man made features. This NRI is also not a static document. As new and revised data become available, the inventory should be updated to insure its completeness and accuracy. Interested parties are advised to stay informed on any amendments and updates through the orangecountygov.com/planning postings. Also note that while these maps are published at specific scales and resolution, upon request the County Planning Department can provide most of this data at alternative scale and base map if needed.

Information on the maps comes from different sources, produced at different times, at different scales, and for different purposes. It is often collected or developed from remote sensing data (i.e., aerial photographs, satellite imagery) or derived from paper maps. For these reasons, GIS data often contain inaccuracies from the original data, plus any errors from converting it. Therefore, maps created in GIS are approximate and best used for planning purposes. They should not be substituted for site surveys.

A listing of the map set, with summary descriptions map by map, is as follows:

Base Map. Using basic, geocoded information this locational map uses the US Geological Survey (USGS) base topographic and water feature information and overlays the primary Federal and State road network as well as municipal boundaries. This base information is carried over as underlying locational information in all of the other eighteen (18) maps of the NRI.

Floodplains. Using the same US Geological Survey topographic and water feature information with primary roads, this map delineates Federal Emergency Management Agency (FEMA) flood plain and flood hazard area data along with critical infrastructure and facilities within these areas.

Forest Patches and Regional Linkages. This map delineates contiguous forested areas in 3 area ranges by total acreage. The 2015 data source is Cornell University and NYS Department of Environmental Conservation (NYSDEC) using forest cover data from the Coastal Change Analysis Program (2010). Regional linkages are provided by The Nature Conservancy (2005) and the New York Natural Heritage Program.

Hydrology. Major watersheds, priority water bodies, water quality assessment scores and NYS Department of Environmental Conservation biomonitoring sites are delineated. All data is sourced from USGS and NYSDEC data sets, with water quality assessments based on 2011-2012 Orange County Water Authority field data supplemented by 2012 NYSDEC field data. Biological Assessment Profile (BAP) scores are based on in-stream collection of benthic macroinvertebrate samples and subsequent laboratory analysis. These scores factor in and include species richness, EPT richness, Hilsenhoff's biotic index, percent model affinity, nutrient biotic index, species diversity, and non Chironomidae and Oligochaeta richness.

Land Cover. This map delineates the 2011 National Land Cover database in fifteen (15) different categories including open water, 4 categories of developed lands, deciduous forest, cultivated crops, and woody wetlands.

Protected Land. Protected land depicts a data set maintained by the County Planning Department. Included is public nature preserves; all municipal, County, and State parks; State Forests, Unique Areas, and Wildlife Management Areas; and private lands held with documented conservation easements.

Chemical and Petroleum Risk Sites. This map shows point data/locations for four (4) sets of data plus fuller locational information for NYSDEC Remediation Sites – contaminated sites controlled and monitored by NYSDEC. Risk sites are defined as US Environmental Protection (EPA) regulated facilities, sites subjected to State Pollutant Discharge Elimination System (SPDES) Permit Program administered by NYSDEC, as well as Chemical and Petroleum Bulk Storage Facilities also overseen and monitored by NYSDEC.

Significant Biodiversity Areas. Depicted here are six (6) areas that were identified by the Hudson River Estuary Wildlife and Habitat Conservation Framework (2006) as particularly important to regional biodiversity.

Generalized Soils. The nine (9) major soils units, as defined in the 1979 Orange County/US Department of Agriculture (USDA) Soil Survey and as corroborated by more recent USDA data, are shown overlain on a base map. General descriptions of each soil unit including slope, drainage, texture, and base material are displayed.

Steep Slopes. Slopes in three category ranges (greater than 25%, 15 – 25%, and less than 15%) are shown on base map. Source of data is 10-foot digital elevation model provided by USGS.

Stream Classifications. All streams (rivers, brooks, kills, creeks etc.) in Orange County are delineated if included in the NYSDEC stream classification and mapping data provided by NYSDEC. Also included are known dams and culverts confirmed by data from NYSDEC and Orange County. Stream classifications are based on NYSDEC definitions of existing and best use of the subject water segment or reach. This includes standards for drinking, fishing and swimming/contact recreation waters, as well as ability to support trout population and/or trout spawning.

Surficial Geology. The map shows the areal coverage, county wide, of below surface geology in the eleven (11) categories applicable to Orange County. Dominated by glacial till, other categories are predominately glacial or glacial lake sediments, but also include bedrock, water, and swamp deposits, all as defined and mapped by the New York State Museum.

Terrestrial Habitats. The areal coverage of sixteen (16) generalized but distinct ecological habitats, each with unique characteristics as defined and mapped by the Northeastern Terrestrial Habitat Classification System at a 30-meter pixel grid. Data is provided by The Nature Conservancy and the NY Natural Heritage Program.

Topography. Elevation in Orange County ranges from 0 (sea level) to nearly 2000 feet. Derived from 10 foot digital elevation model data from USGS, topographic elevation is presented in seven (7) ranges shown with major streams and water bodies and major roads.

Watershed and Sub-watersheds. This map depicts the areal coverage of watersheds based on USGS Watershed Boundary Dataset (2016). The eight (8) Major watersheds are defined as the 10-digit hydrologic units, and sub-watersheds as the 12-digit hydrologic units. Streams and water body data is from the National Hydrography Dataset available from nhd.usgs.gov. Unique to Orange County is that our geography includes frontage on both the Hudson and Delaware rivers main stems and direct watersheds.

Water Supply. Drinking water supply sources – both surface and ground water – are mapped. Surface water reservoirs and reservoir watersheds are defined by Orange County Planning Department using 2-foot digital elevation model through NYS Office of Information Technology Services GIS Program Office. These watersheds represent lands drained by streams into drinking water reservoirs. Groundwater well data is provided by County Planning Department in cooperation with County Health Department and shows all public and community wells – but not individual, privately owned wells serving such features as a single business or residence. Groundwater aquifer coverage is provided by NYSDEC.

Wetlands and Hydric Soils. This map shows wetlands delineated by NYSDEC, and other wetlands identified in the National Wetlands Inventory. Probable or possible wetlands are derived from Orange County soil maps and are based on drainage class (poorly drained and somewhat poorly drained respectively)

Tidal Wetlands and Submerged Aquatic Vegetation (2 map set = Northern Orange and Southern Orange). A two-map set, depicting the extend and composition of tidal wetlands and submerged aquatic vegetation along the Hudson River main stem and associated tidal tributary mouths. This dataset was created by NYSDEC, the Cornell Institute for Resource Information Sciences, and the Hudson River Estuarine Research Reserve. Fourteen (14) separate classes of wetlands and vegetation are delineated.

Map 1.1

N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles

Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Base Map

Municipal Boundary
- Town or City
- Village
- Hamlet

Hydrology
- Major Stream
- Water Body

Major Roads
- Interstate
- Federal Highway
- State Route

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 1/8/2018

This map depicts floodplains as delineated by the Federal Emergency Management Agency (FEMA). A 100-year floodplain poses a 1% chance of flooding per year. A 500-year floodplain poses a 0.2% chance of flooding per year. Critical facilities, such as schools, care facilities, medical facilities, and emergency services, are also represented along with bridges and buildings that fall within floodplains.

Map 1.2

N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles

Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Floodplains

Major Watersheds

- Delaware River
- North Wallkill River
- South Wallkill River
- Moodna Creek
- Ramapo River
- Quassaic Creek
- Upper Hudson River
- Lower Hudson River

FEMA Floodplains

- 100-Year Floodplain
- 500-Year Floodplain

Critical Facilities Within Floodplains

- Care Facility
- Emergency Facility
- School
- Fire Department
- Police Department

Infrastructure Wthin Floodplains

- Bridges
- Buildings

Hydrology

- Major Streams
- Water Bodies

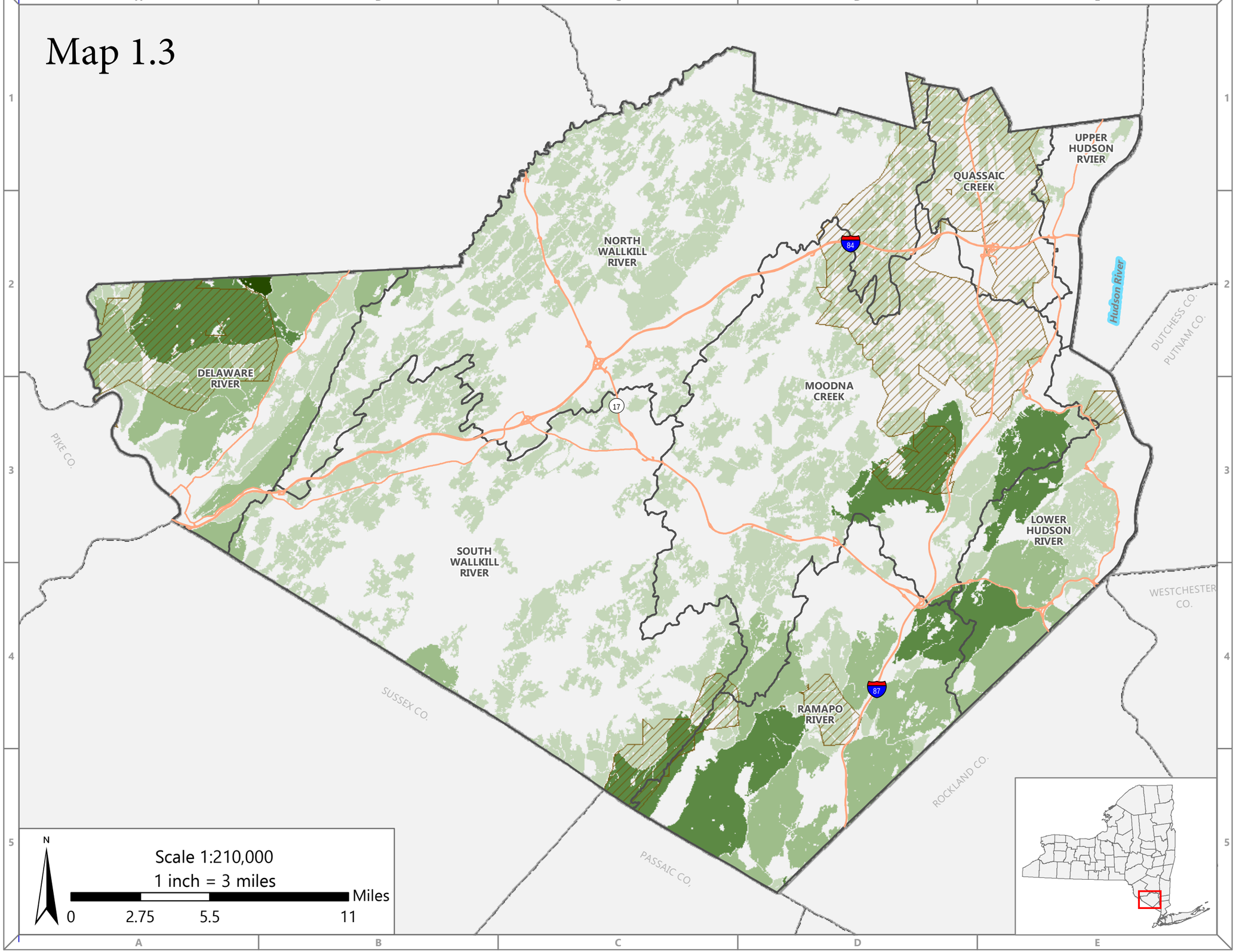
Major Roads

- Interstate
- Federal Highway
- State Route

DATA SOURCE: United States Geologic Survey, New York State Dept. of Environmental Conservation, Federal Emergency Management Agency, New York State Dept. of Transportation, Orange County Planning Dept.

Cartography by Benjamin Freiman 1/8/2018

Map 1.3



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County Executive

NATURAL RESOURCES INVENTORY

Forest Patches and Regional Linkage Zones

Forest Patches (acres)

- Stepping Stone
- Locally Significant
- Regionally Significant
- Globally Significant
- Regional Forest Linkage Zone

Hydrology

- Major Watersheds
- Major Streams
- Water Bodies

Major Roads

- Interstate
- Federal Highway
- State Route

This map depicts contiguous forested patches of Orange County by acreage. The patches were developed by Cornell University and the New York State Department of Environmental Conservation using forest cover data from the Coastal Change Analysis Program. Size classes are based on ecological importance. Regional linkage zones were developed by The Nature Conservancy and the New York Natural Heritage Program.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Natural Heritage Program; The Nature Conservancy; Coastal Change Analysis

Cartography by Benjamin Freiman 6/4/2020

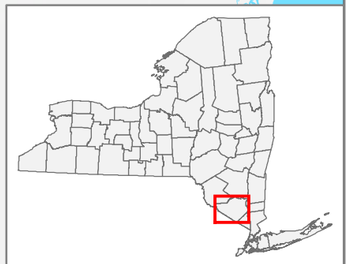
Water Quality Assessment shown on this map was performed by the Orange County Water Authority (OCWA) in 2011 and 2012 and by the NYS DEC in 2012, although both agencies collected data in this geographic extent prior to those years. Biological Assessment Profile (BAP) scores are based on in-stream collection of benthic macroinvertebrate samples and subsequent lab analysis. Parameters for developing a BAP score include species richness, EPT richness, Hilsenhoff's biotic index, percent model affinity, nutrient biotic index, species diversity, and non-Chironomidae and Oligochaeta richness. This biomonitoring method is used by the NYS DEC, as well.

Map 1.4

N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles



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NATURAL RESOURCES INVENTORY

Hydrology

Major Watersheds

- Delaware River
- North Wallkill River
- South Wallkill River
- Moodna Creek
- Ramapo River
- Quassaic Creek
- Upper Hudson River
- Lower Hudson River

Priority Water Bodies

- Impaired
- Threatened
- Threatened (Possible)
- Minor Impacts
- No Known Impacts
- Needs Verification
- Unassessed Stream
- Impaired Water Body
- Unassessed/Unimpaired Water Body

Water Quality Assessment (BAP Score)

- 7.5 - 10.0 Not Impacted
- 5.0 - 7.49 Slightly Impacted
- 2.5 - 4.99 Moderately Impacted

NYS DEC Biomonitoring Sites

- NYS DEC Biomonitoring Sites

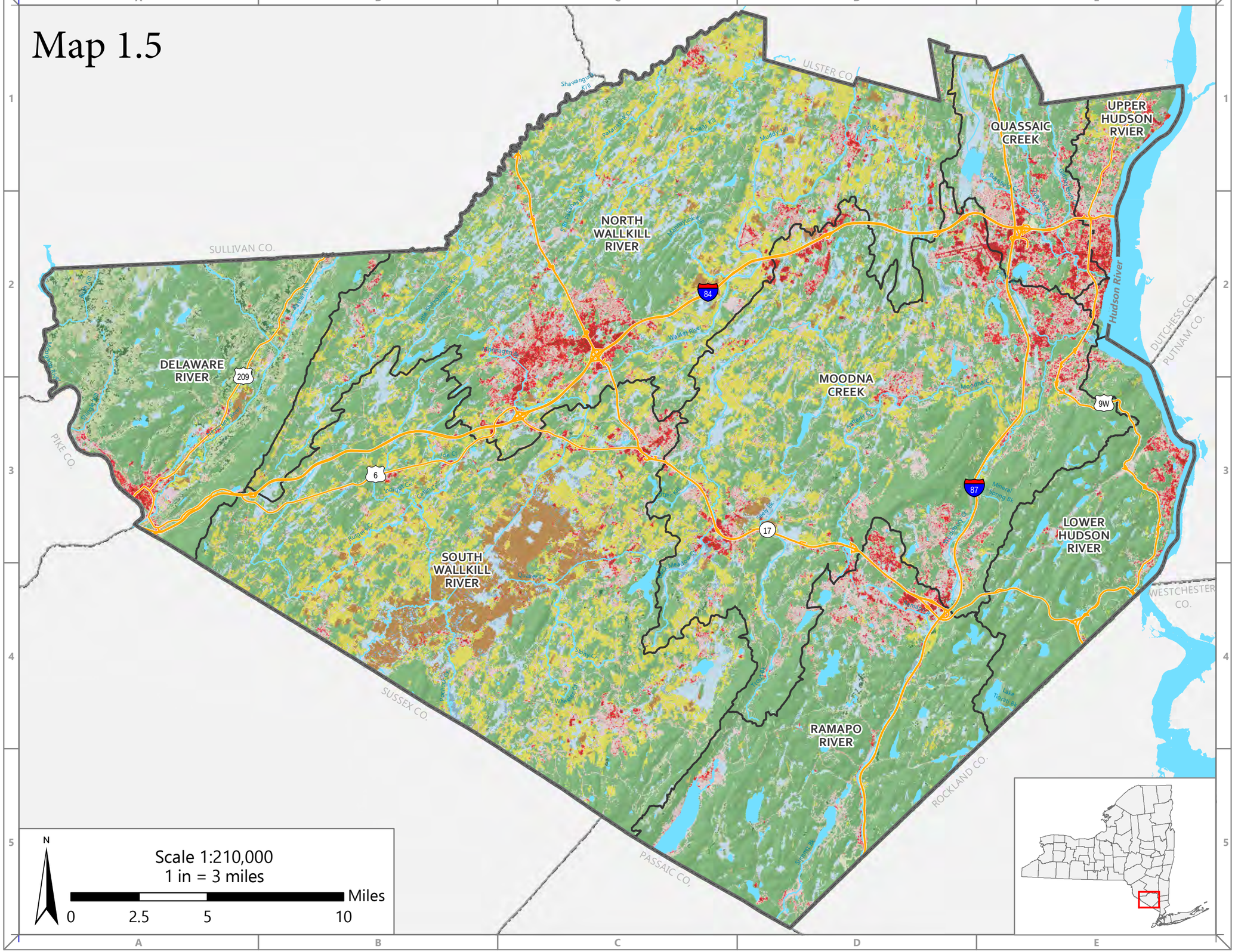
Major Roads

- Interstate
- Federal Highway
- State Route

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 1/8/2018

Map 1.5



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NATURAL RESOURCES INVENTORY

Land Cover

Land Cover

- Open water
- Developed, open space; 0-19% impervious
- Developed, low intensity; 20-49% impervious
- Developed, medium intensity; 50-79% impervious
- Developed, high intensity; 80-100% impervious
- Barren land (rock/sand/clay)
- Deciduous forest
- Evergreen forest
- Mixed forest
- Shrub/scrub
- Grassland/herbaceous
- Pasture/hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

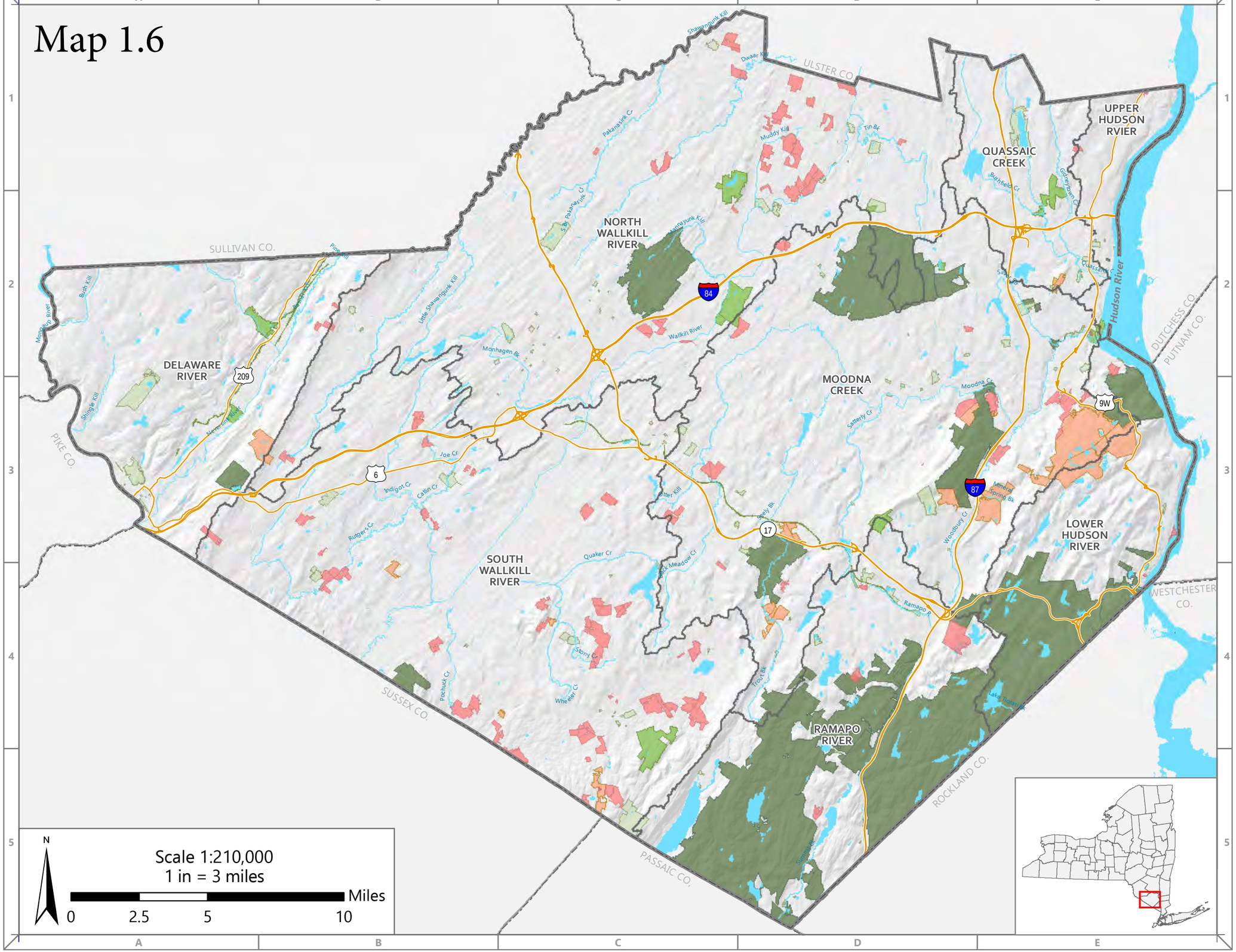
Major Roads

- Interstate
- Federal Highway
- State Route

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; National Land Cover Database (2011); New York State Dept. of Transportation; Orange County

Cartography by Benjamin Freiman 5/29/2020

Map 1.6



N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles

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County Executive

NATURAL RESOURCES INVENTORY

Protected Open Space

Protected Open Space
- Conservation Easements
- Public Nature Preserves
- Municipal Park
- County Park
- State Lands

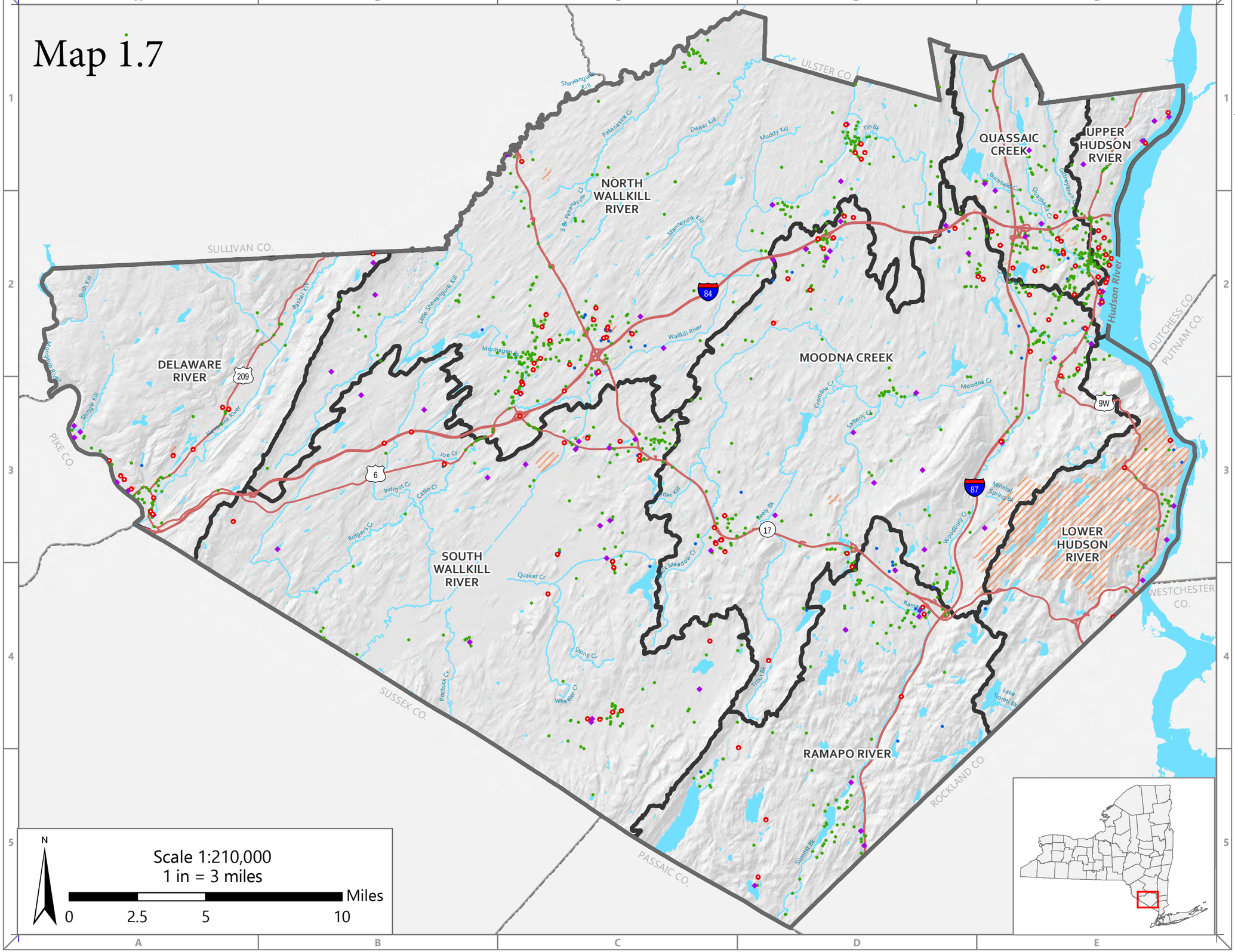
Hydrology
- Major Watersheds
- Major Streams
- Water Bodies

Major Roads
- Interstate
- Federal Highway
- State Route

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; Orange County Land Trust; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 5/29/2020

Map 1.7



N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles

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NATURAL RESOURCES INVENTORY

Chemical and Petroleum Risk Sites

Risk Sites

- US EPA Regulated Facilities
- SPDES Permits and Owners
- Petroleum Bulk Storage Facilities
- Chemical Bulk Storage Facilities
- NYS DEC Remediation Sites

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

Major Roads

- Interstate
- Federal Highway
- State Route

EPA Regulated Facilities – These sites are companies tracked by the US Environmental Protection Agency major data systems. These systems include Air Facilities Superfund (CERCLIS) Facilities, Water Permit Facilities, and Conservation and Recovery Act Facilities.

SPDES - The State Pollutant Discharge Elimination System (SPDES) Permit Program is a program run by the New York State Dept. of Environmental Conservation. It is designed to eliminate and prevent the pollution of waters in New York State. Permits granted to businesses, municipalities, and individuals allow for highly regulated and monitored disposal of wastewater.

Chemical Bulk Storage Facilities – The Chemical Bulk Storage Program, operated by the New York State Dept. of Environmental Conservation, monitors any aboveground storage tank larger than 185 gallons that stores "hazardous substances" as defined in NYCRR Part 597. This program also monitors any underground storage tank of any size as well non-stationary tanks used to store 1,000 kg of chemicals for 90 consecutive days or more.

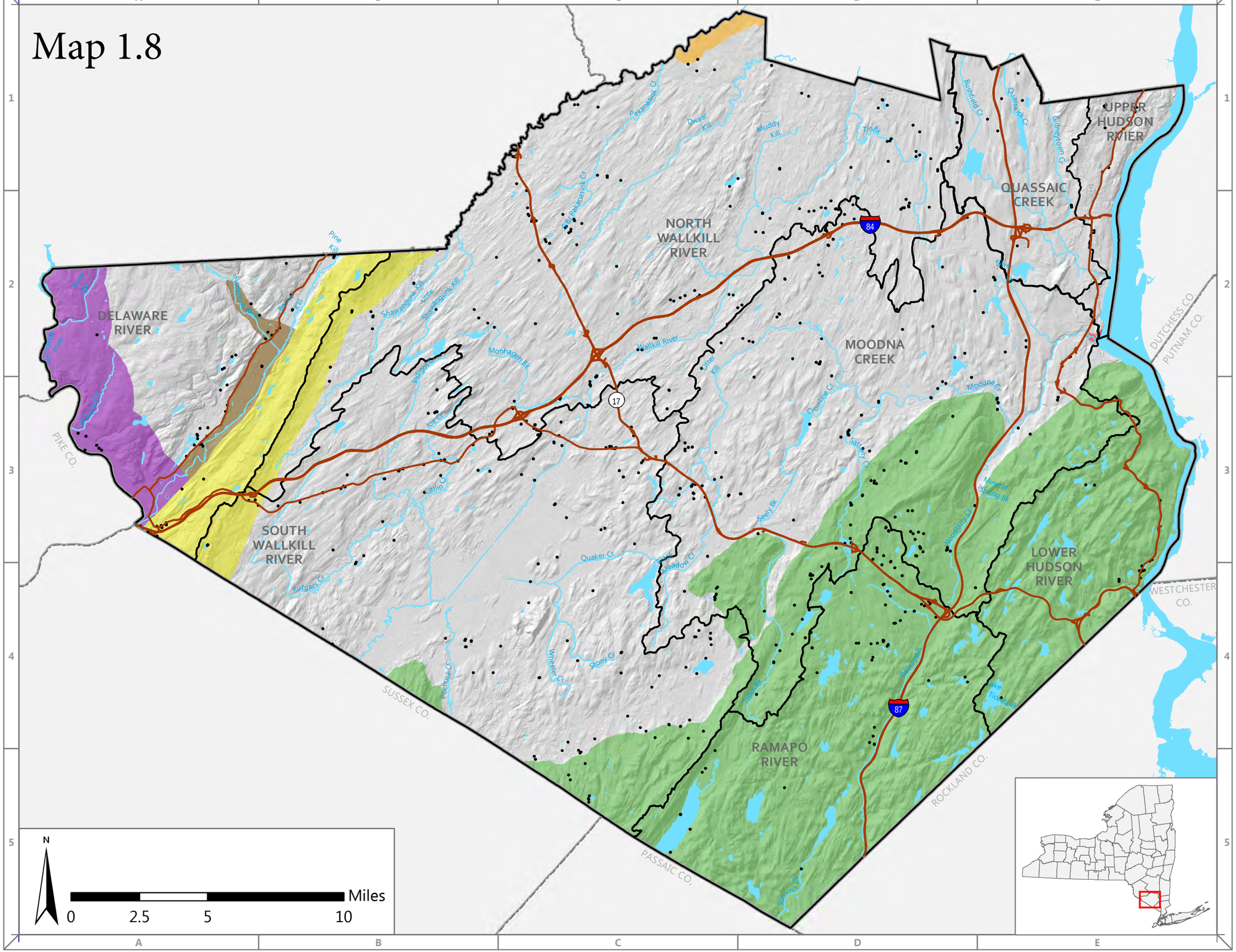
Petroleum Bulk Storage Facilities – The Petroleum Bulk Storage Facilities Program, operated by the New York State Dept. of Environmental Conservation, monitors any facility that stores more than 1,100 gallons of petroleum in aboveground and underground storage tanks. This program also monitors any facility with underground storage tanks larger than 110 gallons.

NYS DEC Remediation Sites – Remediation sites are contaminated sites controlled and monitored by the New York State Dept. of Environmental Conservation.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 7/1/2019

Map 1.8



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NATURAL RESOURCES INVENTORY

Significant Biodiversity Areas

Significant Biodiversity Areas

- Delaware Mongaup Rivers
- Hudson Highlands West
- Mid Hudson River
- Neversink River
- Shawangunk Kill
- Shawangunk Ridge

Hydrology

- Major Streams
- Other Water Bodies
- Major Watersheds

Major Roads

- Interstate
- Federal Highway
- State Route

This map depicts "Significant Biodiversity Areas" as designated by the New York State Department of Environmental Conservation. These areas are defined by unique topography, geology, hydrology, and biology. These are not the only important areas within Orange County.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 1/8/2018

This map depicts the major soil units within Orange County. The textures described in the legend refer to the texture of the surface layer of the major soils in each map unit. Soil data was collected in the Orange County Soil Survey (1979) and is corroborated by the US Department of Agriculture.

Map 1.9

N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles

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County Executive

NATURAL RESOURCES INVENTORY

Generalized Soils

Soil Descriptions

ARNOT-SWARTSWOOD-HOLLIS: Dominantly sloping, somewhat excessively drained to moderately well drained, medium textured soils that are shallow and deep over sandstone or gneiss and schist; on uplands

CARLISLE-WAYLAND: Dominantly level, deep, very poorly drained organic soils and nearly level, deep, poorly drained and very poorly drained, medium textured mineral soils; on depressional lowlands and flood plains

HOLLIS-ROCK OUTCROP: Dominantly slopping and moderately steep, somewhat excessively drained and well drained, medium textured soils that are shallow over schist, granite, and gneiss; and Rock outcrop; on mountainous uplands

HOOSIC-MARDIN-CANANDAIGUA: Dominantly gently sloping, deep, somewhat excessively drained to very poorly drained, moderately coarse textured and medium textured soils; on lowland plains and in valleys

MARDIN-ERIE: Dominantly gently sloping and sloping, deep, moderately well drained and somewhat poorly drained, medium textured soils; on uplands

NASSAU-BATH-ROCK OUTCROP: Dominantly gently sloping to hilly, somewhat excessively drained and well drained, medium textured soils that are shallow and deep over shale; and Rock outcrop; on uplands

PITTSFIELD-FARMINGTON: Dominantly gently sloping and sloping, well drained and somewhat excessively drained, medium textured soils that are shallow over limestone; on uplands

RIVERHEAD-MIDDLEBURY-CHENANGO: Dominantly nearly level and gently sloping, deep, somewhat excessively drained to somewhat poorly drained, moderately coarse textured and medium textured soils; on valley floors and plains

SWARTSWOOD-ALDEN: Dominantly nearly level to sloping, deep, well rained, moderately well drained, and very poorly drained, very stony, medium textured soils; on uplands

Major Roads

Interstate
Federal Highway
State Route

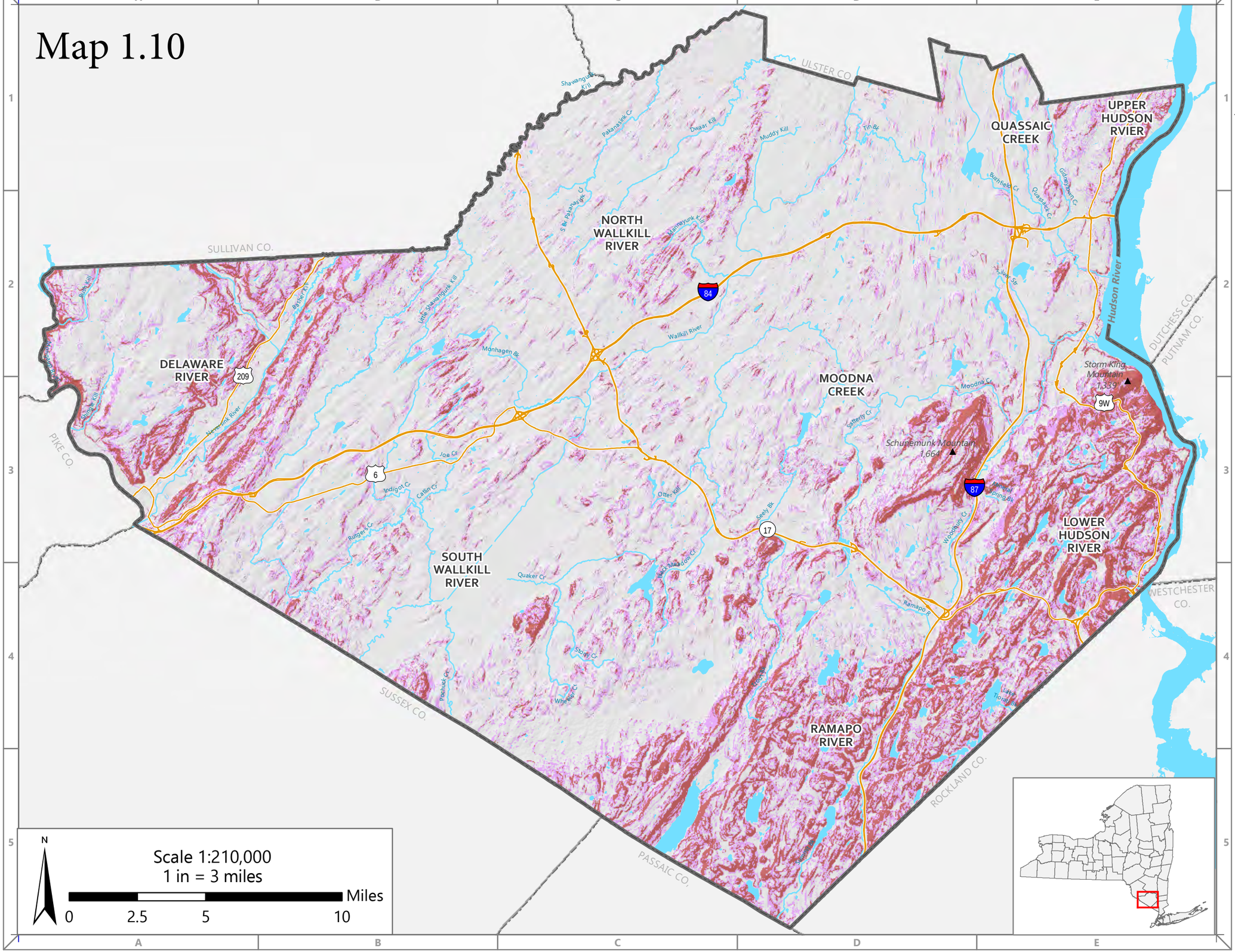
Hydrology

Major Streams
Water Bodies
Major Watersheds

DATA SOURCE: Orange County Soil Survey (1979), United States Dept. of Agriculture, New York State Dept. of Environmental Conservation, New York State Dept. of Transportation, Orange County Planning Dept.

Cartography by Benjamin Freiman 1/8/2018

Map 1.10



N

Scale 1:210,000
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0 2.5 5 10 Miles

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NATURAL RESOURCES INVENTORY

Steep Slopes

Slope Grade

- 0 - 15% Slope
- 15 - 25% Slope
- >25% Slope

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

Major Roads

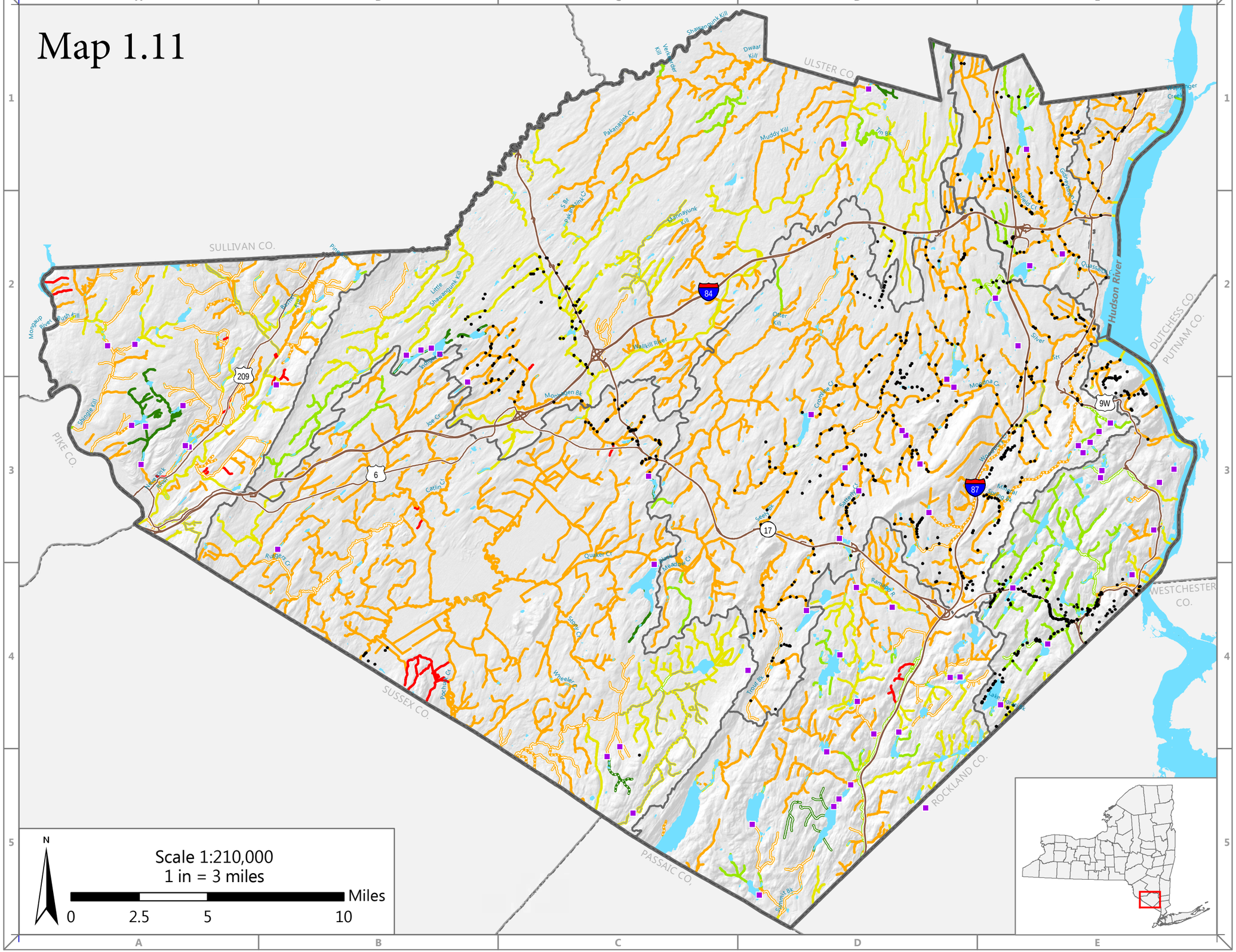
- Interstate
- Federal Highway
- State Route

Slopes grades were derived from a 10-foot digital elevation model provided by the United States Geologic Survey.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 5/29/2020

Map 1.11



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NATURAL RESOURCES INVENTORY

Stream Classifications

NYS DEC Stream Classes and Standards*

- AA
- AA(T)
- AA(TS)
- A
- A(T)
- A(TS)
- B
- B(T)
- B(TS)
- C
- C(T)
- C(TS)
- D

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds
- Known Dams
- Known Culverts**

Major Roads

- Interstate
- Federal Highway
- State Route

*CLASSES - Stream classes are defined by the NYSDEC based on existing or best usage. The classification AA or A is assigned to waters used as a source of drinking water. Classification B indicates a best usage for swimming and other contact recreation, but not for drinking water. Classification C is for waters supporting fisheries and suitable for non - contact activities. The lowest classification and standard is D.

STANDARD - The standards of quality and purity established for all classifications (A, B, C, etc.). Waters with classifications A, B, and C may also have a standard of (T), indicating that it may support a trout population, or (TS), indicating that it may support trout spawning (TS). Special requirements apply to sustain these waters that support these valuable and sensitive fisheries resources.

** The mapping of culverts in Orange County is an ongoing project conducted by the New York State Department of Enviornmental Conservation. The culverts depicted on this map have been identified as of 2017 and do not represent all of the culverts in Orange County.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

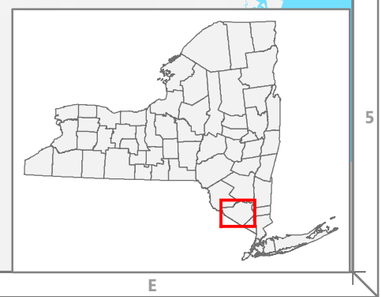
Cartography by Benjamin Freiman 1/8/2018

Map 1.12

N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles



Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Surficial Geology

Surficial Geology

- Recent alluvium
- Alluvial fan
- Kame deposits
- Lacustrine delta
- Lacustrine sand
- Lacustrine silt and clay
- Till
- Swamp deposits
- Water
- Outwash sand and gravel
- Bedrock

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

Major Roads

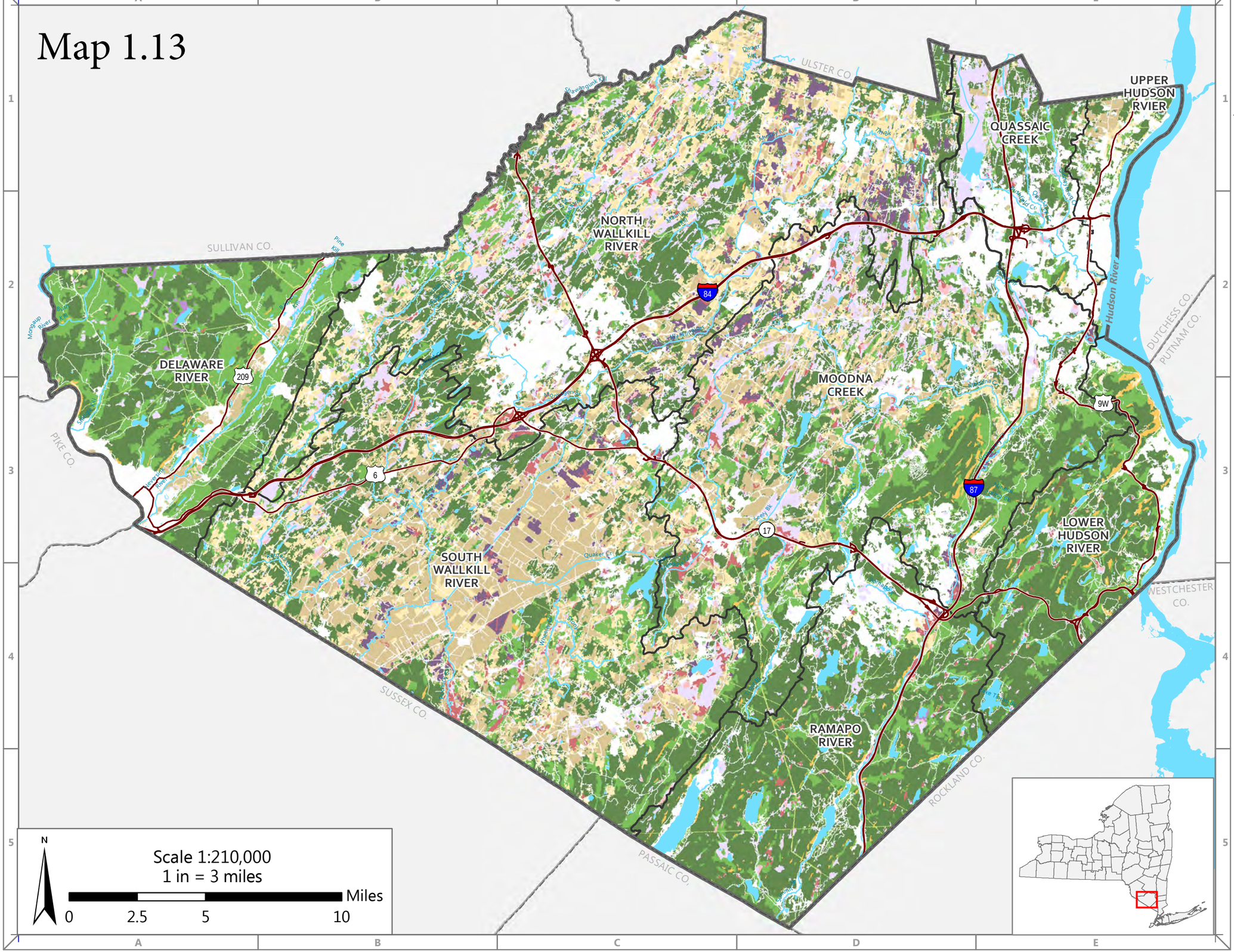
- Interstate
- Federal Highway
- State Route

The surficial geologic data of Orange County was provided by the New York State Museum.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; New York State Museum; Orange County Planning

Cartography by Benjamin Freiman 1/8/2018

Map 1.13



Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Terrestrial Habitats

Habitats

- Agriculture, cultivated crops
- Agriculture, pasture/hay
- Forest, oak-pine
- Forest, hardwood-conifer
- Ruderal shrubland/grassland
- Glade
- Cliff/talus
- Barren land
- Swamp, hardwood
- Peatland and fens
- Swamp, mixed
- Marsh
- Wet meadow / shrub swamp
- Large river floodplain
- Developed land
- Open water

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

Major Roads

- Interstate
- Federal Highway
- State Route

This map depicts ecological habitats mapped by the Northeastern Terrestrial Habitat Classification System, provided by the Nature Conservancy and the Natural Heritage Program. This data is presented as a 30-meter pixel grid of wildlife habitats. Habitats have been slightly generalized and grouped according to biome for clarity and ease of use.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; New York State Natural Heritage Program; The

Cartography by Benjamin Freiman 1/8/2018

Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Tidal Wetlands and Submerged Aquatic Vegetation (SAV)

NORTHERN ORANGE COUNTY

Map 1.14

This map depicts the extent and composition of tidal wetlands and submerged aquatic vegetation (SAV) along the Hudson River. This dataset was created by New York State Department of Environmental Conservation, the Cornell Institute for Resource Information Sciences, and the Hudson River National Estuarine Research Reserve.

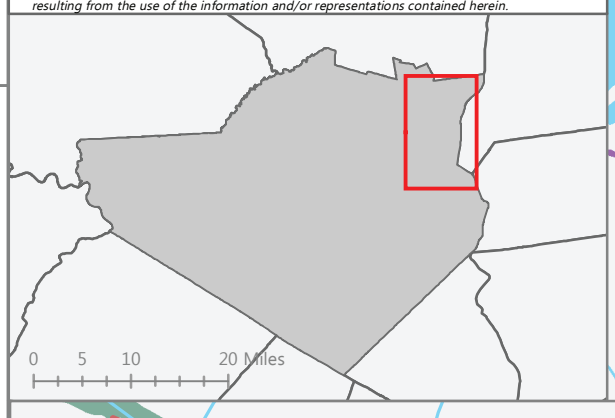
Tidal Wetlands Class and SAV

- Spartina Alterniflora Dominant
- Trapa Natans Dominant
- Phragmites Australis Dominant
- Typha Angustifolia Dominant
- Lower Intertidal Mix
- Upper Intertidal Mix
- Wooded Swamp
- Submerged Aquatic Vegetation
- Unvegetated Flats
- Scrub / Shrub
- Salt Meadow
- Upland
- Open Water
- Documented Submerged Aquatic Vegetation

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

DATA SOURCE: New York State Dept. of Environmental Conservation, Cornell Institute for Resource Information Sciences; Hudson River National Estuarine Research Reserve; New York State Dept. of Transportation, Orange County Planning Dept.



UPPER HUDSON RIVER

QUASSAICK CREEK

Gidneytown Cr.

Quassaick Cr.

MOODNA CREEK

LOWER HUDSON RIVER

Scale 1:45,000
1 in = 1 miles
N
0 0.5 1 2 Miles

Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Tidal Wetlands and Submerged Aquatic Vegetation (SAV)

SOUTHERN ORANGE COUNTY

Map 1.15

This map depicts the extent and composition of tidal wetlands and submerged aquatic vegetation (SAV) along the Hudson River. This dataset was created by New York State Department of Environmental Conservation, the Cornell Institute for Resource Information Sciences, and the Hudson River National Estuarine Research Reserve.

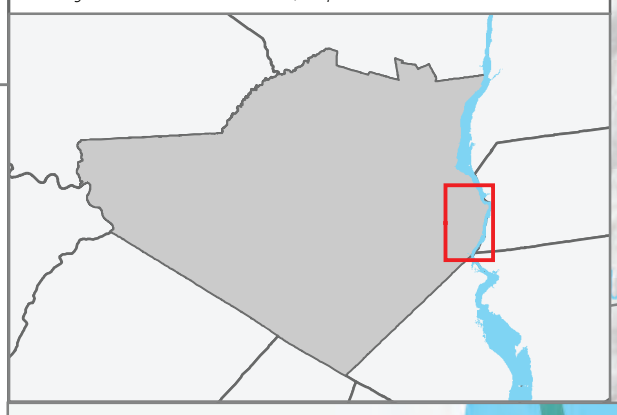
Tidal Wetlands Class and SAV

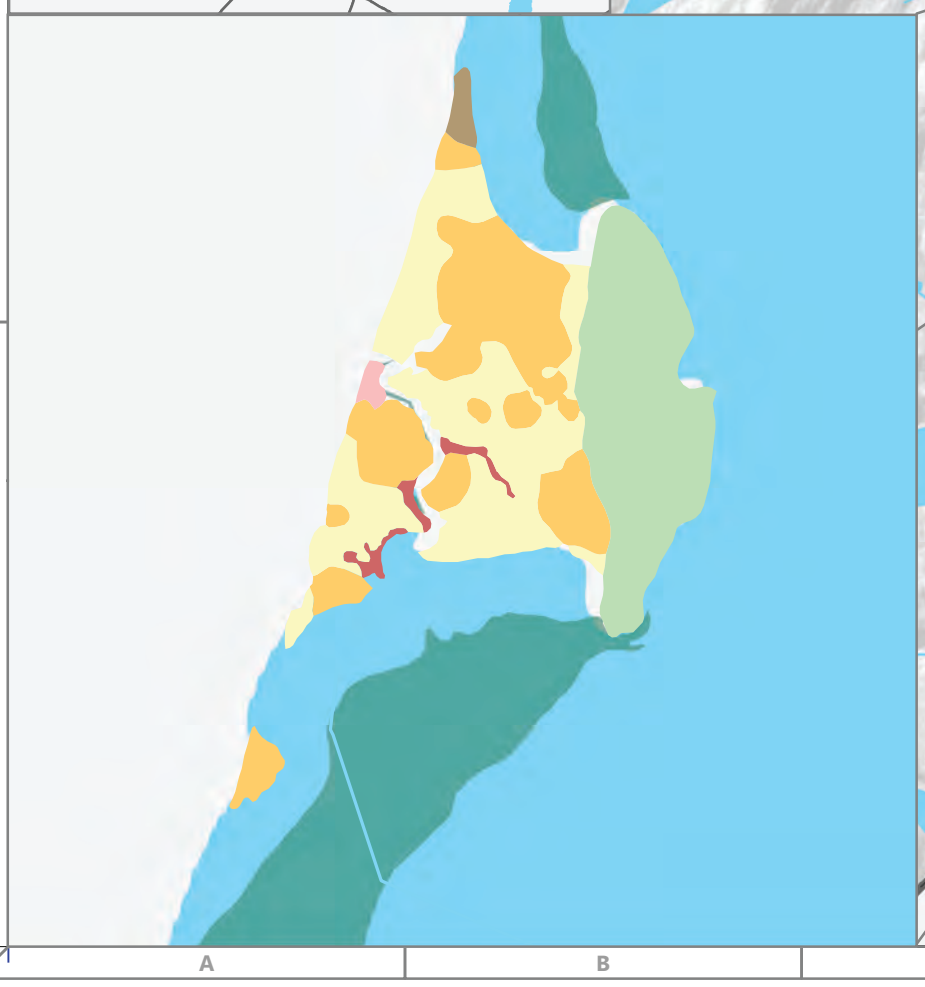
- Spartina Alterniflora Dominant
- Trapa Natans Dominant
- Phragmites Australis Dominant
- Typha Angustifolia Dominant
- Lower Intertidal Mix
- Upper Intertidal Mix
- Wooded Swamp
- Submerged Aquatic Vegetation
- Unvegetated Flats
- Scrub / Shrub
- Salt Meadow
- Upland
- Open Water
- Documented Submerged Aquatic Vegetation

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

DATA SOURCE: New York State Dept. of Environmental Conservation, Cornell Institute for Resource Information Sciences; Hudson River National Estuarine Research Reserve; New York State Dept. of Transportation, Orange County Planning Dept.





MOODNA CREEK

LOWER HUDSON RIVER

Hudson River

PUTNAM CO.

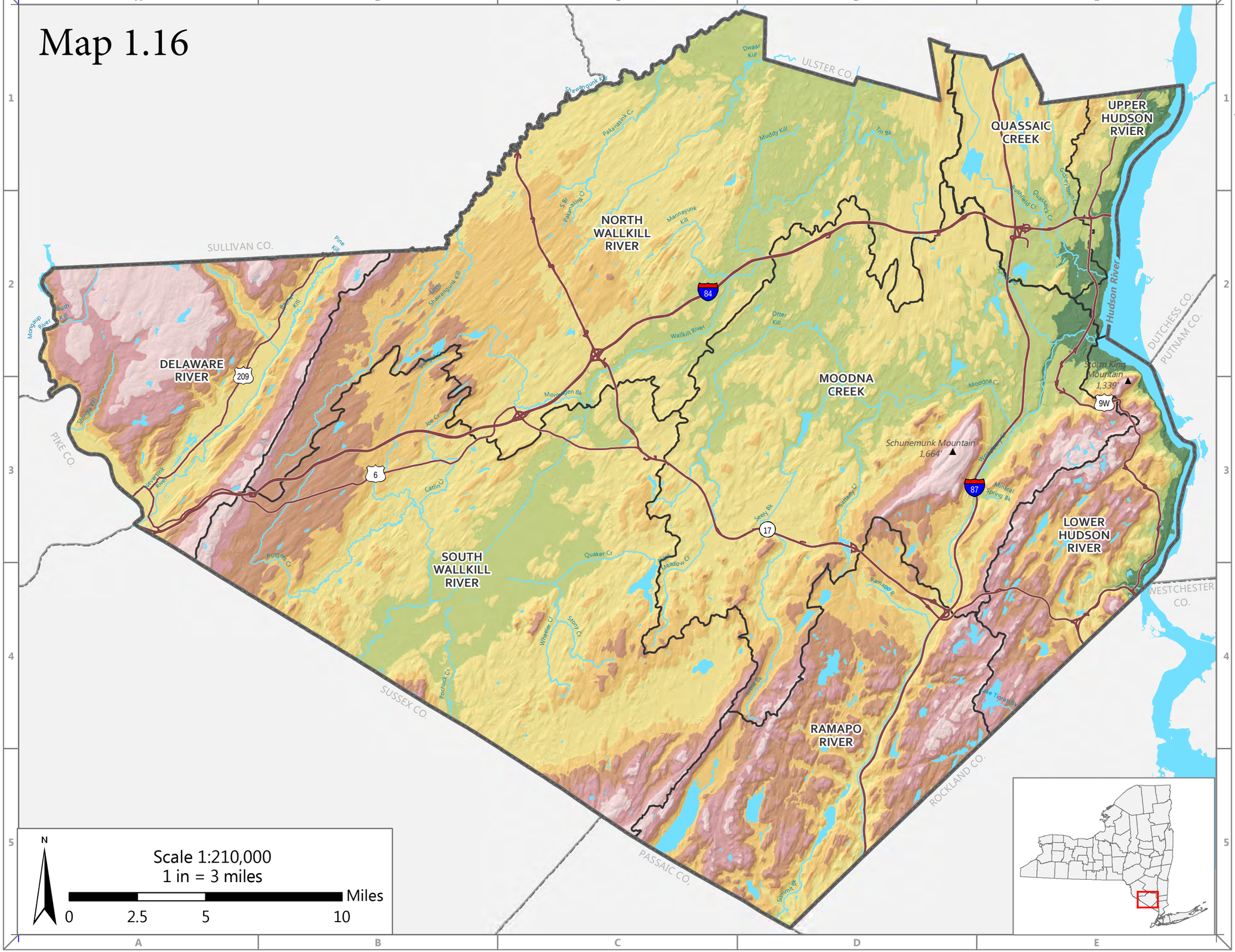
WESTCHESTER CO.

N

1 inch = 0.47 miles
Scale 1:30,000

0 0.25 0.5 1 Miles

Map 1.16



N

Scale 1:210,000
1 in = 3 miles

0 2.5 5 10 Miles

Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Topography

Elevation

- 0 - 200
- 201 - 400
- 401 - 600
- 601 - 800
- 801 - 1,000
- 1,001 - 1,200
- 1,201 - 1,664

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

Major Roads

- Interstate
- Federal Highway
- State Route

Elevations were derived from a 10-foot digital elevation model provided by the United States Geologic Survey. The highest points in Orange County are Schunemunk Mountain (1,664 feet) and Storm King Mountain (1,339 feet). The lowest points are at sea level along the banks of the Hudson River.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 1/8/2018

Map 1.17

Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Watersheds and Sub-watersheds

Major Watersheds

- Delaware River
- North Wallkill River
- South Wallkill River
- Moodna Creek
- Ramapo River
- Quassaick Creek
- Upper Hudson River
- Lower Hudson River

Hydrology

- Major Streams
- Water Bodies

Major Roads

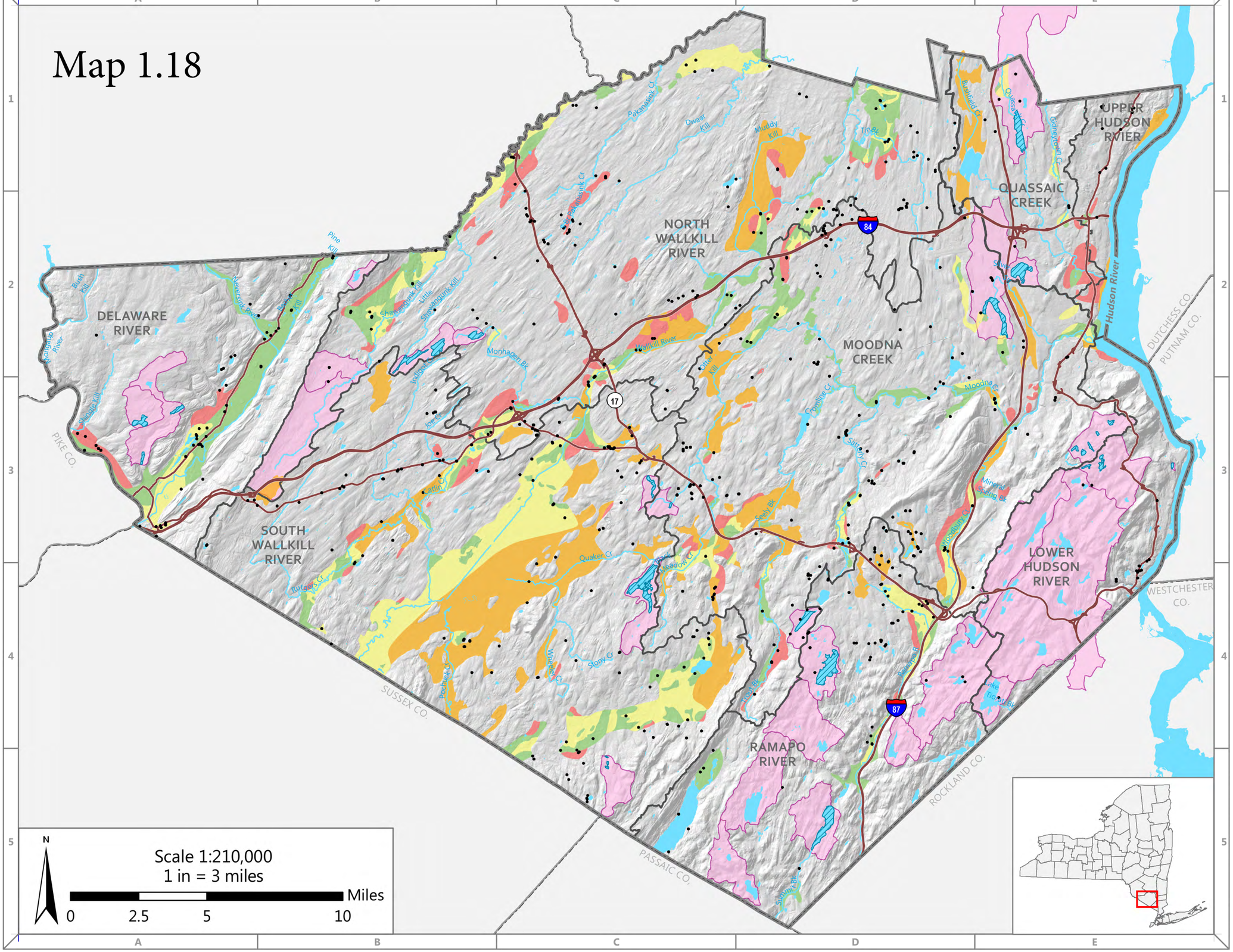
- Interstate
- Federal Highway
- State Route

This map depicts major watersheds and sub-watersheds as represented in the USGS Watershed Boundary Dataset (2016). Major watersheds are defined as 10-digit hydrologic unit codes and sub-watersheds are defined as 12-digit hydrologic unit codes. Stream and water body data was acquired from the National Hydrography Dataset available from nhd.usgs.gov. Road data was provided by the New York State Dept. of Transportation and municipal data was provided by the Orange County Planning Department.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 1/9/2018

Map 1.18



Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Water Supply

Water Supply Features

- Wells
- Major Streams
- Reservoirs
- Reservoir Watersheds
- Other Water Bodies
- Major Watersheds

Sand and Gravel Aquifers

- Stratified sand and gravel at land surface and below water table
- Stratified sand and gravel below clay or silt and the water table
- Stratified clay and silt with no or thin layers of sand and gravel at land surface and below water table
- Stratified sand and gravel at land surface and above water table

Major Roads

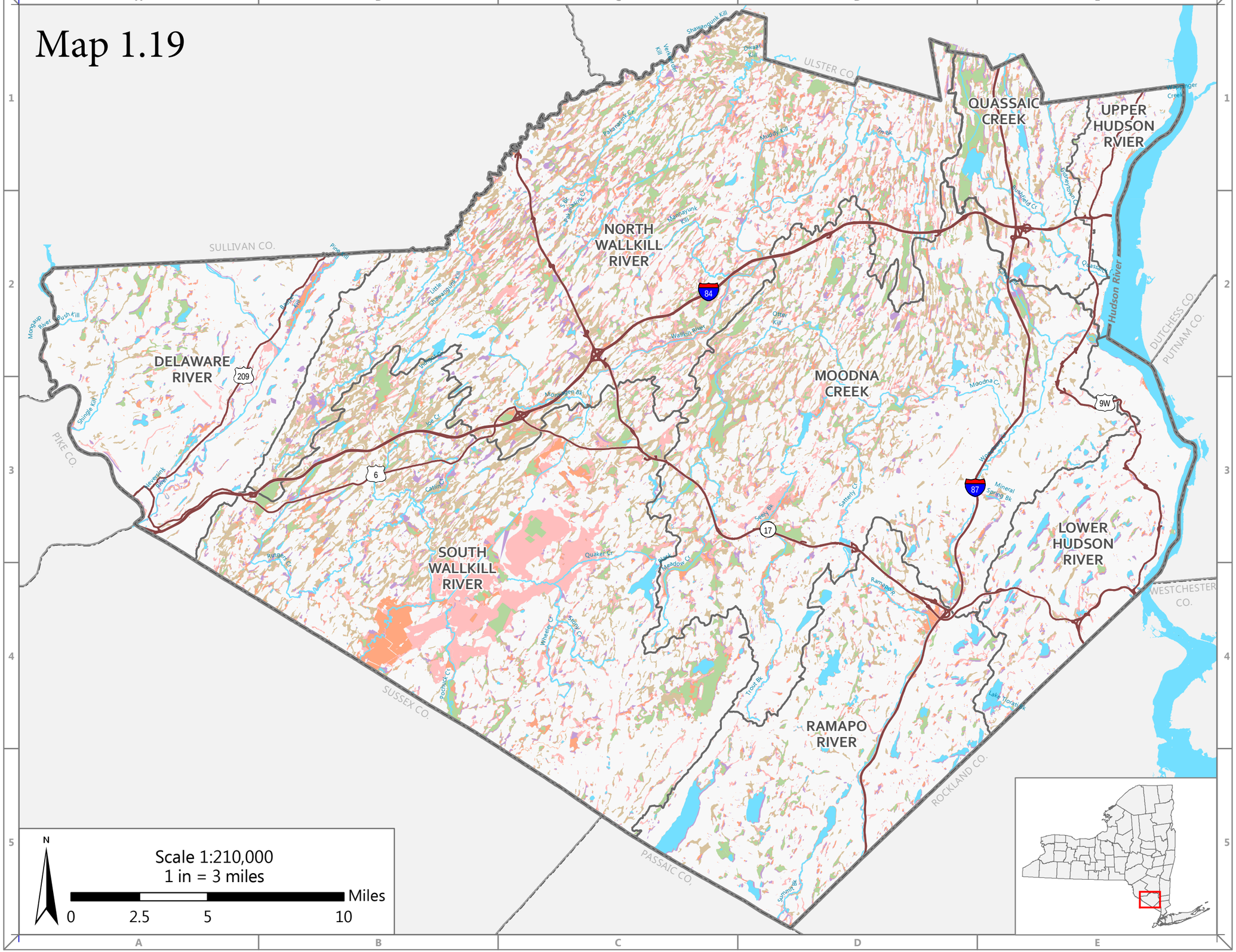
- Interstate
- Federal Highway
- State Route

This map depicts features within Orange County that are used as sources of drinking water. Reservoir watersheds were created by the Orange County Planning Department from a 2-foot digital elevation model provided by the New York State Office of Information Technology Services GIS Program Office. These features represent regions where streams drain into drinking water reservoirs. Aquifer data was provided by the New York State Dept. of Environmental Conservation and well locations were provided by the Orange County Planning Department.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; New York State Dept. of Transportation; Orange County Planning Dept.

Cartography by Benjamin Freiman 1/9/2018

Map 1.19



Stephen M. Neuhaus
County Executive

NATURAL RESOURCES INVENTORY

Wetlands and Hydric Soils

Wetlands and Hydric Soils

- NYS DEC Wetlands
- NWI Wetlands (Federal Wetlands)
- Probable Wetlands (Poorly Drained Soils)
- Possible Wetlands (Somewhat Poorly Drained Soils)

Hydrology

- Major Streams
- Water Bodies
- Major Watersheds

Major Road

- Interstate
- Federal Highway
- State Route

This map depicts wetlands delineated by the New York State Department of Envrionmental Conservation (NYS DEC), and federal wetlands identified in the federal National Wetlands Inventory. Probably and possible wetlands are also show. These areas were identified based on soil drainage. Probably wetlands consist of hydric soil and possible wetlands consist of somewhat poorly drained soil.

DATA SOURCE: United States Geologic Survey; New York State Dept. of Environmental Conservation; National Wetland Inventory; United States Department of Agriculturet; New York State Dept. of

Cartography by Benjamin Freiman 1/9/2018

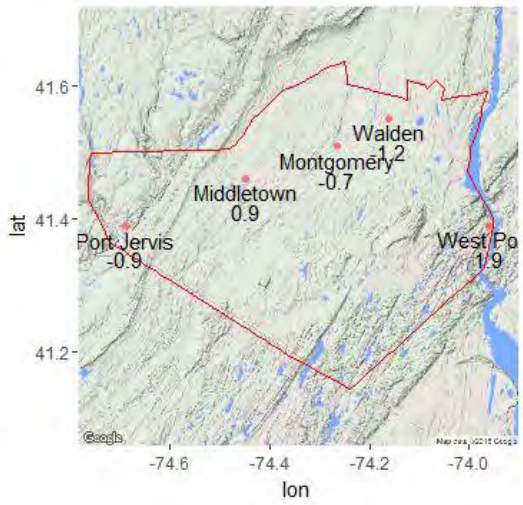
Vulnerability Assessment

Orange County Climate Profile

This overview of the county's climate includes historical trends and predictions based on expected climate change impacts on: temperatures, precipitation, severe weather, sea level rise, and flooding. Climate data is from the weather stations at West Point in eastern Orange County and Port Jervis in western Orange County (unless otherwise noted), and in most cases was available from 1900 through 2013.

Orange County is comprised of 838.9 square miles extending from the Hudson River to the eastern edge of the Catskill Mountains, an area known as the Allegheny Plateau. This geographically varied county is locally governed through forty-three municipalities and has a diversity of economic and natural resources. It spans the basins of two of America's major rivers, the Hudson and the Delaware. There are four distinct seasons with warm, humid summers and cold winters with heavy precipitation. The climate is temperate, with varied conditions across its expanse. The variation in climate, for example, depends on such local conditions as latitude, elevation, closeness to the Hudson River and proximity to urban areas that generate heat. Two locations on the eastern (West Point) and western (Port Jervis) sides of the county have long-term weather data collections with 105 overlapping years. West Point is consistently warmer than Port Jervis. There are five total sites across the county with overlapping weather station data from 2002 to 2005. Some sites are warmer while other sites are cooler than the countywide average for this time period. West Point is typically about 2°F warmer than average, while Port Jervis and Walden are about 1°F cooler than average.

Map 2.1. Orange County Weather Stations



Source: Menne et al (2017).

Orange County is affected by extreme weather events including ice storms, floods, droughts, heat waves, hurricanes, and major storms. 'Nor'easters' are storm systems that originate in the Atlantic Ocean off the northeast coast and can be among of the more powerful storms in the Northeast. Tornadoes are fairly uncommon, but in May 2018, as part of just one storm, four tornadoes killed 5 people in the Northeast, including an 11 year old girl in Newburgh.

Temperature

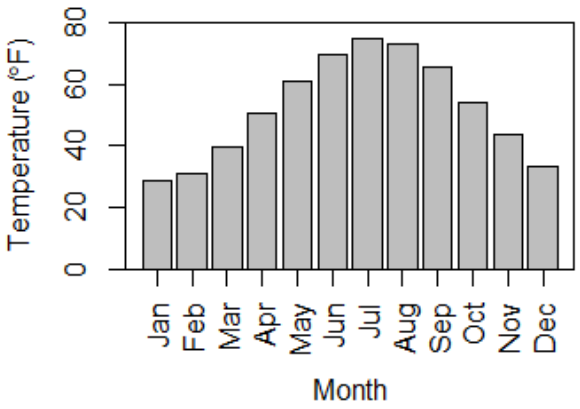
Average Temperatures

Orange County's four distinct seasons are marked by corresponding fluctuations in air temperature. From 1985 to 2013, the annual average temperature was 52°F, measured at the West Point weather station. Seasonal temperature averages for this time period were in the 30°F range for winter, 40°F to 60°F for spring, 60°F to 75°F for summer, and 35°F to 55°F for fall. From 1985 to 2013, the hottest month has been July, with average temperatures at about 75°F.

Observed Trends

In general, Orange County has seen warming trends, with variation based on both time period and season. From 1900 to 2013, the annual average temperature increased by 1.3°F per decade, with significant seasonal warming in the spring (+0.9°F per decade), summer (+0.6°F per decade), and winter (+1.8°F per decade).

Figure 2.1. West Point Average Monthly Temperature 1985-2013



Source: Menne et al (2017)

More recently, there was a decrease in spring temperatures of 1.2°F per decade from 1970 to 2013 and no significant annual trends in any other season. Limiting attention to the most recent time period available, from 1986 to 2013, there has been an increase in fall and summer by greater than 0.6°F each decade.

In sum, although trends are inconsistent across all seasons, there has been significant warming over the past century in Orange County, parallel to the most recent warm years in the United States and New York State generally (2013 to 2017). The country experienced three of the four hottest years on record in 2015, 2016, and 2017. In New York State, 2016 was the fourth and 2017 was the eleventh hottest year on record (NOAA 2018).

Table 2.1. West Point Annual Temperature Trends by Time Period and Season

Time Period	Annual (°F/Decade)	Spring (°F/Decade)	Summer (°F/Decade)	Fall (°F/Decade)	Winter (°F/Decade)
1900 to 2013	0.13*	0.09*	0.06*	0.09	0.18*
1900 to 2000	0.11*	0.13*	0.01	0.08	0.13*
1970 to 2013	0.14	-0.12*	0.13	-0.01	0.22
1986 to 2013	0.39	0.03	0.7*	0.61*	0.02

Source: Menne et al (2017). * indicates statistically significant difference

Projected Climate Change Impacts

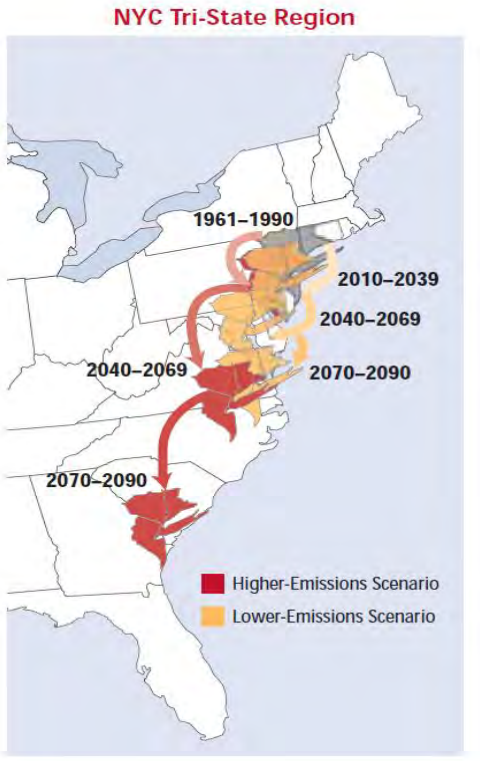
Climate models predict Orange County average temperatures will rise over the next century. Comparing the change in temperatures from 1971 to 2000, by the end of this century, county annual temperatures are expected to increase by between 1.6°F and 3.5°F in the 2020s, 3.1 to 6.9°F by the 2050s, 4.0°F to 10.7°F by the 2080s, and 4.3°F to 12.6°F by 2100. Climate models suggest that each season will experience a similar level of warming relative to the 1971 to 2000 baseline period (NYSERDA 2014 ClimAID Update).

Table 2.2. Orange County (Port Jervis) Predicted Average Annual Temperature Changes Through 2100

Baseline (1971-2000) 50.0°F	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentil
2020s	+1 .6°F	+2.2 to +3.1°F	+3.5°F
2050s	+3.1°F	+4.2 to 6.1°F	+6.9°F
2080s	+4.0°F	+5.4 to 9.6°F	+10.7°F
2100	+4.3°F	+6.2 to 11.2°F	+12.6°

Source: ClimAID Region 2. Predicted averages calculated using baseline temperature of 50.0°F (average temperature for this region from 1971 to 2000 in Port Jervis, NY). (NYSERDA 2014 ClimAID Update)

Figure 2.2. Migrating State Climates Under High and Low Emission Scenarios Projected Through 2090



Source: Confronting Climate Change in the U.S. Northeast (2007)

A high-emission scenario assumes a fossil fuel-intensive economy and a global population that peaks mid-century, and then slowly begins to use more resource-efficient technologies, while the low-emission scenario expects rapid increases resource-efficient technologies (Frumhoff et al. 2007). Under the former, Orange County may have a climate similar to that of South Carolina by the end of this century.

Extreme Temperatures

In Orange County from 1985 to 2013, the number of days with extreme heat, defined as days with 90°F+ temperatures, peaked during the summer months. There were an average of 8 annually in July, but some were as early in the year as April and as late as September.

Observed Trends

From 1900 to 2013 there was an overall decrease of 1 extreme heat days per decade in Orange County. However, looking back over a shorter period of time, from 1985 to 2013, the county has experienced a significant increase in extreme heat days, 23.6 days per decade. In the 1980s and 1990s Orange County experienced some cooler years that likely resulted in a lower average over the full 1970 to 2013 period.

Table 2.3. West Point, Orange County Annual Average Number of Days Each Year with Maximum Temperatures Greater than 90°F, 1900 to 2013

Time Period	Annual (days over 90F/decade)
1900 to 2013	-0.10
1900 to 2000	0.00
1970 to 2013	-1.04*
1986 to 2013	2.36*

Source: Menne et al (2017). * indicates statistically significant difference

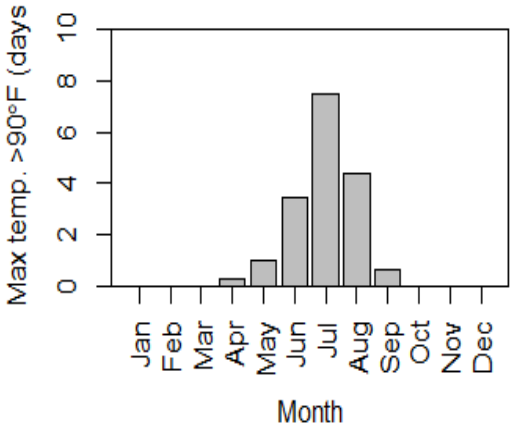
Table 2.4. Extreme Heat Event Projections through 2080s, Port Jervis, Orange County, NY

2020s	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days Over 90°F (12 days)	16	19-25	27
Number of Heat Waves (1 wave)	2	3	4
Duration of Heat Wave (4 days)	4	5	5
Days Below 32°F (138 days)	106	106-108	120
2050s	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days Over 90°F (12 days)	24	31-47	56
Number of Heat Waves (1 wave)	3	5-6	8
Duration of Heat Wave (4 days)	5	5-6	6
Days Below 32°F (138 days)	79	86-108	108
2080s	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days Over 90°F (12 days)	31	38-77	85
Number of Heat Waves (1 wave)	3	5-9	9
Duration of Heat Wave (4 days)	5	5-7	8
Days Below 32°F (138 days)	59	65-89	101

Source: NYSERDA 2014 ClimAID Update. These projections were calculated using a 6-component approach that incorporated local and global factors and is based on a 2000-2004 base period.

As noted, more recent years, especially 2016 and 2017, have been some of the warmest years on record with increasing heat waves.

Figure 2.3. Orange County Monthly Average Number of Days Each Year with Maximum Temperatures Greater than 90°F, 1985 to 2013



Projected Climate Impacts
Climate change is likely to increase the number of days with extreme heat in Orange County, as well as the number of heat waves (defined as three consecutive days over 90°F). By the 2080s, the annual average number of days with temperatures reaching above 90°F in the county is projected to increase from a low estimate of 31 and a high estimate of 85; the number of annual heat waves could increase from four to nine per year. At the other extreme, the number of days reaching below 32°F may also decrease to as few as 59 days each year by the 2080s.

Precipitation

Average Precipitation
Orange County currently receives approximately 51 inches of rainfall per year on average (excluding snow events) with the spring, summer, and fall seasons contributing between 11 and 14 inches each. During the winter, when most precipitation is snow, rain contributes fewer than 10 inches to the total.

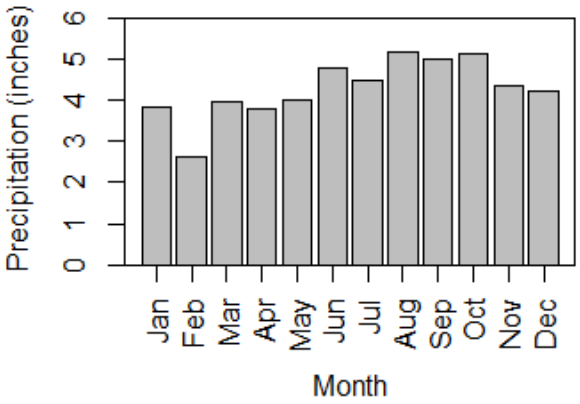
Table 2.5. West Point Annual Non-Snow Precipitation Trends

Time Period	Annual (in/Decade)
1900 to 2013	0.99*
1900 to 2000	1.05*
1970 to 2013	1.14*
1986 to 2013	2.14*

Source: Menne et al (2017). * indicates statistically significant difference

Observed Trends
Orange County is experiencing increasing precipitation with acceleration change occurring in the most recent time period. From 1900 to 2013, there was a significant average increase in precipitation of one inch per decade. Over the past 50 or so years, precipitation per decade increased by 1.14 inches. From 1986 to 2013, the increase per decade reached 2.14 inches.

Figure 2.4. Non-snow Rainfall at West Point by Month, 1985 to 2013



Source: Menne et al (2017).

Projected Climate Impacts Projections for precipitation in Orange County are highly uncertain due to the variability in observed trends and small scale modeling challenges. By the 2020s, Orange County could experience up to a 10 percent increase in precipitation, with up to a 24 percent increase by 2100 (NYSERDA ClimAID Update 2014). Although there is more uncertainty for seasonal projected precipitation changes, most of the increases are expected to be during the

Table 2.6. Predicted Average Annual Changes in Precipitation through 2100, Port Jervis, NY

	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	-1%	+1 to +8 %	10%
2060s	1%	+3 to +11 %	14%
2080s	2%	+6 to +14%	18%
2100	-6%	+1 to +18 %	24%

Source: Predicted averages calculated using baseline temperature of 46.0 inches (average precipitation for this region from 1971-2000 in Port Jervis, NY). (NYSERDA 2014 ClimAID Update) (ClimAID Region 2).

winter months (NYSERDA 2014). Increasing trends of rain mixed with snow during the winter may also lead to more frequent snow melts, less snow cover, increased ice, and more winter flooding.

Extreme Precipitation

An extreme precipitation event is defined as a 24-hour period with over one inch of precipitation. Heavy rainfall during such events can lead to flooding during every season, especially in urban areas with impermeable surfaces, steep slopes, and areas of low elevation. Flooding is most frequent in the spring, when rain and rapid snowmelt lead to increased runoff. Ice jams can also contribute to flooding locally in the winter and spring.

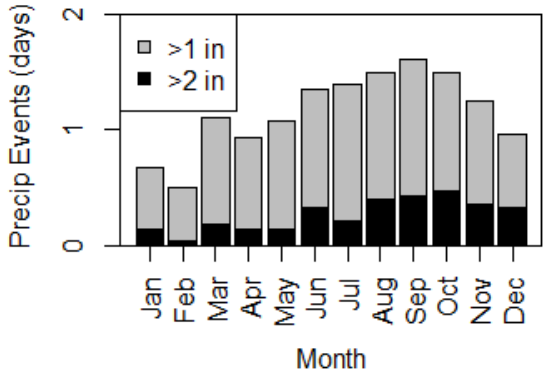
Observed Trends

On average from 1986 to 2013, most extreme precipitation events in Orange County occurred from June through October. From 1986 to 2013 yearly rainfall exceeded one inch on an average of 13.9 days, and 2 inches on an average of 3.1 days.

Looking back just over the last 50 years, there has not been a significant increase in these types of large storms, but there has been a significant increase in the frequency of storms per decade that exceeded one inch and two inches of rainfall from 1900 through 2000 and 1900 through 2013.

Multiple large storm systems (e.g., tropical cyclones) have hit the county in recent years, including Tropical Cyclones Irene, Lee, and Sandy, mostly in August and September. In Orange County, Hurricane Sandy (October 22 through November 2, 2012) was mostly a wind event coupled with storm surge on the Hudson River. Hurricanes Irene (August 21 through August 28, 2011) and Lee (September 1 through September 5, 2011) caused substantial flooding in many Orange County communities, notably in Washingtonville near the Moodna Creek.

Figure 2.5. Average Number of Observed Extreme Precipitation Events, >1 Inch and >2 Inches Per Day, 1985 to 2013



Source: Menne et al (2017).

Table 2.8. Trends in Extreme Precipitation Events, Increase In >1 Inch and >2 Inches Per Day, 1900 to 2013, West Point

TimeFrame	>1" (Events /decade)	>2" (Events /decade)
1900 to 2013	0.21*	0.19*
1900 to 2000	0.23*	0.16*
1970 to 2013	0.38	0.00
1986 to 2013	0.36	0.00

Source: Menne et al (2017). * indicates statistically significant difference

Table 2.7. Extreme Precipitation Event Projections through 2080s, Port Jervis, NY

2020s	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 1" Rainfall (Baseline of 13.9 days)	12-13	14-15	16-17
Days over 2" Rainfall (Baseline of 3.1 days)	3-4	3-4	4-5
2050s	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
Days over 1" Rainfall (Baseline of 13.9 days)	13-14	15-16	17-18
Days over 2" Rainfall (Baseline of 3.1 days)	3-4	3-4	5-6
2080s	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
Days over 1" Rainfall (Baseline of 13.9 days)	13-14	15-16	17-18
Days over 2" Rainfall (Baseline of 3.1 days)	3-4	3-4	5-6

Source: Projections calculated using a 6-component approach that incorporates local and global factors, and is based on a 2000-2004 base period. Precipitation measurements were taken in Port Jervis, NY. (NYSERDA 2014 ClimAID Update)

Projected Changes

Though there is uncertainty about the annual projected increases in precipitation, the intensity, duration, and frequency of extreme precipitation events are predicted to grow (NYSERDA, 2014). The number of days in which the amount of rainfall exceeds 1" could increase from 12 days to 16 days by 2100, and the number of days on which the amount of rainfall exceeds 2 inches may increase from two days to three days by 2100, depending on the emissions forecast scenario.

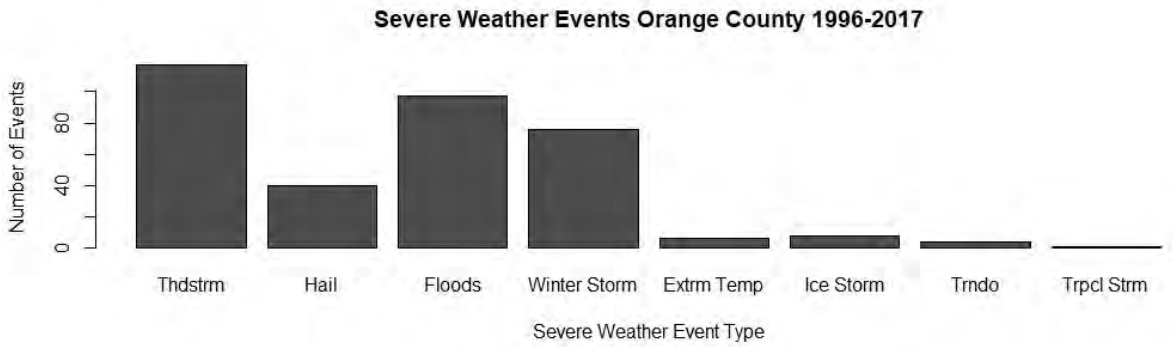
Severe Weather

Severe weather events pose a serious threat to Orange County citizens and often result in injuries, and in some cases death (NOAA Storm Events Database). The County frequently experiences such storms, with thunderstorms, hail storms, and winter storms most common. These can lead to floods and avalanches, resulting in extreme damage. Protection against these natural disasters at various locations has

been listed as medium to high priority in the Orange County Hazard Mitigation Plan.

Although an increase in the frequency of hurricanes has not been directly related to climate change, hurricane intensification rates have increased due to the passage over warmer ocean water (Fraza et al 2016, Mudd et al 2014). Therefore, while the number of hurricanes hasn't been linked to climate change, the strength and intensity of these storms is, and with it, increases in impacts and damage. The devastation Orange County experienced as a result of Hurricanes Irene and Lee in 2011 and Sandy in 2012 exemplifies this region's vulnerability to severe weather events.

Figure 2.6. Severe Weather Events, Orange County, 1996 to 2017



Source: (NOAA Storm Events Database). Winter storms include blizzards, heavy snow, and snowstorms.

Projected Changes

Local projections for severe weather events are not reliable for Orange County or elsewhere. These discrete events are difficult to predict and there is still a high degree of uncertainty in techniques for future trend projection (NYSERDA, 2011). Nonetheless, increases in the frequency and intensity of severe storms have proven to have dangerous consequences and have resulted in substantial economic and infrastructure costs; future developments therefore must be assessed as best as is possible (Walsh et al 2014, Smith et al 2015).

Nor'easters, Hurricanes, and Tropical Storms

NYSERDA's climate projections for large scale storms, including tropical storms, hurricanes, and nor'easters suggest that there will be an increase in intense, mid-latitude cold-season storms, and that they will take a more northerly track (NYSERDA 2011; Kunkel et al. 2008). There have been increases in Atlantic hurricane activity since the 1980s, and this is in part linked to higher sea surface temperatures in the Atlantic Ocean (Walsh et al 2014). This, however, is not the only factor that leads to hurricane development; research is still unclear on how climate change will affect hurricanes in the Northeast.

Nor'easters develop when a warm low pressure air mass rising from the Gulf of Mexico collides with a high pressure, cold air mass extending from the Canadian arc. Since climate change will affect oceanic and atmospheric patterns, the timing and frequency of these storms will likely be affected; however, changes in their intensity are unknown (Frumhoff et al 2007).

Thunderstorms and Tornadoes

Climate change increases the frequency of severe convective storms, including thunderstorms and tornadoes (Diffenbaugh et al. 2013). The factors that cause tornadoes and severe thunderstorms are a combination of atmospheric instability and increased wind speed, with altitude. There are projections for increases in the conditions that produce thunderstorms in the Northeast (Trapp et al. 2013; Trapp et al. 2007; Del Genio et al. 2007).

Sea Level Rise and Flooding

Global sea level is rising due to thermal expansion from warmer water temperatures and melting of land-based ice. Although Orange County has no ocean coast, several communities in the county are located along the Hudson River including Newburgh, New Windsor, Cornwall, and West Point/Highland Falls. The Hudson River is a tidal estuary and thus will be directly affected by sea level rise.

Observed Trends

Since 1990, sea level has risen by 13 inches in the lower Hudson, and mid-range projections predict that it will rise approximately 10-20 inches by mid-century (NYS DEC). Under a rapid-ice melt scenario, Hudson riverfront communities could experience up to six feet of sea-level rise by the end of the century. Sea-level rise coupled with more frequent and intense precipitation could lead to more frequent flooding along the Hudson River and threaten waterfront assets.

Flash floods are defined as a life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam). Floods are defined as any high flow, overflow, or inundation by water that causes damage. Since 1996, Orange County has experienced 66 flash floods and 31 floods. Most flash floods were caused by heavy rain, while floods were caused by either heavy rain, snowmelt, or tropical storms.

Projected Changes

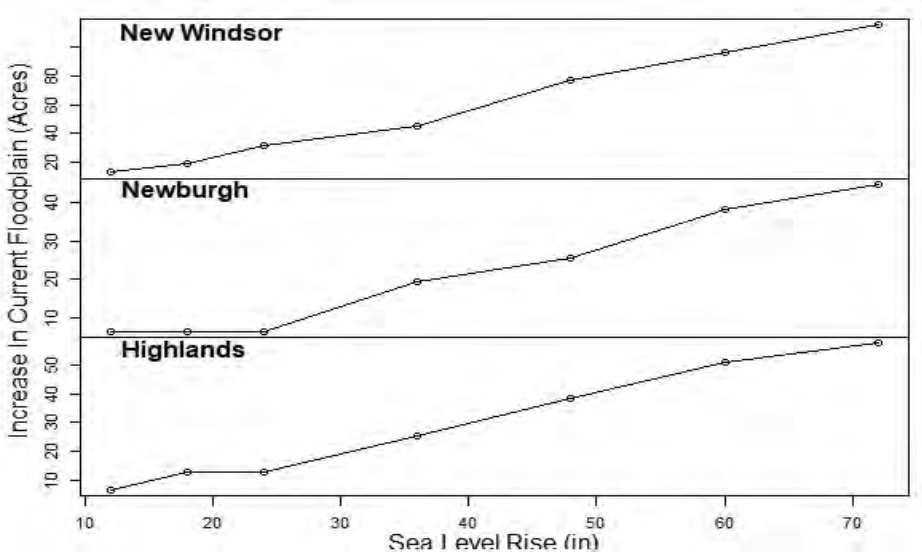
Regions in the lower Hudson Valley, including Orange County, can expect a 2 to 5 inch rise in the Hudson River by the 2020s. In the rapid ice-melt scenario, the river is predicted to rise as much as 41-55 inches. Rises of these magnitudes will result in flooding throughout areas in Orange County along the Hudson River. With increased precipitation, flooding could extend to more inland parts of the county. The 10-year floodplain for Newburgh and Highlands is predicted to increase 0.01 square miles with 12 inches of sea level rise; for New Windsor, increases by 0.02 square miles under the same sea level rise scenario are expected.

Table 2.9. Sea Level Rise Predictions for the Lower Hudson Valley and Long Island

Lower Hudson Valley and Long Island	2020s	2050s	2080s
Sea Level Rise	2-5 in	7-12 in	12-23 in
Sea Level Rise with Rapid Ice Melt Scenario	5-10 in	19-29 in	41-55 in

Source: NYSERDA ClimAID 2011. Reported values are the central range (middle 67%) of values from model based probabilities (16 global climate models by 3 greenhouse gas (GHG) emissions scenarios) rounded to the nearest inch. Rapid ice-melt scenario is based on acceleration of recent melt rates of the Greenland and west Antarctic ice sheets and paleoclimate studies.

Figure 2.7. Projected Increases in Floodplain Area for New Windsor, Newburgh, and Highlands

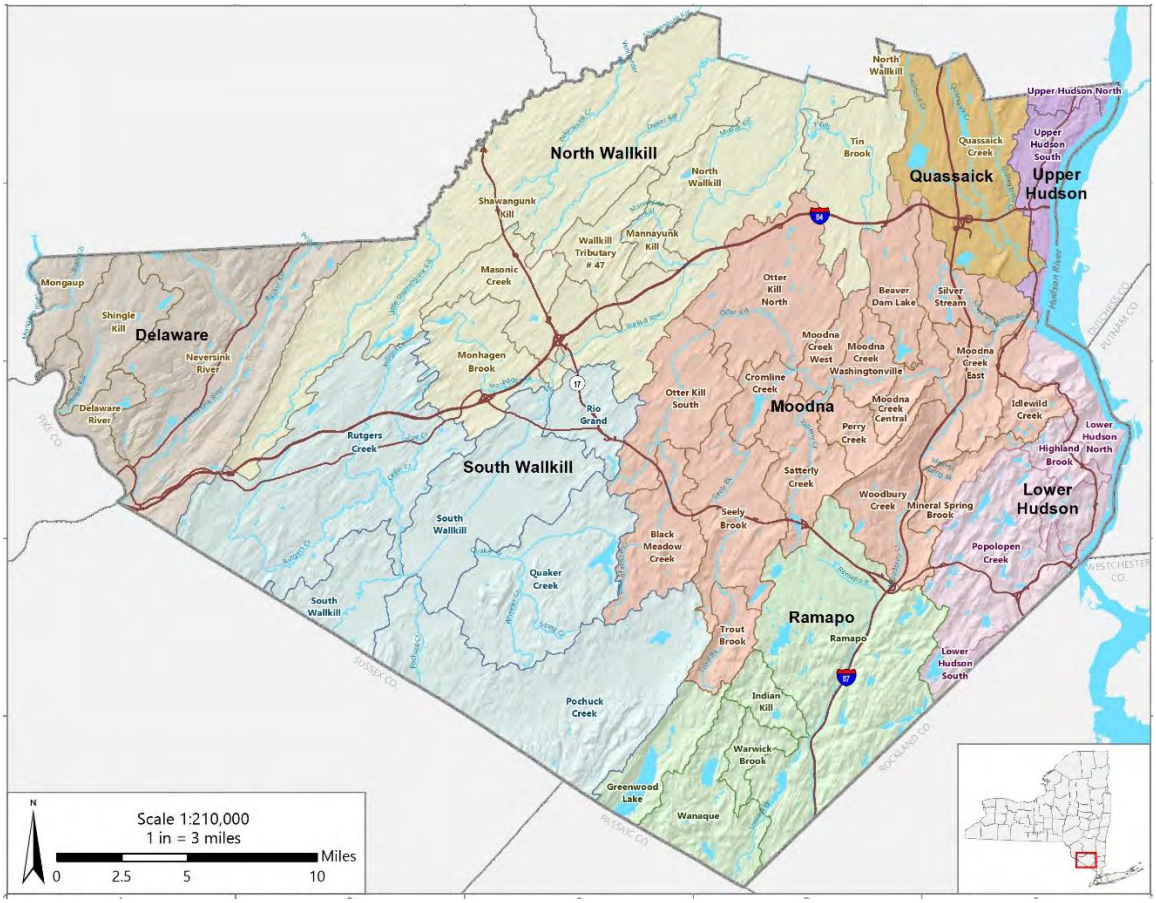


Source: NYSERDA Sea Level Rise Viewer

Orange County Watersheds

Orange County's 838.9 square miles are within eight watersheds: Upper Hudson River, Lower Hudson River, Quassaick Creek, Moodna Creek, Ramapo River, North Wallkill River, South Wallkill River, and Delaware River. A large portion of the Quassaick Creek watershed is contained within Orange County, with the remainder in Ulster County. The tributaries directly adjacent to the Hudson River are grouped into two watersheds that are defined as the Upper Hudson (northeast corner of Orange County) and Lower Hudson (eastern edge of Orange County). The rest of the watersheds extend beyond the county borders, but this analysis includes only the portions of these watersheds within Orange County.

Map 2.2 Orange County Watersheds



Key descriptors provided here for Orange County as a whole and each of the eight watersheds include square mileage and land cover, land, roads, bridges and critical facilities in flood plains, prevalence of steep slopes, percent of land that is protected open space, population and population density, miles of roads and railroads lines, drinking water sources, county owned assets and parkland, and the number of hazardous risks sites. Throughout this report, we will refer to climate vulnerability either as countywide or as specific to each watershed.

County Overview

Orange County is in the Hudson River Valley. It is bounded on the east by the Hudson River and on the west by the Delaware River. The county is bordered to the north by Sullivan and Ulster counties and to the south by Rockland County and the states of New Jersey and Pennsylvania. The county has 21 towns, 19 villages, and 3 cities. Seventy percent of its land cover is mostly forests, with a smaller proportion being water and wetlands. The county as a whole is less than 10 percent developed. Impervious surface cover is concentrated in or around its three cities - Newburgh, Middletown, and Port Jervis - and other towns and villages. Additionally, Orange County has thousands of acres of black dirt glacial beds in the Wallkill River valley that are prime agricultural lands and the locus of most of its agricultural production.

Orange County is home to nearly 385,000 people (United States Census Bureau Population Estimates Program, as of July 1, 2019). The County's 3.3% rate of population growth between 2010 and 2019 is higher than New York State's growth rate over that same time period, but lower that of the United States overall. This growth is primarily due to natural increase; the County lost population due to migration out of the County to other states. This "out-migration" is typically attributed to high housing prices and property taxes compared to neighboring counties further upstate and in Pennsylvania, an exodus of employers from New York State, and retirees looking for warmer climates. Orange County has actually seen a substantial increase in jobs, although many employers have left New York State in the last decade. However, the counties to which the most Orange County residents moved in the last ten years did include Broward County, Florida, a prime retirement destination, and Pike County, Pennsylvania, a county adjacent to Orange County with a significantly lower cost of living.

However, from 2015 to 2017, Orange County was ranked second in the New York State for population increase. The county is the northwestern-most county on the west side of the Hudson River with facilities served by Metro-North and the Metropolitan Transit Authority. This facilitates migrants coming to it from counties closer to New York City in the greater New York Metropolitan Area. Municipalities in commuter-friendly locations for jobs to the south all have positive growth trends. The most significant growth has taken place in the Village of Kiryas Joel, an insular Hasidic Jewish community that maintains the highest growth rate in the United States due to a cultural predilection for early marriage, a high birth rate, and in-migration from sister communities in Brooklyn. Kiryas Joel had a population increase of nearly 900 percent from 1980 to 2010. In that same time period, the towns of Greenville and Monroe and the Village of Washingtonville tripled and the villages of Chester, Harriman, and Montgomery doubled in population.

Orange County's water supply comes from three main sources: surface-water reservoirs, groundwater aquifers, and New York City's water supply aqueducts (Orange County Water Plan 2010). Twenty-nine municipal systems rely on surface reservoirs to provide 33 percent of the water used in the county. Many of these are located within developed areas, adjacent to the communities they serve. One hundred thirty-one systems draw 58 percent of the water used from groundwater aquifers through wells. By far, the majority of the county (80 percent by land area) relies on private, individually-owned wells that serve single-family residences. Four systems (New York Stewart International Airport, Cornwall-on-Hudson, City of Newburgh, Town of Newburgh, and Town of New Windsor) draw the remaining 11 percent of the county's water supply from the New York City Aqueduct. The New York City Aqueduct originates from large surface water reservoirs in counties north and west of Orange County. State law requires that it be made available within Orange because two New York City aqueducts (Catskill and Delaware) pass through the northeast corner of the County before crossing under the Hudson River. Orange County has 63 water districts and many cross municipal boundaries.

As in much of the United States, food supplied to people in Orange County is not locally sourced. Water shortages, soil degradation, and an increase in pests due to climate change will make food production in the United States more challenging (Rosenzweig et al 2014), and could adversely impact food security in Orange County. Also, drought in the western parts of the country may displace individuals; since the Northeast is expected to experience an increase in precipitation, the region will become a more desirable place to live, and population could potentially grow as a result (NYSERDA ClimAID 2011). With the threat of sea level rise in coastal areas of New York City, Orange County could have even more population growth than predicted, which could stress its water resources more heavily. Population growth in New York State is predicted to occur in higher-income exurban areas like Orange County that are further away from New York City than typical suburbs (NYSERDA ClimAID 2011).

<u>The Watersheds</u>

Moodna Creek Watershed The Moodna watershed is located in the eastern-central portion of Orange County. It covers an area of 181 square miles; 9 percent of its land is in the 100- and 500-year floodplains and 26 percent on steep slopes. The watershed is comprised of 17 sub-basins that are in all or parts of 22 municipalities. The Moodna watershed has the second largest population of the eight watersheds in the county but has moderate population density. Fifty miles of passenger and freight railroad lines and 80 miles of county-owned roads lie within the watershed. Most of these roads are located in the floodplain (69.6 miles). Land cover in the Moodna watershed is primarily comprised of forest (69 percent) and

agriculture (12 percent). The Moodna is home to over 400 acres of County parkland including portions of The Heritage Trail, Kowawese Unique Area, the Brick House Museum, and Gonzaga Park. The watershed has a total of 34.2 square miles of protected open space, including federal land, state parks and forests, privately owned preserves, and county-owned parks. Farming in the Moodna watershed is a substantial industry. Farmland is concentrated in areas with high-quality soils and flatter topography in the northern, western, and central parts of the watershed. Municipalities in the Moodna watershed rely on surface-water from eight reservoirs, and from private and municipal groundwater wells. These are primarily fed by deep bedrock aquifers and a small number of shallow sand and gravel aquifers. There are 423 stream miles in the watershed, and a stream density of 2.3. A total of 299 hazardous risk sites, including 14 remediation sites associated with agriculture, business, and industry are located throughout the watershed (Moodna Creek Watershed Conservation and Management Plan).

Quassaick Creek Watershed

The Quassaick watershed is located in the northeastern portion of Orange County. It covers an area of 33 square miles, with about 15 percent of its land in the 100 and 500 year floodplains and 14 percent on steep slopes. This watershed encompasses all or parts of four municipalities including the City of Newburgh and the Towns of Newburgh, New Windsor, and Plattekill (in Ulster County). The Quassaick is the second most densely populated watershed in the county. There are 2.4 miles of passenger railroad lines, and 11.2 miles of county-owned roads within it; all of this transportation infrastructure located in the floodplain. Land cover in the Quassaick watershed is primarily comprised of forests and natural features (68 percent) and urban areas (18 percent). The watershed has a total of 1.7 square miles of protected lands, including town parks, privately-owned preserves, and county-

Mount Saint Mary College science students recently aided the NYS Department of Environmental Conservation (DEC) eel-monitoring project in Newburgh's Quassaick Creek

owned parks. Urban land makes up 18 percent of the watershed. Water is supplied for municipalities in the Quassaick watershed from two surface-water reservoirs and the New York City's Catskill and Delaware aqueduct system, as well as private groundwater wells. There are 78 stream miles in the watershed, and a stream density of 2.4. There are 190 hazardous risk sites -- including 20 remediation sites associated with sanitation, agriculture, business, and industry.

Lower Hudson Watershed The Lower Hudson watershed is located in the southeastern portion of Orange County and covers an area of 52 square miles. About 9 percent of its land is in the 100- and 500-year floodplains and 56 percent on steep slopes. It encompasses all or parts of six municipalities -- including portions of Highland, Cornwall, Tuxedo, and Woodbury -- and has a low population size and density. No county-owned roads run through the Lower Hudson watershed. 10.8 miles of freight railroad lines lie within it, with portions of tracks in the floodplain. Land cover in the Lower Hudson is primarily comprised of forested areas (89 percent); the remaining 11 percent is made up of urban area, open water, and wetlands. A total of 23.9 square miles of open space is made up of protected lands state parks and forests, privately-owned preserves, and county-owned parks. There is no farmland in the Lower Hudson watershed. The water supply for municipalities comes from eight reservoirs, and 260 private and municipal groundwater wells primarily fed by deep bedrock aquifers. There are also a small number of shallow sand and gravel aquifers. There are 75 stream miles in the watershed, and a stream density of 1.5. Forty-one hazardous risk sites, and 3 remediation sites located throughout the watershed are associated with military waste, business, and industry.

Upper Hudson Watershed The Upper Hudson watershed is located in the northeastern portion of Orange County and covers an area of 15 square miles. One fifth of its land is in the 100- and 500-year floodplains and 25 percent on steep slopes. It encompasses all or parts of the City and Town of Newburgh and Town of New Windsor and is the most densely-populated watershed in the county. 11.9 miles of freight railroad lines as well as 10 miles of county-owned roads lie within it, but only about 10 percent is located in the floodplain. Land cover in the Upper Hudson is primarily comprised of forest (67 percent) but it has the highest impervious cover in the county (24 percent). The Upper Hudson is home to over 360 acres of county-owned parkland. The watershed has a total of 2.1 square miles of open space in state parks and forests, privately-owned preserves, and county-owned parks. Among the watersheds, the Upper Hudson relies the most heavily on New York City drinking-water aqueducts and surface reservoirs. There are 11 stream miles in it and a stream density of .9. There are 97 hazardous risk sites and 8 remediation sites associated with agriculture, sanitation, business, and industry.. The Upper Hudson ranked second in social vulnerability among the county's watersheds; half of its vulnerability flags are related to socio-economic status.

Wallkill River Watershed (both North and South) The Wallkill River runs north from it source in northern New Jersey to its confluence with the Rondout Creek in Ulster County before entering the Hudson River in the City of Kingston. The portion in Orange is located in the western-central portion of the county and encompasses 18 municipalities, including the City of Middletown, the Town of Wallkill, and the Town and Village of Goshen. The watershed covers an area of 382 square miles in the county, with about 26 percent of its land in the 100- and 500-year floodplains and 31 percent on steep slopes. A total of nearly 2000 acres of parkland is found in in Warwick (705.4 acres), the Thomas Bull Memorial Park (675.2 acres), Winding Hills (518.8 acres), the Glenmere (10 acres) and parts of the Blackbourne property.

For the purposes of this report, the Wallkill River watershed is divided into two sections – the North Wallkill and the South Wallkill – because of differences in the importance of agriculture and the City of Middletown's location in North Wallkill. Among the watersheds, the Wallkill watersheds has the highest population size but moderate to low population density. The headwaters of the Monhagen Brook are near Monhagen Lake, which serves as a water supply reservoir for the City of Middletown.

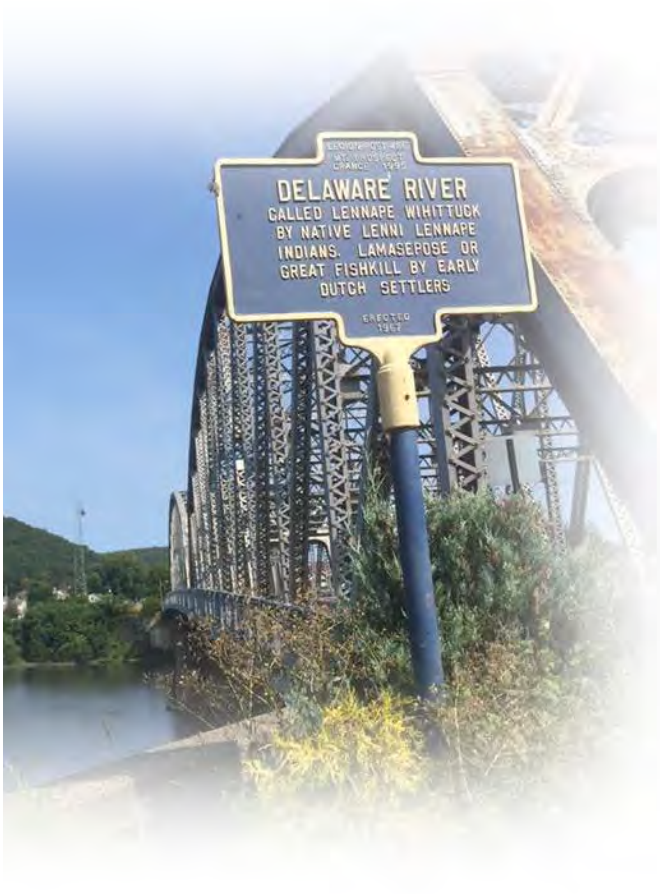
In South Wallkill 11.7 miles of freight railroad lines and 82.2 miles of county-owned roads lie within the watershed. Portions of this transportation infrastructure located in the floodplain, including a preponderance of the roads (78.9 miles). Among the watersheds, the South Wallkill has the highest percentage of land devoted to farming (30 percent).

The watershed has a total of 13.3 square miles of open space including federal land, state parks and forests, privately-owned preserves, and county-owned parks. Agriculture is a substantial source of income in the South Wallkill watershed, as it includes the Black Dirt Region, an area of glacial soil that yields high productivity.

There are 453 stream miles, and a stream density of 2.4. 169 hazardous risk sites, and 10 remediation sites are associated with sanitation, business, and industry.

27.9 miles of passenger and freight railroad lines as well as 94.11 miles of county-owned roads lie within the North Wallkill watershed, with portions of this transportation infrastructure located in the floodplain. Land cover in the North Wallkill has the second highest portion dedicated to agriculture (16 percent) among the watersheds. It has a total of 16.8 square miles of open space made up of state parks and forests, privately-owned preserves, and county-owned parks. Farming in the North Wallkill watershed is also a substantial business. The water supply for the City of Middletown consists of five connected surface-water reservoirs and ponds, including Monhagen Lake. There are 464 stream miles in the watershed, and a stream density of 2.4. 337 hazardous risk sites and 14 remediation sites are associated with sanitation, business, and industry.

Ramapo Creek Watershed The Ramapo watershed is located in the southernmost part of Orange County and covers an area of 93 square miles. About 6 percent of its land is in the 100- and 500- year floodplains and 49 percent on steep slopes. The watershed encompasses all or parts of nine municipalities including parts of Woodbury, Kiryas Joel, Tuxedo, Monroe, and Harriman, and has moderate population size and density. As noted, Kiryas Joel is the fastest growing community in the county. 10.3 miles of passenger railroad lines as well as 23.9 miles of county-owned roads lie within the watershed, with portions of this transportation infrastructure located in the floodplain, including about three-quarters of the roads (17.7 miles). Land cover in the Ramapo is primarily comprised of forest (86 percent), with the remaining 14 percent made up of open water, wetlands, and urban land. The watershed has a total of 53.4 square miles of protected lands including federal land, state parks and forests, privately owned preserves, and county owned parks. The water supplies for municipalities in the Ramapo watershed include surface water from Lake Mombasha and Walton Lake, which serve the Village of Chester, Village of Monroe, and Town of Monroe. Additionally, groundwater supplies portions of the Town of Monroe and the Village of Harriman. There are 125 stream miles in the watershed, and a stream density of 1.3. 124 hazardous risk sites and 8 remediation sites are associated with research facilities, business, and industry located throughout the watershed. The Ramapo ranked highest in social vulnerability among the county's watersheds; nearly half of its vulnerability flags related to socio-economic status.



Delaware River Watershed

The Delaware River is one of several major eastern United States rivers, starting in the southwestern Catskill Mountains and flowing along the New York/Pennsylvania and New Jersey/Pennsylvania borders before passing through Philadelphia and emptying in the Delaware Bay. The Orange County portion of the Delaware River on its far western side covers an area of 80 square miles, with about 9 percent of its land in the 100- and 500- year floodplains and 33 percent on steep slopes. The watershed encompasses all of the Town of Deerpark and City of Port Jeris and portions of Mount Hope, Otisville, and Greenville. It has both low population size and density. There are15.8 miles of passenger railroad lines and 10.7 miles of county-owned roads lie within this watershed, with portions of this transportation infrastructure in the floodplain. Land cover in the Delaware is primarily comprised of forest (89 percent), with the remaining 11 percent made up of urban land, agriculture, wetlands, and open water. The Delaware watershed is home to nearly 500 acres of county-owned parkland including the Swartwourt and D and H Canal properties. It has a total of 4.8 square miles of protected lands including state parks and forests, privately-owned preserves, and county-owned parks. Water is supplied for municipalities in the Delaware Watershed from three main reservoirs in the City of Port Jervis. Water in the Town of Deer Park is from private wells that primarily draw from the Neversink-Bashakill aquifer. There are 160 stream miles in the watershed, and a stream density of 2. There are 95 hazardous risk sites and 30 remediation sites associated with research labs, business, and industry.

Table 2.10. Orange County Owned Critical Infrastructure in 100- and 500-year Floodplains

Watershed	Critical Facilities in Floodplain	Bridges in Floodplain	Roads in Floodplain (mi)	Railroad Tracks in Floodplain (mi)
Upper Hudson	2	0	1.7	1.0
Lower Hudson	2	0	0	8.7
Quassaick	2	3	11.4	-
Moodna	7	29	69.6	4.7
Ramapo	-	5	17.7	3.1
North Wallkill	6	21	39.7	0.8
South Wallkill	12	38	78.9	3.7
Delaware	9	8	28.28	0.8

Figure 2.8. Orange County Watersheds by Land Cover

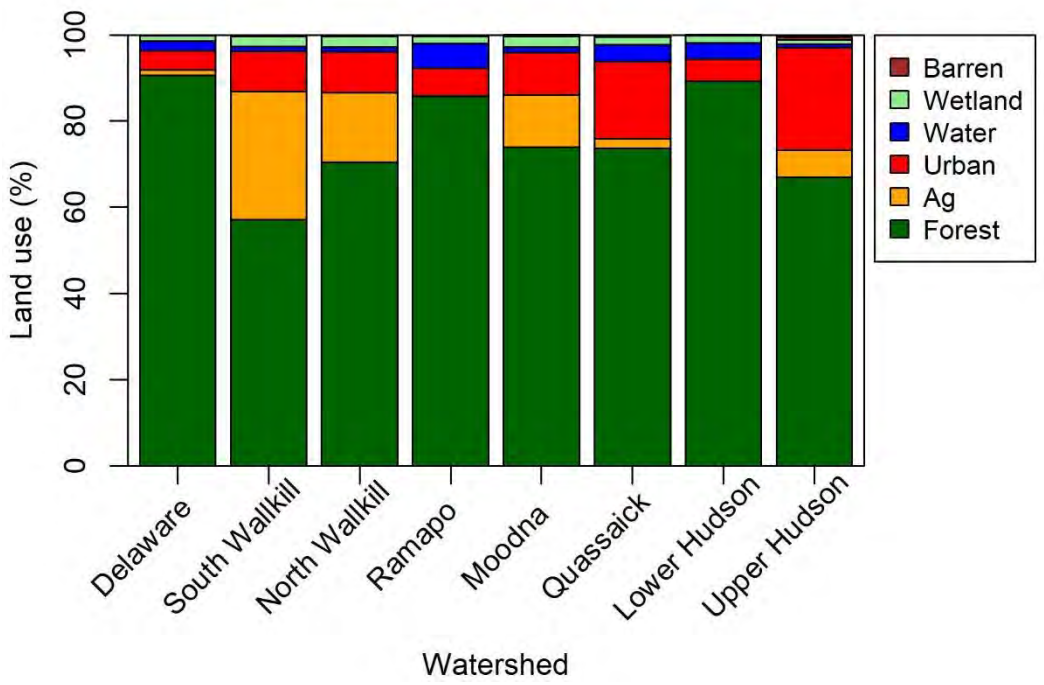
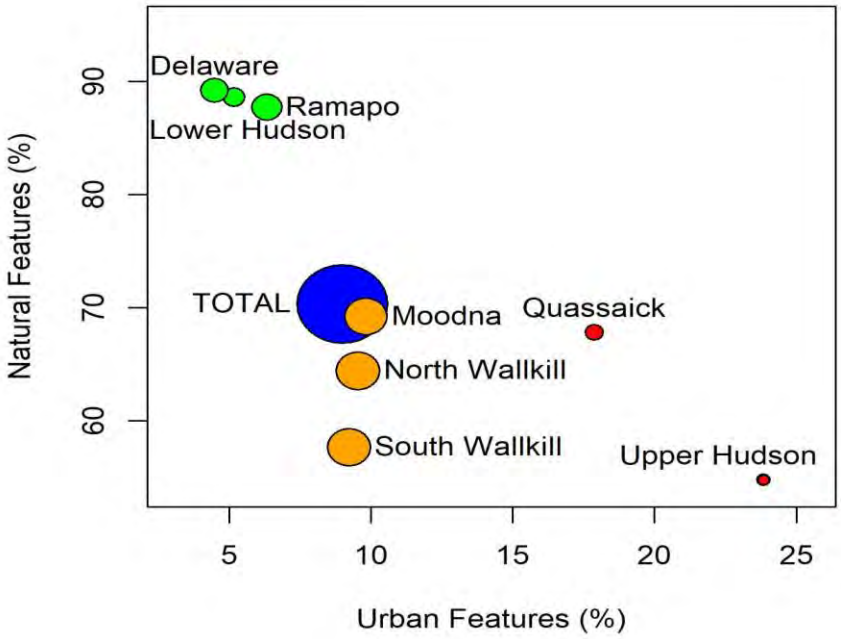


Figure 2.9. Orange County Watersheds Categorized Urban and Natural Features



Orange County is covered by urban features, characterized by impervious surfaces, and natural features, including forests, open water, and wetlands. The size of the point reflects the percent of the area in the particular watershed. Orange represents watersheds with more than 12 percent agriculture, red represents those with greater than 17 percent impervious surface, and green those with greater than 80 percent natural features. Blue indicates Orange County as a whole.

Figure 2.10. Orange County Watersheds: Stream Density, Miles of Streams, and Percent in Floodplains

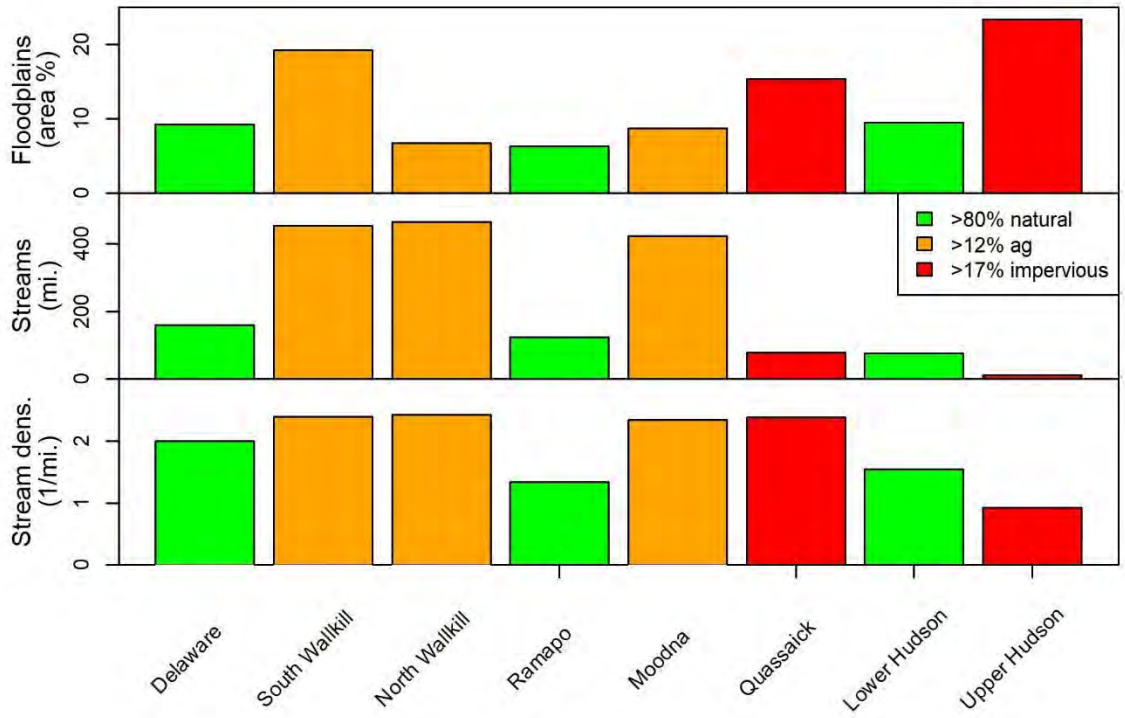


Figure 2.11. Orange County Watersheds: Population Size and Density

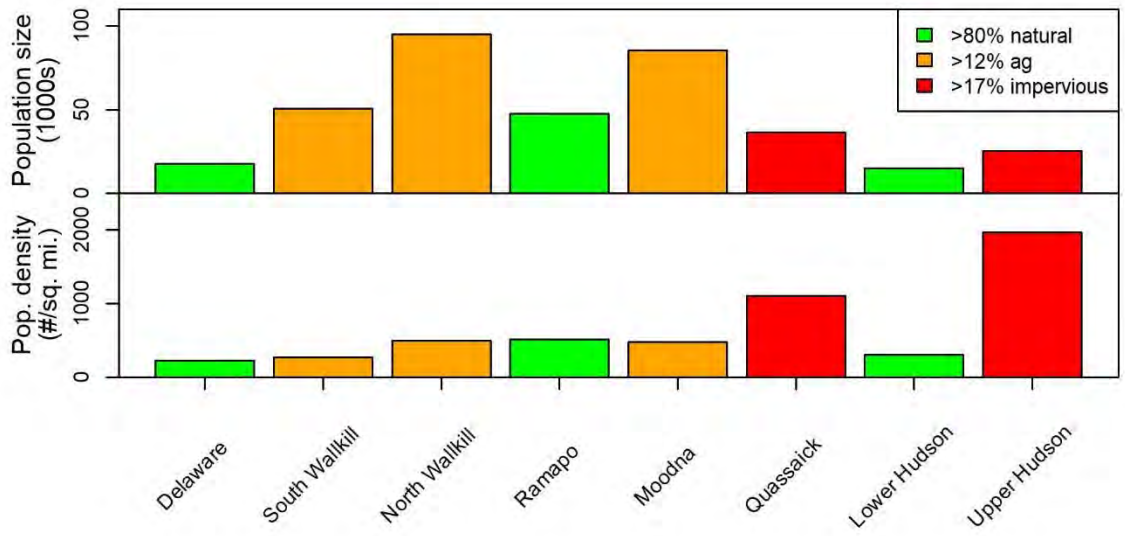


Table 2.11. Orange County Hazardous and Remediation Sites, by Watershed

Watershed	Remediation Sites
Upper Hudson	29
Lower Hudson	3
Quassaick	20
Moodna	14
Ramapo	7
North Wallkill	13
South Wallkill	9
Delaware	7

Natural Resources System Profile

Climate change will have serious impacts on Orange County's natural resources, including waterways, parks and public lands, and natural habitats.

Waterways

Climate change is likely to have both direct and indirect effects on water quality in Orange County lakes and rivers. Warmer ambient temperatures will increase water temperature in both rivers and lakes, resulting in a decrease in the concentration of dissolved oxygen available to support aquatic life, with negative effects on biodiversity. Warmer temperatures, combined with changes in precipitation, may also lead to more periods of low flow, disrupting the expected transport patterns and consequences of both point and nonpoint source pollutants, with greater chances of contamination (NYSERDA 2011).

Over 100 remediation sites exist within the eight watersheds in the county. Impact will be greatest on the Upper Hudson and Quassaick watersheds (with 29 and 20 remediation sites respectively). With changes in flow, all will require more rigorous monitoring procedures, making them the most vulnerable to these impacts.

Sea level rise will affect both rivers and associated wetlands, particularly the Hudson and its tributaries. By 2080, the Hudson River could rise up to 39 inches, causing wetlands to shrink and destroying coastal habitats (NYSDERA 2014). More intense precipitation could lead to streambank destabilization; sensitive riparian habitat could slump

Algae Blooms

The Wallkill River has recently experienced cyanobacterial blooms due to the combined effect of anthropogenic land use and climate change. The first bloom was noticed in August 2015, in New Paltz, Ulster County, downstream of Orange County. From August through October of 2016, another bloom was observed that reached from Orange County to the confluence of the Wallkill River with the Rondout Creek in Ulster County. The New York State Department of Environmental Conservation (NYS DEC) found that the algae causing these blooms was microcystis, a cyanobacteria that is capable of producing neurotoxins with negative effects on humans, dogs and other household pets dogs. Acute effects on human health can include vomiting, nausea, diarrhea, blistering around the mouth, and pneumonia. Harmful algal blooms can also lower dissolved oxygen levels throughout the water column, making it more challenging for aquatic life to survive. Microcystis density in the Wallkill River has at times exceeded 25 times past the maximum acceptable contamination level, requiring authorities to close recreational beaches. Cyanobacterial blooms develop where there are high temperatures, slow-moving or stagnant water, and an excess of dissolved nutrients (from, for example, a combination of urban and agricultural runoff and sewage overflows). Climate change will cause rising temperatures, prolonged periods of drought, and more intense storm events that can send a sudden surge of nutrients into otherwise slow-moving waters. Although cyanobacterial blooms are more common in lakes and reservoirs, these climate change effects may make the Wallkill more susceptible to these blooms (Riverkeeper).

Watersheds Impacted: North and South Wallkill

into rivers if these fail. This precipitation will also increase the concentration of suspended sediments and turbidity in rivers, making less light available for aquatic life. Warmer temperatures and changes in precipitation may also lead to eutrophication of rivers and lakes, redistributing nutrients and increasing the growing season for harmful algal blooms (Moss et al 2011).

Climate Change Impacts on Biodiversity in the Moodna

Climate-change driven threats to water quality in Orange County waterways will decrease habitat suitable to sustain aquatic biodiversity; the effects are likely to be most intense watersheds where land use is primarily agricultural or urban. The Moodna Creek and its tributaries support a variety of ecologically important communities. Riparian zones along the creek and its tributary the Otterkill Creek have been designated as a Priority Aquatic System. Floodplains and wetlands associated with the Seely Brook and Black Meadow Creek corridors have also been recognized as important areas for conservation (Biodiversity of the Moodna Creek Watershed 2008). The Moodna watershed is heavily agricultural. Biodiversity there is already vulnerable due to conversion of natural habitat to farmland. This, along with higher temperatures and more intense precipitation associated with climate change, can result in a destructive cycle that will threaten biodiversity. Larger quantities of excess nutrients from agricultural runoff entering waterways during intense storm events, coupled with higher temperatures, may produce harmful algal blooms. The result: even further decrease in of suitable habitat to sustain aquatic biodiversity for extended parts of the year.

Watershed Impacted: Moodna

The most vulnerable watersheds to sea level rise and flooding are those with high percentages of land in their flood plains: (Upper Hudson (23 percent); South Wallkill (19 percent); and Quassaick (15 percent)). Also at high risk are those bordering the Hudson and Delaware Rivers (Upper and Lower Hudson, Ramapo, Delaware), and the Wallkill and Moodna Creeks, because they have the highest stream mileage and stream densities.

Parks and Public Land

Orange County parks offer a variety of outdoor activities that enhance the quality of life for residents. These include hiking, camping, boating, and fishing. Simultaneously they preserve the county's natural resources, open space, and historical sites. By preserving open space, Orange County parks allow native biodiversity to thrive and rare habitats to shelter wildlife and be enjoyed by people. Changes in precipitation will likely make flooding in these areas more unpredictable, and could also alter drainage patterns, leading to decreased water quality. Preserving open space and designating park land within floodplains is therefore an attractive strategy, one that can prevent flood damage to residential and commercial areas by creating natural buffer zones.

Natural resources preserved in Orange County parks are vulnerable to climate change. With warmer temperatures, invasive species like the Hemlock Wooly

Adelgid and the Emerald Ash Borer will expand their range further and potentially considerably reduce the number of Hemlocks and Ash trees in Orange County forests. Warming temperatures will also change the composition of forests, pushing the lower latitude and elevation successional hardwood forests further north and upslope. Seven tributaries of the Moodna Creek are within Orange County, and provide critical riparian habitat for several endangered and species of concern including Wood Turtles, Northern Red Salamanders, Northern Dusky Salamanders, Cerulean Warblers, Indiana Bats, and Eastern Footed Bats. With more intense precipitation events due to climate change these riparian habitats will become more vulnerable to flooding, and streambanks will become destabilized, possibly diminishing the supportive environment for these important species.

Table 2.12. Orange County Owned Parks, by Watershed

County Park	Acres	Unique Features	Climate Change Threats	Watershed(s)
Swartwout	132.4	Ponds/rivers/streams Undeveloped parklands/ reservoir	Invasive species and pathogen outbreaks, species range shifts decreasing biodiversity, increased understory grazing by deer, increased cyanobacteria blooms, decreased water quality	Delaware
Warwick	705.4	Nature trails Ponds/rivers/streams	Increased cyanobacteria blooms, decreased water quality	Wallkill
Heritage Trail	160.2	11.85 mile trail extending through wildlife sanctuaries, forest, and along streams	Invasive species and pathogen outbreaks, species range shifts decreasing biodiversity, increased understory grazing by deer, increased cyanobacteria blooms, decreased water quality, flooding of pathway during severe precipitation events	Moodna
Thomas Bull Memorial Park	675.2	Arboretum Nature tails Ponds/rivers/streams	Invasive species and pathogen outbreaks, species range shifts decreasing biodiversity, increased understory grazing by deer, increased cyanobacteria blooms, decreased water quality	Wallkill
Winding Hills	518.8	Nature trails Ponds/rivers/streams	Increased cyanobacteria blooms, decreased water quality	Wallkill
Brick House Museum	37.5	Historical 1768 Homestead	Increased severe weather events may cause structural damages or flooding on the property	Moodna

County Park	Acres	Unique Features	Climate Change Threats	Watershed(s)
Gonzaga	216	Undeveloped parklands/reservoir	Invasive species and pathogen outbreaks, species range shifts decreasing biodiversity, increased understory grazing by deer, increased cyanobacteria blooms, decreased water quality	Moodna
Algonquin	44.8	Nature trails Ponds/rivers/streams	Increased cyanobacteria blooms, decreased water quality	Upper Hudson
Cronomer Hill	317.9	Nature trails Ponds/rivers/streams	Increased cyanobacteria blooms, decreased water quality	Upper Hudson
Kowaese Unique Area at Plum Point	102	Nature trails Hudson Riverfront Beach Shore	Sea level rise will increase flooding of the shoreline and decrease habitat available for wildlife.	Lower Hudson
D and H Canal	339.6	Nature trails Basha Kill Wildlife Management Area: protected marsh wetland Limestone caves Oak-hickory-birch-maple forest	More intense precipitation events may destabilize soil and streambanks, decrease wetland water quality, and flood caves.	Delaware
Blackburne Property	67.7	Undeveloped parklands/reservoir	Invasive species and pathogen outbreaks, species range shifts decreasing biodiversity, increased understory grazing by deer, increased cyanobacteria blooms, decreased water quality	Wallkill
Total	3327.5			

The Hudson River Climate Change Impacts

The Hudson River is a tidal estuary and thus more directly connected to the Atlantic Ocean than any other water body in Orange County; therefore the river has the greatest potential to be affected by sea-level rise. Today's 100-year flood will likely become a 50-year flood by the 2020s and will have an even smaller recurrence interval by mid-century (NYSDEC-Hudson River Estuary Program Report DATE). With bigger events, flooding will intensify and valuable wetlands and riparian habitat in the Hudson River Estuary Areas of Biological Concern will be negatively affected. Rare habitats of the Hudson River Estuary tidal wetlands in Orange County include floodplain forests, dwarf shrub bogs, shrub swamps, calcareous fens, and mud flats. They support a great diversity of plants, reptiles, and amphibians. Six turtle species are listed by the state as endangered, threatened, or of special concern. Rare bird species in these wetlands and listed as threatened include the Least Bittern. Riparian zones along the Hudson River offer shade, leaf litter as a food source, undercut banks, soil stabilization, and woody debris for aquatic species. They also sustain stream health by moderating water temperature moderation, control erosion and sedimentation, and remediate non-point source pollution. With sea-level rise, wetlands in this area will have to migrate upland, but can only do so if adequate open space in which to move exists. A model developed by researchers at Scenic Hudson to determine how marshes will migrate upland in the Hudson River Estuary under several sea level rise scenarios determined that by 2100, based on the current sea level rise trend, 33 percent of new wetlands would occur in undeveloped uplands. Of these lands, nearly half (47 percent) are in already protected area, with the remaining portion (53 percent) vulnerable to potential development (Tabak et al 2016). The undeveloped uplands require protection to enable the preservation of moving wetland habitat. If land is developed or physically separated from tidal wetland, rises in sea level coupled with more frequent intense storms will saturate floodplain forest soils for longer durations of time, and trees may no longer be able to survive. Loss of that ecosystem function will decrease thermal regulation, stream bank stability, and overall water quality in the Hudson River. There will be decreased dissolved oxygen, increasing nutrient loads, and increasing suspended sediments in the water. Under this scenario, the Hudson River Estuary ecological communities could also experience substantial declines in biodiversity as a result of climate change.

Watersheds Impacted: Upper and Lower Hudson, Quassaick, Moodna, Ramapo

Natural Habitat

All natural areas and state parks in Orange County are a part of the Northeastern Coastal Forests ecoregion. This ecoregion is dominated by temperate broadleaf and mixed forest ecosystems. Critical habitat types that make up these ecosystems include dry-mesic oak forests, hemlock-northern hardwood forests, dry oak-pine forests, pine-oak rocky woodlands, early successional plant communities dominated by Eastern Red Cedar, and freshwater wetlands (Olsen et al 1998). Typical terrestrial mammals in this ecoregion are white-tailed deer, eastern gray squirrels, chipmunks, red foxes, coyotes, beavers, and black bears. Over 250 species of birds rely on this ecoregion as a year-round habitat or breeding ground. The area is also home to a variety of reptiles, including copperheads, timber rattlesnakes, and snapping turtles. This ecoregion is vulnerable to climate change. Although many of these species can tolerate higher temperatures and will benefit from a lengthened and more productive growing season, outbreaks of invasive species will increase, and changes in precipitation may also present several obstacles. Changes in precipitation patterns may affect soil moisture and hillslope stability, leading to altered disturbance regimes, with more wildfires and large erosion patterns.

Climate Change Impacts on Biodiversity in the Quassaick Creek Watershed

The Quassaick Creek is one of 65 major streams and rivers that flow directly into the Hudson River Estuary. The creek provides natural habitats for a wide range of species, and contributes freshwater and essential nutrients to the Hudson River. The Lower Quassaick Creek has steep river-bank slopes and low-lying ponds that serve as potential breeding habitat for amphibians. The Quassaick is a critical passageway for the American Eel in its glass eel life stage, as it journeys from its marine origins in the Sargasso Sea to its freshwater habitat. In recent years this Creek has been listed on DEC's Priority Waterbodies List (PWL) because of a combination of urban runoff and sewer/storm overflows from Newburgh and New Windsor. Climate-driven changes in precipitation may increase the amount of polluted stormwater runoff; with more intense storm events, breeding habitat for amphibians may also be threatened if slopes are destabilized. A Quassaick Creek Watershed Management Plan was developed in 2012 by the Orange County Water Authority in collaboration the Quassaick Creek Watershed Alliance as an important step conserving, managing and improving this watershed

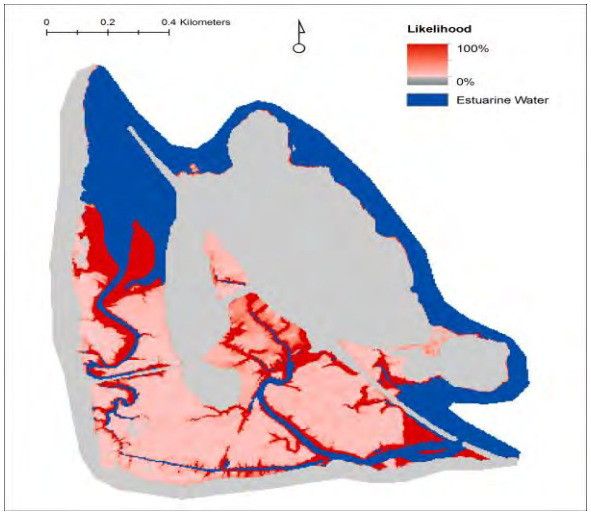
Watershed impacted: Quassaick

Forests in Orange County are typically composed of hardwood species including maple, beech, and birch. Higher elevations are dominated by spruce/fir forests. With climate change, maple, beech, and birch ranges are projected to move significantly northward, and suitable spruce/fir areas will become scarcer or non-existent (Frumhoff et al 2007). With higher temperatures, the growing season will increase, but invasive species like the Emerald Ash Borer and the Hemlock Wooly Adelgid will be able to extend their ranges and destroy more trees in a year. The Eastern Hemlock has an important

role in northeastern ecosystems that is especially vulnerable to climate change because its preferred habitat is along shady stream banks. Also, it's threatened by the Wooly Adelgid. The Eastern Hemlock preferred habitat is expected to shrink by up to 50 percent under the high emissions scenario, and by 25 percent under the low emissions scenario (Frumhoff et al 2007). Without Hemlocks to cool streams, stabilize stream banks, and provide habitat for native brook trout, aquatic ecosystems will become more vulnerable to severe storm events.

The ecologically important Iona Island/Doodletown Bird Conservation Area is located within Bear Mountain and Harriman State Parks in Orange and Rockland Counties. This area, which encompasses one of the largest tidal wetlands on the Hudson River and a steep, rocky undeveloped forest, has been designated as a Significant Coastal Fish and Wildlife Area, a National Natural Landmark, and the Hudson River National Estuarine Research Reserve. The tidal wetland ranges from freshwater to brackish habitats, with non-vegetated tidal flats, subtidal aquatic beds, tidal creek channels, a high gradient freshwater creek, and rocky uplands. . Both sections, which provide important habitats for over 165 species of birds, as well as fish spawning and nursery areas (NYS Parks), are vulnerable to climate change. Sea level rise will convert tidal wetlands to areas of open water, especially if the current wetlands are located on or near steep slopes. Changes in winter precipitation and warmer temperatures can increase the growing season for the Doodletown forest, but more frequent intense precipitation events may destabilize rocks and soil.

Figure 2.12. Projected Iona Island Marsh Tidal Wetland Inundation by 2100



Source: Projection is part of study done by Scenic Hudson using the Sea Level Affecting Marsh Model (SLAMM) to predict the potential for wetland migration in the Hudson River Estuary (Tabak et al 2016).

Infrastructure System Profile

Climate change will have significant impact on Orange County' infrastructure, including sewer and sewer systems, transportation, waste disposal, communications and emergency response systems, and energy supply modalities.

Water and Sewer

Water supplies and sewer systems are vulnerable to several climate change factors. Higher temperatures will increase evapotranspiration, and -- when this is coupled with more sporadic precipitation events -- droughts may become more frequent. Both water and sewer systems will be affected by an increase in extreme weather, which could lead to combined storm water/sewage overflows, a decrease in water quality, and floods.

Water Supply

Just under half (44 percent) of Orange County's water supply comes from surface water sources that include natural and manmade reservoirs and the New York City aqueducts; the remaining (56 percent) is supplied from groundwater. The local sources, moderately sensitive to climate change, are unlikely to be depleted by it, though summer droughts may become more frequent.

Warmer air temperatures will bring more frequent intense precipitation events, separated by more frequent, longer dry periods, and increased rates of evapotranspiration (ClimAID 2011). This may alter surface-groundwater dynamics, making recharge rates less predictable and putting stress on these water supply systems. Surface water sources are more vulnerable to climate change. Higher temperatures and increased severe storms will increase nutrient discharge and may lead to both eutrophication, and an increased amounts of suspended sediment. Higher rates of evapotranspiration associated with higher temperatures will lead to less stored water, especially in the warmest summer months, and higher concentrations of contaminants. While the current demand for water in Orange County is likely to be sustained into the future, an increase in the population and an increase in agricultural demand for water could put stress on the county's water resources.

The Contamination of Newburgh's Water Supply

Prior to May of 2016, the City of Newburgh received its drinking water supply from the Washington Lake reservoir which is located within the Quassaick Creek watershed. Testing conducted by the City starting in 2013 through 2016 under the US EPA's UCMR-3 (Unregulated Contaminant Monitoring Rule #3) program, revealed the presence of PFAS chemicals in the City of Newburgh's source water at Washington Lake reservoir. The PFAS chemical of the highest concentration was perfluorooctane sulfonate (PFOS), a chemical that is widely used in airports and military bases as a constituent in firefighting foam. According to the US EPA PFOS causes reproductive and developmental issues in fetuses and newborns and has been associated with high cholesterol, thyroid disease, and immune suppression (REF). The contamination of the source drinking water in Washington Lake exposed the City's population to this toxic chemical, possibly over decades. Site investigations undertaken by the Air National Guard, US Army Corp. of Engineers and reviewed by the New York State Department of Environmental Conservation have demonstrated that Stewart Air National Guard Base is a major source of the ongoing PFAS contamination of the watershed. New York State has constructed a Granular Activated Carbon facility at the City's Water Treatment Plant in a planned attempt to treat contaminated Washington Lake water for use as a drinking water supply for the City of Newburgh. However, this plan has been rejected by the City of Newburgh as the viability of this treatment system remains questionable, and the City Council has passed a resolution preventing the City from going back onto Washington Lake as a source of drinking water. PFAS contamination is no longer present in the City's drinking water supply since the City switched sources from Washington Lake to the New York City Department of Environmental Protection's Catskill Aqueduct in June 2016. However, pollution continues to be discharged from the upstream airport property into the watershed of Washington Lake. The City has since closed diversion gates to prevent contaminated runoff in the tributaries from continuing to reach the reservoir. This contaminated runoff is now diverted to the watersheds of the Quassaick Creek and Moodna Creek. Any long-term drinking water protection plan requires a commitment to remediating the watershed and protecting the source waters for the reservoir. Preserving these source waters will involve meticulous monitoring of the land uses within the watershed, quality of streams, groundwater, and wetlands so that water reaching the reservoir is free from contaminants Remediation of PFAS chemicals in the source waters may become even harder to achieve with climate change, since precipitation and streamflow patterns will become more intense and variable, thus requiring any future remedial measures to be appropriately sized and positioned to accommodate such extreme events. An increase in the intensity and frequency of severe weather events will also complicate protection of source waters, since wetlands provide valuable water remediation processes, and are most vulnerable to these events.

Watersheds Impacted: Quassaick and Moodna

The county has 63 water districts; many cross municipal boundaries. Many municipalities are reliant on water sources with watersheds that lie at least partially beyond their own municipal borders.

Table 2.13. Water Supply Vulnerability to Climate Change in New York State

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

Source: NYSERDA 2011

Kiryas Joel Water Supply

In 2019, the Hassidic Village of Kiryas Joel was included in the newly created, larger Town of Palm Tree. Access to water has been the subject of almost twenty years of litigation between the village of Kiryas Joel and neighboring communities. Hassidic communities are densely settled and rapidly growing. Increased demand for water is expected. The new town must secure a water source by 2021. For the village, a first phase of developing new water supply infrastructure included a 6.5 mile pipeline reaching across Woodbury, and connecting to a well in the Mountainville area of Cornwall. The projected cost is $37 million and includes 24 inch diameter pipes, two pump stations, two storage tanks, generators, and a chlorination plant. Kiryas Joel is currently permitted to pump 612,000 gallons a day from this well. There are several lawsuits concerning whether pumping this quantity of water will deplete groundwater supplies and the Woodbury Creek. To address this, the village has begun a second phase, costing $23 million, to add another seven miles of pipeline to tap into New York City's Catskill Aqueduct system and build a treatment plant to filter water coming from the Ashokan Reservoir. Almost certainly, Palm Tree's water needs will drive conflict with surrounding towns as the area becomes more densely populated and with potential climate change related droughts.

Watersheds Impacted: Moodna and Ramapo

Increased Demand from Population Growth

We saw in the post 9-11 period how crisis there encourages outmigration from New York City. Sea level rise and storm surge arising from climate change may cause people to move away from low-lying downstate coastal areas to surrounding areas at a higher elevation. Orange County may be a desirable location to which to relocate, since it is less vulnerable to coastal flooding and because of its close proximity to the city. There is also a potential for people from the Western United States to move to the Northeast because of predicted long-term droughts in those areas (ClimAID 2011). While the water demand for current population projections for

Orange County present minimal supply deficits for the county overall, some localized issues may arise including decreased water quality and supply from small reservoirs and increased stress on local aquifers.

Increased Industry Demand

Agricultural land use in Orange County is substantial in some watersheds, in particular the South Wallkill (30 percent), North Wallkill (16 percent), and Moodna (12 percent), and potentially may stress on the county's water resources as a result of climate change impacts. As noted earlier in this Report, seasonal trends in precipitation are uncertain, but decreased rainfall and prolonged periods of drought in summer months could increase the demand for water in the indusstrial sector (NYSERDA 2011). This may also force farm owners who can no longer rely on regular precipitation to sustain their crops to install or expand existing irrigation systems. The demand for agricultural production in Orange County may also increase due to a longer growing season and decreased agricultural capacity in areas of the country that serve as traditional food suppliers. New York State may see a return to historic agricultural land cover to make up for the deficit in production elsewhere.

Algal Blooms in Water Supplies and Anoxia

Cyanobacteria are photosynthesizing organisms that exist in lakes and reservoirs across the world. Some cyanobacterial species have the ability grow into massive blooms that produce harmful toxins and modify food webs through oxygen depletion. Algal blooms favor warm and calm lake and reservoir water. Increased temperatures, increasing stratification strength in freshwater ecosystems, and alteration of flood and drought periods due to climate change may enhance cyanobacterial blooms (Pearl and Huisman 2009). In drinking water reservoirs and lakes, management of nutrient loads and hydrology are the primary techniques used to controlling harmful algal blooms. But also, climate change must be considered in management planning. In 2018, eight waterbodies tested positive for HABs.

Middletown Algae Blooms

The City of Middletown ha five surface water sources that feed two water treatment plants. Two impoundments (Kinch Pond and Mill Pond) both feed the Shawangunk Reservoir, which, in turn, feed both Highland Lake and Monhagen Lake. Highland Lake supplies water to the Highland water treatment plant and has a connection into Monhagen Lake, which then supplies water to the Monhagen water treatment plant. No algal blooms with cyanobacterial neurotoxins were found during a 2000-2005 survey of the lake (Yang 2007). However, Monhagen Lake later experienced blooms that forced closure of the reservoir in 2016. The other reservoirs were used for water supply while the Monhagen system was flushed clear of the algal bloom (Middletown Common Council Meeting June 2016 minutes). Temperature increases and drought/storm cycles associated with climate change are producing conditions that are optimal for cyanobacterial blooms. The number of water supply systems that, like Middletown, have experienced these is growing. Current water treatment methods used at Monhagen Lake are often not effective for removing the cyanobacteria and their toxins. Unless alternative methods are put in place, harmful algal blooms will shut down water supplies until the toxins decrease below harmful levels (NYS DOH). It could cost municipalities millions of dollars to install treatment controls and set up toxin testing protocols (EPA 2015). In 2018, the Middletown water supply was one of twelve included in a multi-million dollar statewide initiative to understand and prevent harmful algal blooms that threaten recreation and drinking water.

Watersheds Impacted: North and South Wallkill

Sewage Treatment and Stormwater Management

Wastewater treatment plants are typically located on the banks of rivers for easy discharge of treated water. Several wastewater treatment systems in Orange County are within the current 500-year floodplain by necessity, making pollution of these waterways inevitable. An increase in the frequency of severe storms and intense precipitation events will increase the occasions on which Orange County's sewage and stormwater management systems are overloaded. This would discharge untreated sewage and stormwater into surface waters, and certainly decrease overall water quality.

Newburgh's Wastewater Treatment Plant on the Banks of the Hudson

The City of Newburgh processes wastewater through a treatment plant and combined sewage overflow (CSO) collection system that drains into the Hudson River. These facilities are owned by the City of Newburgh and operated by INFRAMARK Water Infrastructure Operations, a licensed private contractor hired by the City. In 2012, Hurricane Sandy passed over Orange County resulting in high winds, large volumes of precipitation, and increasing river stage levels. The resulting storm surge flooded a portion of the wastewater treatment plant property. According to the City of Newburgh Wastewater Treatment Plant October 2012 monthly report from the contract operator, normal operations were not affected but cleanup to the plant and repairs to several pumps cost tens of thousands of dollars. In January of 2016, the City executed an order on consent with the NYSDEC to implement a 15-year Long Term Control Plan to reduce the frequency and duration of combined sewer overflows into the Hudson River and Quassaick Creek by increasing the combined sewer capture rate from the current 73% to greater than 85% so that water quality would return to swimmable status within a reasonable time period following a storm event.. With climate change, more intense storms will produce even more stormwater and combined sewer flows. The City of Newburgh will need to expend more than $42 million to implement its 15 year Long Term CSO Control Plan in an effort to comply with this mandate and accommodate these storm events. .

Watershed Impacted: Upper Hudson

Combined Sewage Overflows and Sewage Backups

During intense precipitation events, stormwater runoff exceeds the amount of water that can infiltrate into the ground and sewage systems. This causes a combined sewage overflow, and results in., untreated sewage and stormwater being released into rivers, resulting in high levels of bacteria. Sewage backups into homes also can occur during heavy precipitation events. Increased severe storms and precipitation events can result in simultaneous increased sewage backups and combined sewage overflows. This along with sea level rise can lead to more flooding of sewage systems and decreased surface water quality.

Transportation

Orange County has state roads and highway; local roads; airports; and freight and commuter rail. These interconnected modalities support commuting to work throughout the metropolitan region, all local business activity and every manner of local and long distance travel for County residents and visitors. All are likely to be affected by climate change.

Public Transportation

Sixteen individual transit operators in Orange County provide public transportation service in four general categories: Commuter Bus, Local Bus (fixed route), Dial-A-Bus, and Paratransit services. These services, known as Transit Orange, coordinated by the Orange County Planning Department. Sea level rise will increase the number of miles of bus routes that are within the floodplain, making them less reliable in storm events. Public transportation in Orange County also includes a ferry service that connects Newburgh to Beacon. Sea level rise and an increase in more intense precipitation events could damage ports and harbors required for ferry services. Extreme heat may also cause rider discomfort and generate worker safety issues. The number of days that air conditioning on buses is used is likely to increase, and the number of days that maintenance work on public transportation infrastructure can occur may be reduced due to unsafe working conditions in extreme heat.

Roads

247 miles of roads and 104 bridges in Orange County are located within the floodplain. Most are in the Moodna (69.6 miles of road, 29 bridges) and South Wallkill (78.9 miles, 38 bridges) watersheds. Roads along the Hudson River will be subject to an increased flood risk due to sea level rise and more frequent intense precipitation events. Elevated highways will not have this risk; however, exit and entrance ramps could be affected by flooding. Intense precipitation events can overloaded stormwater system may lead to flooded roads, delays, car accidents, and damage to infrastructure. To minimize damage in flood events, roads that currently show early signs of failure should be repaired, and rock-catchment barriers reinforced to prevent landslides from reaching roads. Bridges should be reinforced and larger hydraulic openings built to prevent flood damage from ice jams.

Ice Jams in the Delaware Threaten Infrastructure

When an ice jam occurs, water rises rapidly behind it and water pressure builds. When the jams face rapid flooding downstream occurs, resulting in conditions similar to flash flooding. In 2007, New York State was ranked as the state with the second highest number of flash floods (NYS Hazard Mitigation Plan 2011). Ice jams in Orange County along the Delaware River are a common occurrence and present great danger to residents living in high risk areas. The most recent jam on the Delaware River occurred in January 2018 in Westbrookville, NY. Route 209 and homes along the road were flooded; six people had to be evacuated by the fire department. The most vulnerable areas to ice jams and violent flash floods are along shallow river channels those with steep slopes, and at restrictions like bridges and natural bends. With climate change, intense precipitation, severe winter storms, and freeze-thaw cycles will increase, resulting in stream bank destabilization, channel restriction, and therefore increased risk of "freeze-up" ice jams, where floating ice may slow down or completely stop. More intense precipitation and higher winter temperatures may increase the risk of "break-up" ice jams. These occur as a result of rapid increases of runoff with heavy rainfall, snowmelt, and warmer winter temperatures. An increase in the frequency of ice jams could severely damage roads, bridges, and other critical infrastructure, and residences near flowing water or in the floodplain.

Watersheds impacted: Delaware

Many culverts and road crossings that were built years ago are already undersized given expected flooding based on current climate and land use. As precipitation events and populations both increase in size, an increasing proportion of culverts will be undersized; resultant flooding will lead to major costs for infrastructure repair and declines in water quality due to erosion and debris in stream channels (Simpson et al. 2012).

Railroads

One passenger railroad and 26 freight lines run through Orange County, providing transportation within it and connections to New York City and New Jersey. Passenger lines include the Metropolitan Transit Authority (MTA) Metro-North Port Jervis Line, the Pascack Valley Line, and the Hudson Line. There are 22.78 miles of railroad tracks located within the floodplain. Projected precipitation and temperature increases arising from climate change can cause damage and bring more debris to tracks. An increase in thunderstorms may make travel conditions unsafe. Extreme heat can also cause delays to travel, since trains must reduce their speeds and use cooling trains to spray water on tracks when temperatures are high to keep tracks and rails from weakening. Extremely high temperatures may cause sun kinks to form on tracks; when the steel expands and buckles an increased risk of derailment arises (Chinowsky et al 2017).

Flooding of Train Infrastructure in Orange County Has Already Cost Millions. *Hurricane Irene and Tropical Storm Lee, which affected the county in 2011, caused the privately owned Echo Lake and Arden Dam to breach and send 100 million gallons of water into the Ramapo River. This surge formed an eight-foot dynamic wave that damaged fourteen miles of Metro-North Port Jervis line in the Tuxedo and Sloatsburg area. The Echo Lake Dam, considered low-hazard under the regulations of the New York State Department of Environmental Conservation,, hadn't been inspected since 1986. Damage from Hurricane Irene cost the Metropolitan Transit Authority around $110 million, with $50 million directly spent on repairs to the Metro-North Port Jervis line. The 2,300 daily passengers that this line services experienced delays and disrupted commutes through fall 2012. With climate change, the intensity of hurricanes and tropical storms is predicted to increase and will likely cause similar damage to transportation infrastructure in the future.*

Aviation

Orange County has 25 public and private airports and heliports; those most heavily trafficked are New York Stewart International Airport and the Orange County Airport. Climate change risks associated with airport infrastructure include flooding, extreme heat, and other extreme weather events. Runway surfaces will need new performance specifications to adjust for increased days with extreme heat. More severe weather events will cause flight cancellations, delays, flight detours, or even temporary shutdowns of airports. Runways may need to be realigned based on future floodplain projections to avoid possible flooding. Realignment has already been completed at the Orange County Airport. Changes in wind patterns and air temperatures will cause service disruptions and reduce the lift capacity for planes. This will require flight takeoff and landing patterns to be recalculated and runways to be lengthened or loads reduced (NYSERDA 2011).

Waste Disposal Techniques and Systems

42 percent of greenhouse gas emissions in the United States are associated with energy used to manufacture, transport, and dispose of the goods we use and the food we eat (EPA 2009). Reducing individual consumption of these products, and by reusing, recycling, and composting to reduce waste, the carbon footprint can be reduced. Orange County does have a higher recycling rate (38 percent) than the statewide average (35 percent), but it is lower than the regional rate (42 percent). The county's municipal solid waste (MSW) disposal rate (3.8, pounds per person, per day) is lower than the statewide rate (4.1) and on par with the regional rate (3.7) (Mid-Hudson Sustainability Plan 2013).

Waste management services in Orange aren't operated by the county government; several individually contracted companies offer these. By enforcing countywide waste management laws, Orange County can reduce its overall greenhouse gas emissions and garbage accumulation in landfills.

The county operates transfer stations in New Hampton, Newburgh, and Port Jervis. There are no currently operating landfills in the county, but with increased precipitation due to climate change sites where landfills were formerly located near or within the floodplain still pose a risk of contamination to waterways.

Moreover, landfills still emit greenhouse gases for decades after their closure. Inactive landfills in the region emitted 39,648 MTCO2E in 2010, with Orange County representing 30 percent of those emissions in the region (Mid-Hudson Sustainability Plan 2013).

Communication Systems and Emergency Response Systems

More numerous severe weather events can damage phone lines or cell phone towers and cause electrical fires, resulting in phone service outages. Many wireless sensor networks are outdoors and are therefore vulnerable to fluctuations in temperature and humidity. Both extremes, high temperatures and high relative humidity when temperatures are below 0°C, decrease radio signal strength (Luomala et al 2015). Precipitation also has a strong effect on Wi-Fi signals, since water droplets can absorb and block 2.4 Ghz radio frequency waves.

Orange County uses several emergency alert systems to send residents warning notifications. These systems operate on several governmental levels, including Everbridge for the County, NYAlert for the State, and Emergency Alert System (EAS) and Integrated Public Alert and Warning System (IPAWS) at the national level. These alert systems use mobile phone services to transmit the warning messages and are vulnerable to climate change in ways similar to communication systems. During emergencies it is essential that the Orange County 911 Center, Message Center, Support Team, and Coordinating Officers are able to maintain operations, and redundancies in their communication systems should be required.

Table 2.14. Orange County Critical Facilitates in the 100- and 500-year Floodplains

Critical Facility Class	Number of Critical Facilities in Floodplain
Ambulance Dispatcher	1
Educational Facility	4
DPW Facility	6
Fire House	14
Police Station	1
Medical Facility	3
Utilities Facility	3
Wastewater Treatment Facility	15
Gas Station and Refinery	8
Electrical Substation	6
Total	61

Critical Facilities

Critical facilities in Orange County include fire, emergency medical services, police stations, public works facilities, schools, public libraries, health service facilities, and water/wastewater treatment and utility supply plants. The Federal Emergency Management Agency (FEMA) recommends that no critical facilities that provides necessary services, particularly during emergencies, be located in a floodplain. If these facilities are located in a floodplain by necessity, then they must be elevated or flood-proofed so that they can function during times of natural disasters. Orange County has a total of 61 critical facilities in the floodplain, including 15 wastewater treatment plants. Several wastewater treatment facilities in Orange County are located in the 500 year floodplain by necessity; many have undergone structural evaluations to ensure capability to function during states of emergency (Town of Wallkill City of Middletown Natural Hazards Mitigation Plan). With climate change, floodplains are predicted to expand. To account for this predicted increase, additional precautionary measures must be taken to make sure that wastewater treatment facilities, and other critical facilities in the 500 year floodplain can function when flooding occurs.

Table 2.15. Climate Risks to New York State Energy Supply and Distribution

Vulnerability	Principal Climate Variable(s)	Specific Climate-Related Risks
Thermoelectric Power Plants	Temperature	The thermal efficiency of power generation is affected by air temperature
Coastal Power Plants (and cogeneration at wastewater treatment facilities)	Extreme weather events and sea level rise	Flood risk at individual facilities depends on the likelihood and intensity of storm surges associated with extreme weather events and their interaction with sea level rise. Operational impacts may be different than impacts fuel storage or fuel unloading operations.
Water-cooled Power Plants	Temperature	Water-cooled nuclear plants are affected by changes in the temperature of intake and discharge water
Hydropower Systems	Precipitation and temperature	Hydropower availability at individual plants is affected by the timing and quantity of precipitation, as well as snowmelt, which is affected by seasonal temperature
Wind Power Systems	Wind speed and direction	Availability and predictably of wind power
Solar Power Systems		Availability and predictably of solar power
Biomass-fueled Energy Systems	Temperature and precipitation	Biomass availability depends on weather conditions during the growing season
Transmission Lines	Extreme weather events and temperature	Frequency, duration, and spatial extent of outages are affected by winter storms, particularly ice storms and high winds. Sagging lines can result from increased load associated with higher temperatures.
Transformers	Temperature	Transformers rated for particular temperatures may fail during prolonged periods of increased temperature
Natural Gas Distribution Lines	Temperature, extreme weather events, and flooding	Changing temperatures may affect vulnerability to frost heave risks, which can threaten structural stability of the pipeline. Flooding risks can also jeopardize pipeline stability/operations. Extreme weather may threaten underwater pipelines in the Gulf Coast region, a large source of natural gas supply for New York.

Source: NYSERDA Table 8.7,2014

Energy

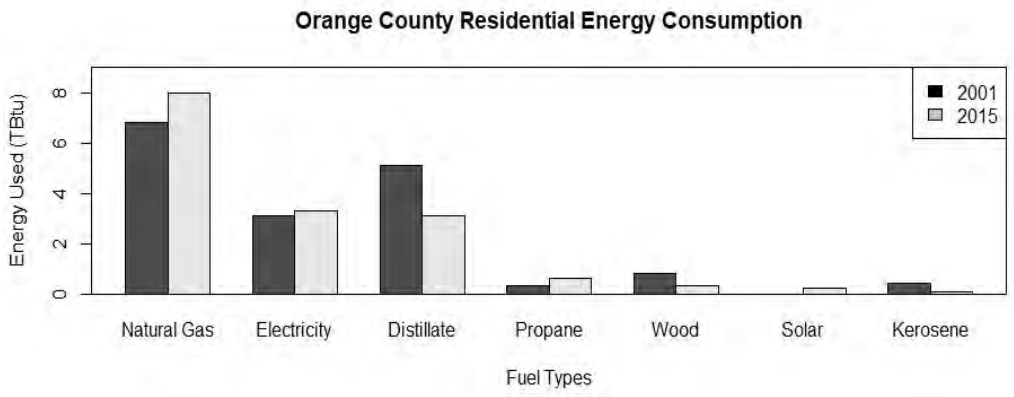
In 2010, Orange County's net energy consumption (MMBtu) was 162 per capita, higher than the regional average of 157; 52 percent of this demand was generated by transportation, 24

percent by residences, 19 percent by commercial activity, but only four 4 percent by industry (Mid-Hudson Sustainability Plan 2013).

Although electricity and gas supply distribution systems in New York State have been highly reliable, extreme weather events can damage equipment, disrupt fuel supply chains, reduce plant output levels, and increase the demand for energy beyond a system's capacity (NYSERDA 2014). Climate stressors to Orange County's infrastructure can cause more power outages and transformers to fail during times of extreme heat or during severe winter storms. Warmer winters causing earlier snow melt and summers, with longer periods of drought, may led to low-flow conditions in late summer that will reduce the capacity of hydropower systems. The water-cooled Indian Point nuclear power plant, across the Hudson River from Orange County, is scheduled to fully shut down by April 2025. Hotter ambient temperatures that warm surface waters, making it more challenging to operate such plants. Warmer summers and heat waves may also increase electricity demand, leading to more blackouts and brownouts (NYSERDA 2011). Finally, these climate-related developments could cause the price of energy to increase, since there would be higher maintenance costs, increased summer demand, and reduced supply.

In 2010, 46 percent of household heating was fueled by natural gas, 36 percent by fuel oil or kerosene, and 10 percent by electric. The remaining 8 percent of homes were reliant on other sources: wood, bottled tank or LP gas, or solar energy. Emissions from energy supply activities (MTCO2e) total 139,020 in 2010 (Mid-Hudson Sustainability Plan 2013).

Figure 2.13. Average Annual Residential Fuel Use by Type, Orange County, 2001 and 2015.

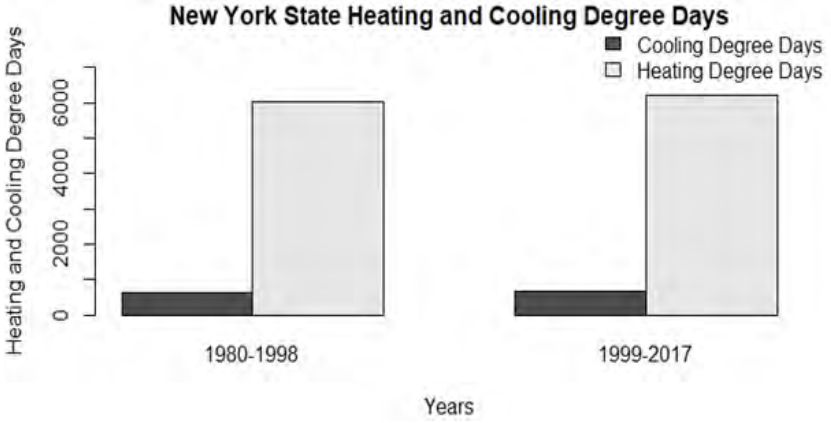


Source: NYSERDA 2015

From 2001 to 2015 the demand for electricity, natural gas, propane, and solar energy for space heating increased in Orange County residences. There is potential for solar power to become a larger source of energy supply for the county. If more solar power generators are installed the county's carbon footprint would decrease.

Since 1980, the number of heating degree days in New York State has decreased by 198, and the number of cooling degree days increased by 19. Future projections suggest that these trends will continue. The electricity demand in the 2020s for areas in the Hudson Valley is predicted to increase by 72-145 MWp during the cooling season, and decrease by 12-25 MWp during the heating season. Peak electricity demand in the summer may increase due to more frequent heat waves, and the cooling capacity of cooling systems may not be sufficient if heat waves are extended (NYSERDA 2014).

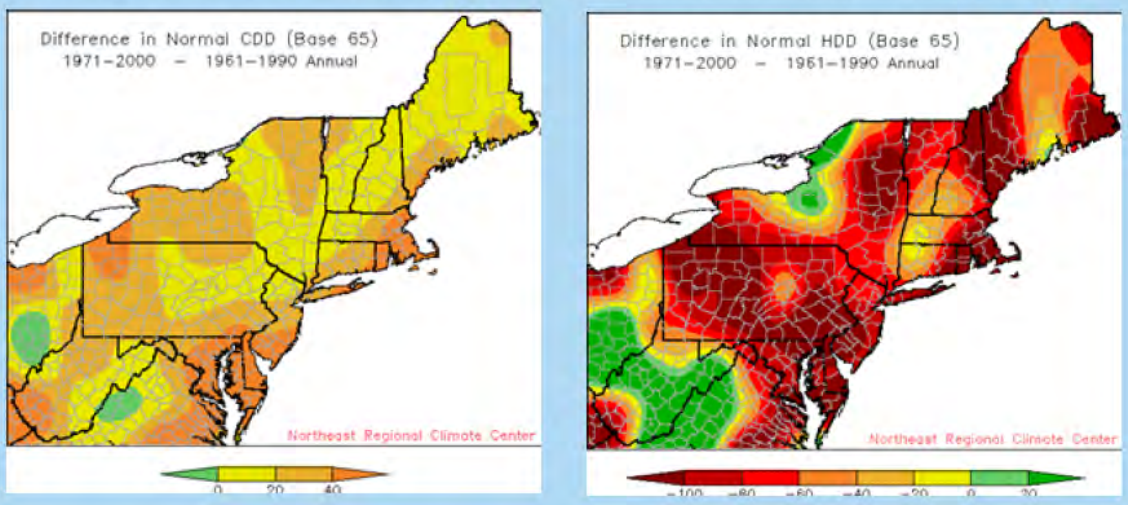
Figure 2.14. New York State Average Heating and Cooling Degree, 1980-1998 and 1999-2017



Source: NYSERDA 2015

Measuring Climate Change: Trends in Heating and Cooling Degree Days

Heating and cooling degree days are a standardized means of measuring the day's temperature relating to the energy demands of air condition and heating. These maps above show the difference in Heating Degree Days (HDD) and cooling degree days (CDD) between two 30 year time periods (1971 to 2000 and 1961 to 1990). CDD have increased during this time period while HDD have declined. Further supporting this claim, NYSERDA reports that between 1970 and 2007, the number of HDD declined by 46.3 days per decade.

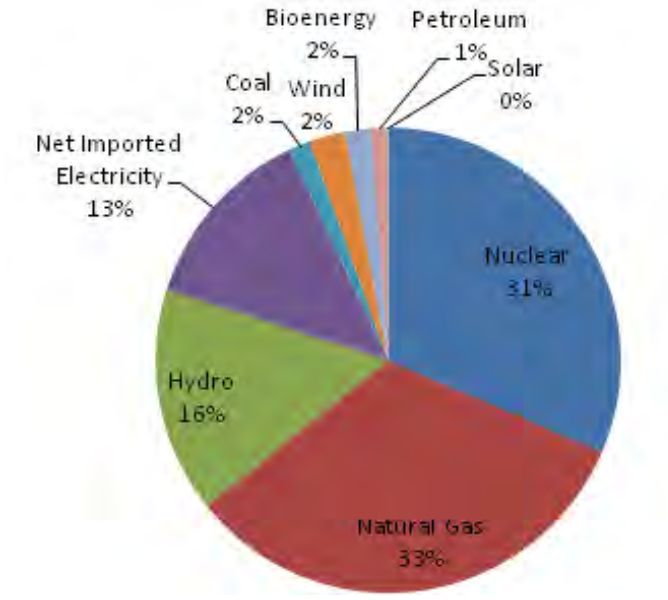


Source: Mid-Hudson Sustainability Plan 2013.

Energy Supply

In 2015, Orange County generated 28,207 MWh of heat and power (NYSERDA 2015). Nuclear energy, hydropower, and natural gas together fuel 80 percent of the electricity generated on in New York State. Climate change may threaten some of these energy supplies. Power plants consume large amounts of water for cooling, and, as regional demand increases, there may be less water available for energy production especially during hot and dry summer months. During times of drought when stream flows are low, hydropower generation may also decline.

Figure 2.15. 2015 Energy for Electricity Generation in New York State



Source: NYSERDA 2015

Energy Demand

Table 2.16. Projected Changes in Peak Electricity Demand in the 2020s, New York State, by Zone

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

Source: NYSERDA 2014, Projections based on current peak demand.

Economic System Profile

Climate change will impact several major sectors of Orange County's economy, including manufacturing, recreation and tourism, agriculture, and food growth and production.

Manufacturing

The manufacturing sector employs 7 percent of Orange County residents (US Census American Community Survey 2016). Food processing and production one of the fastest growing manufacturing industry in the Hudson Valley in significant measure due to the relatively recent addition of Amy's Kitchen, a natural and organic food manufacturing facility in Goshen (NYS Dept of Labor, 2015).

Extreme heat is bad for manufacturing. One study found that for each day temperatures rose above 90°F there was on average about a half a percentage point drop in manufacturing output. Using this metric, rising temperature due to climate change, will lead to a decrease by 12 percent of manufacturing by 2050. And, based on the 2017 value of the dollar, this output loss equates to about $10,000 per firm per each 90°F day (Zhang et al 2017). Regulation of greenhouse gas emissions imposed on manufacturing industries is likely to become more stringent, since this sector is responsible for 19 percent of domestic direct emissions, and 11 percent of emissions indirectly through electricity use (US Industry Today, 2007). This will require companies to explore alternative fuel sources and use more sustainably sourced materials. Companies will also have to reevaluate their waste disposal methods, since climate-related changes in precipitation and the size of the floodplain might alter the known final destination and transport pathways of contaminants released from manufacturing sites.

Recreation and Tourism

In 2016, tourism generated $474 million in Orange County. The autumn season brings high volumes of tourists, with fall foliage and apple picking among the main attractions; both of these are vulnerable to climate change. Changes in temperature and precipitation may produce duller fall color and alter the timing of peak foliage. Moderate heat stress will delay the turning of the leaves, and high heat stress coupled with drought can make the leaves turn faster leading to a shorter and less vibrant season. In the case of severe precipitation events, excess water will stress trees, causing a similar effect (Xie 2016). Climate change will also create challenges for apple orchards. The average annual number of days above 90°F is predicted to increase by between 31and 85 days by the 2080s, causing heat stress that will damage the trees and their fruit (Clarkson University 2011). Tourism in Orange County during this season may decline if fall foliage disappears more rapidly and apple orchards aren't able to produce adequate harvests. In general,

greater incidence of extreme weather will discourage weekend visitors to the county and the region.

Agriculture

Agriculture has been on the decline in New York State for over a century; in 1910, 72 percent of the land in Orange County was utilized for agriculture; by 2007 this had dropped to 16 percent (Obach and Tobin 2011). Orange County had 48 fewer farms in 2012 (658) than in 2002 (706). However, there was an increase of 16 farms since 2007 (642). During that same time period, farmland acreage in production decreased by nearly 20,000 acres, but again, there's been a rebound since 2007, from 80,990 to 88,030 acres.

Agriculture is a significant economic sector in the county; the total value of agricultural sales increased by over $100 million (52%) from 2007 to 2012. Crops comprised seventy-two percent of agricultural products sold in 2012; the remaining 28 percent was livestock. The top sales by commodity group were nursery, greenhouse, floriculture, and sod ($28.9 million); vegetables, melons, potatoes, and sweet potatoes ($28.8 million); and cow milk ($11.7 million).

Farmland within or near current floodplains is at risk of flooding from predicted increases in storm frequency and severity due climate change. Higher temperatures may either increase or decrease the growing season for certain crops, depending on each crop's particular optimal temperature range. Temperature changes may alter the typical phenology of the crops, and have negative effects on farmers that rely on plant-pollinator interactions for crop production. Heat waves may cause evapotranspiration rates to be beyond the tolerable limit of the crops, and -- coupled with drought -- these may not survive.

Irrigation in the Black Dirt

The Black Dirt farming region covers over 16,000 acres. The organic soils in this region are exceptionally fertile, making this area among the most productive in the United States. Unfortunately, the region is very vulnerable to flooding and requires extensive drainage and flood protection. The Orange County Soil and Water Conservation District has recently developed a mitigation plan to make the area more resilient to the projected increases in economic loss due to larger floods associated with more intense, climate change related storms. This plan involved two main phases: the removal of portions of rock ledges to increase hydraulic capacity; and the creation of floodplain benches on either side of the Wallkill River. These will expand the floodplain to reduce the magnitude and duration of upstream agricultural flooding, while also increasing wildlife habitat. There is potential to reduce flood water elevation by up to two feet during large, 10-year flood events. Currently, the floodplain has been expanded one mile; for the area to receive the full benefit of the project, it must be extended another four to five miles.

Watershed Impacted: South Wallkill

Temperature rises will have myriad impacts. Just one example: growing seasons could lengthen up to one month and farmers will therefore likely have to adapt practices to adjust to more intense, hotter summers and milder winters.

The South Wallkill watershed, with 30 percent agricultural land, is the most heavily agricultural in the county. Its Black Dirt farming region is highly productive, with fertile soils located near rivers to facilitate One of the most important food-producing areas in the northeast, this area already often floods and requires special management practices to optimize drainage. Average annual agricultural damages due to flooding and prolonged wetness have been estimated by the United States Department of Agriculture (USDA) and Cornell Cooperative Extension to be $2 million. Climate change will almost certainly drive up these costs.

Food Insecurity and Deserts

Food deserts are defined at the census tract level as places with low median incomes and lack of proximate supermarkets for residents. Orange County food deserts are located in Port Jervis, Middletown, Newburgh, New Windsor, Kiryas Joel, and Woodbury.

Notwithstanding the importance of agricultural in Orange County, Feeding America reports that about 8 percent, an estimated 31,780 residents, lived in food insecure households there in 2016, representing a $17,907,000 annual food budget shortfall.

Social System Profile

The county's socioeconomic profile reveals social and economic vulnerabilities to climate change. There are also implications for cultural assets and public health.

Population

The population in New York State has recently been growing slowly or declining. Most growth has been in New York City, while upstate population has been stagnant or dropping year to year. Orange County is an exception. It has experienced persistent growth. Between 2010 to 2017, during which time only eleven of 62 New York counties gained population (five of these in NYC) Orange's population increased 2.3 percent, from 373,490 to 382,226. In the two year period between 2015 and 2017 Orange County was ranked second in population increase (+1.2 percent behind Saratoga County at +1.5 percent).

In 2017, Orange County was the 12th most populous county in the state. About one in six residents live in the cities of Middletown, Newburgh, and Port Jervis; the remainder live in the towns and villages.

The population growth has not been evenly distributed across the county. The Village of Kiryas Joel, had a population increase of nearly 900 percent from 1980 to 2010. In that same time period, the towns of Greenville and Monroe and the Village of Washingtonville tripled and the villages of Chester, Harriman, and Montgomery doubled in population.

Orange County is less diverse racially and ethnically than the state as a whole, but communities of color are its fastest growing populations. In 2000, the county was 84 percent white; this dropped to 64 percent in 2018. The percent of Hispanic or Latino residents rose from 12 percent to 21 percent in that same time period.

Table 2.17. Orange County, Race and Ethnicity

	2000	2010	2018
White	84%	77%	64%
Black or African American	8%	10%	13%
Asian	2%	2%	3%
Hispanic or Latino	12%	17%	21%

Source: U.S. Census

The projected changes to the climate in Orange County will impact all its people. Those most vulnerable are: elderly residents; children; individuals with asthma or pre-existing illnesses; low-income residents; owners of small businesses; athletes; and outdoor workers. In addition, residents who don't speak English and/or are socially isolated are more at risk of harm resulting from the impacts of climate change.

Economic Vulnerability

Residents living on low incomes are at greatest risk precisely because they lack financial resources. Additionally, often they don't have strong social networks. Simply stated, low-income individuals and families can't afford what it takes to recover from disasters or to prepare to protect themselves from disasters.

The 2018 median household income in Orange County was $75,176. This is twenty percent above the median household income for New York State ($62,765). Twelve percent of the population live on incomes below the poverty line. Poverty rates differ greatly by demography and municipality. About one in four (23 percent) of children under 5 years of age, 18 percent of black residents and 15 percent of residents of Hispanic or Latino origin live below the poverty line.

The lowest 2017 poverty rate in the county was 3 percent, in the Town of Tuxedo. On the other end of the spectrum, the rate in its three cities is higher than the overall county rate: Newburgh's was 31 percent, Port Jervis's was 18 percent, and Middletown's was 17 percent. The rural areas of Deerpark and Mount Hope also had higher rates than the county as a whole, at 14 and 13 percent respectively. With nearly half of the population living in poverty (48 percent), the Village of Kiryas Joel has the highest poverty rate in the county, and one of the highest in the nation.

According to the New York State Department of Labor, the unemployment rate for Orange County was 3.3 at the end of 2018, ranking it as the tenth lowest in the state. This was lower than the national and statewide rates for that period (both at 3.9).

About one in ten Orange County residents rely on food stamps.This reliance varies by racial-ethnic groups and type of household. Approximately one in five Black households and 15 percent of Hispanic households use on food stamps. Almost one half of people with disabilities, over a third of the children living in the county, and one in five single mothers are food stamp recipients. Not surprisingly, the places with the highest poverty rates have the highest numbers of residents relying on food stamps.

Ten years ago the New York State Department of Environmental Conservation (NYS DEC) created an environmental justice (EJ) program to address the disproportionality of impact of environmental harm and hazards. In Orange County, the potential EJ areas identified by the DEC were in Newburgh, New Windsor, Middletown, Mount Hope, Wallkill, Goshen, and Monroe.

Social Vulnerability

In order to help public officials and emergency response planners prepare and respond to emergency events, the Center for Disease Control (CDC) Social Vulnerability Index (SVI) was developed. It identifies where populations would be most vulnerable during and after emergency events like extreme weather and flooding. The extent to which a place has certain social vulnerabilities impacts community ability to prevent harm and damage as a result of emergency events. Places with high vulnerability are more likely to need greater support before, during, and after these events.

Orange County is rated overall as "medium low" on the social vulnerability index. The southeastern portion of the county has the lowest score, while most of the remainder of the county is rated in the second-lowest quartile. However, several small pockets are rated in the highest quartile, including areas around Middletown and Newburgh. The Port Jervis region in the southwestern portion of the county is in the second highest quartile.

Map 2.3. Orange County, Social Vulnerability Index

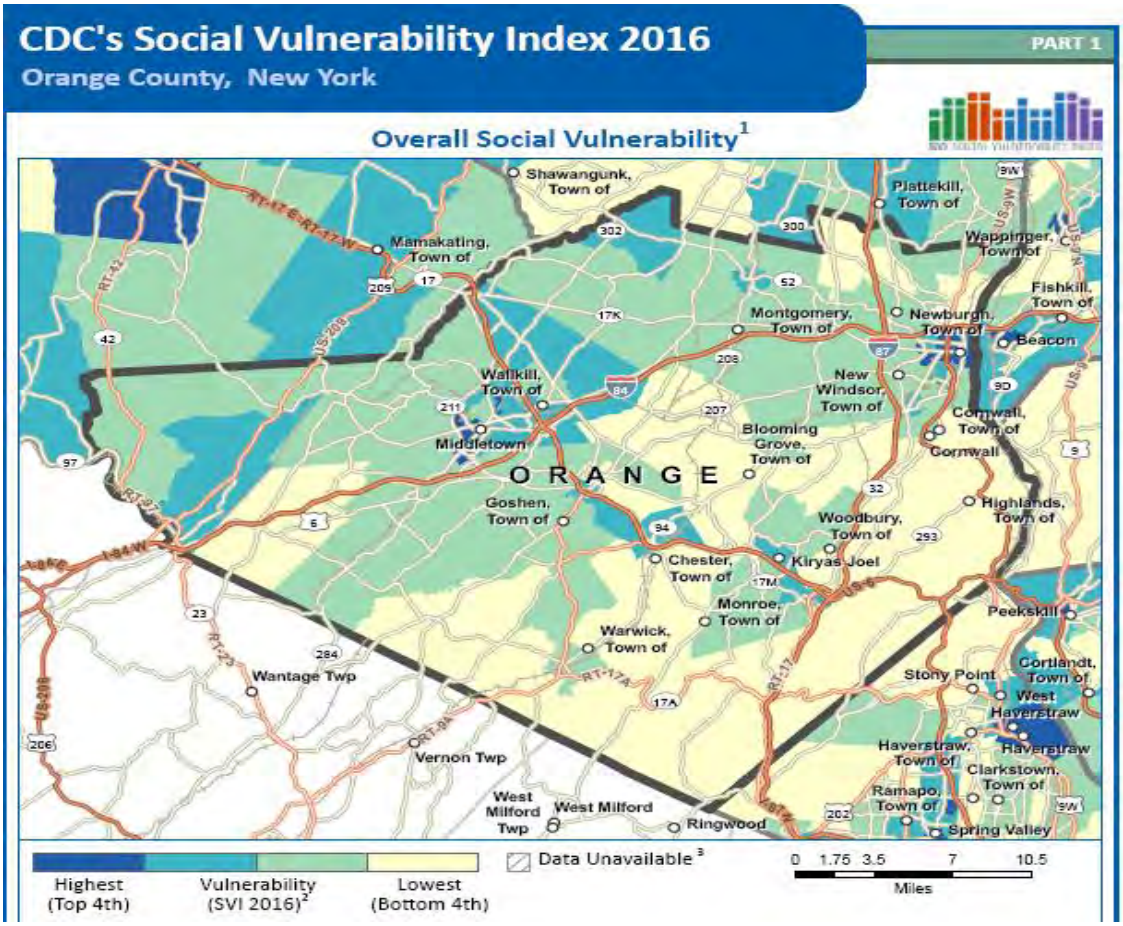


Table 2.18. Orange County, Social Vulnerability Factors

Vulnerability Flags	Orange County	Delaware	Lower Hudson	Moodna	North Wallkill	Quassaic	Ramapo	South Wallkill	Upper Hudson
Total	**74**	**8**	**2**	**3**	**6**	**8**	**26**	**3**	**18**
Socio-economic Status Total	24	0	0	0	1	2	12	0	9
Poverty Rate	7	0	0	0	0	0	4	0	3
Unemployment Rate	1	0	0	0	0	0	0	0	1
Income Per Capita	8	0	0	0	0	1	4	0	3
Less than High School Diploma	8	0	0	0	1	1	4	0	2
Household Composition and Disability Total	28	6	0	1	2	5	5	2	7
Age 65 or older	4	1	0	0	0	0	1	2	0
Age 17 or Younger	12	1	0	1	1	2	4	0	3
Civilian with a Disability	6	4	0	0	1	1	0	0	0
Single Parent HHs	6	0	0	0	0	2	0	0	4
Minority Status & Language Total	5	0	0	0	0	1	4	0	0
Minority Status	1	0	0	0	0	1	0	0	0
Speak English "Less than Well"	5	0	0	0	0	1	4	0	0
Housing and Transportation Total	17	2	2	2	3	0	5	1	2
Multi-unit Structures	1	0	0	0	0	0	1	0	0
Mobile Homes	11	2	1	2	2	0	4	0	0
Crowding	1	0	0	0	0	0	0	0	1
No Vehicle	0	0	0	0	0	0	0	0	0
Group Quarters	4	0	1	0	1	0	0	1	1

Reported here are 15 social vulnerability factors organized into four themes, at the watershed level.[1] Overall, seventy-four census tracts across the county were flagged as socially vulnerable. There were 24 social-economic status flags, 28

[1] We assigned census tracts to watersheds based on the population distribution of each tract. Tract area was not considered. Because of this there are instances where more of the tracts area is within a watershed that is different than it is assigned. This decision was made because the census tract data that was to be used is population and demographic characteristic data, and not geographic and geological data.

household composition and disability flags, five minority status and language flags, and 17 housing and transportation flags. Among the watersheds, the Ramapo, at 26, had the highest number of flags, with nearly half of those in the socioeconomic status category. The Upper Hudson watershed had 18 flags, half of which were in the socioeconomic status category.

Low-lying places that are economically less advantaged tend to be more densely populated and have infrastructure that can be more heavily damaged. Homes lacking solid foundations can be easily washed away. There were 11 mobile home flags in five of the eight Orange County watersheds.

Hurricane Sandy and Irene Hit the Moodna Watershed Hard

Hurricane Irene, Tropical Storm Lee, and Hurricane Sandy hit Orange County within a 15-month span during 2011 and 2012, and caused significant flooding in the Moodna Creek watershed. Accumulated debris damaged infrastructure, public facilities, roads, and private property (including severe impacts to homes in the floodplain). Extreme flood events like these lead to valley-forming flows that re-align stream channels and alter floodplains, and can erode valleys and destabilized slopes to the point of failure (NEIWPCC 2018). Erosion of valley walls past their critical slope angles poses the risk of mudslides that may cause even further damage and life-threatening situations. This is of particular concern when major roads are flooded and evacuation procedures are slowed (NYRCR 2014). Climate change will likely increase the intensity of severe storms, putting municipalities along waterways of the Moodna Creek at even greater risk. Measures to mitigate the damage from these severe storms are being taken through programs like New York Rising, with efforts focused on the upper Moodna Creek basin (NEIWPCC 2018). Preservation of natural land cover is the most effective way to keep stormwater from damaging infrastructure, but more work on resilience strategies is necessary, and e implementation is need throughout the entire watershed.

Watershed Impacted: Moodna

Cultural Assets

Orange County is rich with cultural assets, many dating back to and before colonial times. This includes Fort Montgomery, Washington Headquarters State Historic Site, and the U.S. Military Academy at West Point. The county is also home to Storm King Art Center, the largest outdoor sculpture park in the U.S. Apple orchards are a major tourist draw and the Warwick Applefest alone draws tens of thousands of visitors each year. Orange County also has a rich American Indian tribal history, especially from the Esopus and Lenape Indians. These facilities and activities depend on public support. People don't vacation in extreme climate conditions, or when these are expected. Storm King and other natural sites relies on the natural landscape. In outdoor settings, grasses involve water demand. Apple and other

harvests, and related activites, are susceptible to droughts, early frosts, and heat waves. All tourism, and especially agro-tourism, is vulnerable to climate change.

Public Health

The changing climate is projected to exacerbate a wide range of public health risks and problems, relating to air quality (asthma) increased heat (heat-related illnesses) and including vector-borne diseases.

Air Quality

According to the U.S. Department Environmental Protection Agency (EPA), in 2017, Orange County had 334 good, 31 moderate, and no unhealthy air quality days.

Asthma

Approximately 14 percent of Orange County's population has been diagnosed with asthma. The county hospitalization rate for asthma is 14.0 per 10,000, higher than the regional rate (12.9) but lower than the NYS rate (19.9) Orange County has the highest emergency room visit rate for asthma in the region.

Poor air quality harms young children more than any other age group, as asthma rates are highest among young children. The asthma hospitalization rate for school age children (ages 5-14) in Orange County is higher than the regional and upstate averages. Asthma-related hospital visits are also more common among low-income individuals who can't afford doctor visits and the medications required to manage the disease. In Orange County, residents with less than a high school education have a 17 percent diagnosis rate compared with 11 percent among those with a college education.

In 2014 Joshua Simons, Senior Research Associate at the Benjamin Center for Public Policy Initiatives investigated the link between living in proximity to vacant properties and receiving treatment for Asthma. Using data from the NYS Office of Taxation and Finance, the City of Newburgh Vacant Property Registry, the US Census, and St. Luke's Hospital Patient Database, the study found that there was a statistically significant correlation between the percentage of parcels within a census block that are vacant, and the number of hospital treatments for asthma within the same census block. There was also a statistically significant correlation between the number of vacant housing units within a census block and the number of hospital treatments for asthma within that census block. While the correlations were significant, the amount of the variance explained by the correlation was relatively small. This indicates that there could be a third factor, such as poverty, that correlates to both vacant property and to treatments of asthma. It is also possible that vacant property is a proxy for generally poor housing stock and conditions, but shows that the presence of vacant property could be used to identify areas where increased asthma screening may have the largest impact.

Climate change is expected to lead to increases in asthma rates, which will result in more hospitalization and increased costs for states and local governments.

Higher Pollen Counts

Higher temperatures combined with higher levels of carbon dioxide result in higher pollen counts. This in turn can lead to increases in health problems for those suffering from allergies, asthma, and other respiratory problems.

Indoor Air Quality

Increased precipitation and flooding can lead to growth in indoor molds. Increased air temperatures also mean more humidity in the air; this also leads to increases in mold growth. Such molds can in turn contribute to higher rates of asthma and respiratory diseases. Renters and low-income residents are most vulnerable to mold, as they lack the autonomy and resources to prevent and remediate mold growth via proper sealing of homes/buildings, proper ventilation, and installation of air conditioning systems.

Heat Related Illness

Heat-related illnesses are among the greatest climate change impacts expected in the northeastern United States. Young children, the elderly, and individuals with cardiovascular diseases are the most vulnerable to heat stroke and heat exhaustion. Persons who are active and work outdoors are also at higher risk of heat-related illnesses. Children and young adults who play sports outdoors during the afternoon are at heightened risk, as are workers in occupations that involve physical labor outdoors.

Vector Borne Diseases

The U.S. is witnessing a greater incidence of vector borne diseases that were once typically concentrated in more tropical regions. Orange County has not seen any cases of West Nile Virus, and it has reported 11 cases of Zika Virus.

The Hudson Valley has some of the highest per capita diagnoses of Lyme disease in the state and country. In 2016, the incidence of Lyme disease in Orange County was 140.6 per 100,000, ranking it ninth highest in the state. Orange County documented 531 cases of Lyme disease that year.

The 2013 Mid-Hudson Sustainability Plan notes: “There is a close relationship between land use and Lyme disease. Each shopping mall, golf course, or other residential or commercial development that is in or adjacent to woodlands disturbs habitat and contributes to forest fragmentation. Mice and deer, which thrive in disturbed and fragmented habitat, are especially important as they act as carriers to ticks that carry the Lyme bacteria (*Borrelia burgdorferi*).”

Climate Adaptation Strategies

In order to act on the climate impacts and vulnerabilities detailed about, proposed here are necessary adaptation measures to lessen the current effects of climate change and to prepare for future impacts. Climate adaptation strategies seek to protect human, natural and infrastructure resources from the impacts of climate change. These strategies are based on local hazards, vulnerabilities and Orange County and its watersheds unique local climate risks.

The overall goal here is to improve local climate resiliency by providing watershed organizations, municipalities, and county officials with information to guide policies and plans that will reduce vulnerabilities, conserve natural resources, and make communities more resilient to changing climate and to aid in protecting and improving the health, safety, and economic well-being of residents. These strategies address high risks including flood-risk management, stormwater management, natural systems resiliency, and community resiliency.

Adaptation strategies are detailed here in seven crucial action areas: land use; water systems; infrastructure; public health; public engagement; assisting residents during crisis; and assisting local government during crisis. Also included are suggestions about what needs to be advocated for at the state level. A final section considers implementation of these ideas and ways of tracking progress.

Natural Systems: Land Use

Area	Strategy	Description	Examples
Natural Resources: Land Use	Reduce Development in Flood-prone Areas	Strengthen regulations to direct future development out of flood-prone areas to reduce and minimize future losses	Focus should be placed on the top three watersheds in terms of percent of land in floodplains: the Upper Hudson (23 percent), South Wallkill (19 percent), and Quassaick (15 percent). A good example of these types of protections already exist in the D & H Canal county park where there are protected floodplains and wetlands in ecologically important areas.
Natural Resources: Land Use	Reduce Development in Flood-prone Areas	Create financial incentives to reduce and avoid development in flood-prone areas	For example, floodplain buyouts could be offered in developed flood-prone areas. These types of efforts must be carefully balanced with the expected loss of tax revenues, which could be mitigated by creating usable recreational areas on these lands.
Natural Resources: Land Use	Reduce Development in Flood-prone Areas	Require "No Adverse Impact" standards; Establish and enforce floodplain zoning and flood-related land use and building codes	Enact policy at the county level and be a resource for municipalities to ensure that activities do not change the floodwater storage capacity of wetlands and floodplains and do not increase the flow velocity of streams, especially during floods
Natural Resources: Land Use	Land Preservation	Identify and develop long-term acquisition and easement plans to conserve critical open spaces, biological/ biodiversity areas, wildlife, wetlands, river ecosystems,	Expand on the existing 3,327 acres of county owned park land as well as continue to work with land trusts to protect critical lands. For example, with help from the county, Orange County Land Trust was recently awarded a NYS Farmland Implementation grant to conserve the Willow Hill Farm in

Area	Strategy	Description	Examples
		and agricultural resources	the Town of Montgomery. This project will help protect the Wallkill River riparian forest.
Natural Resources: Land Use	Reduce Fragmentation	Protect continuous habitat: movement corridors, stepping stones, and refugia; prevent future fragmentation	Work with the NYS DEC and utilize their Hudson Valley Resource Mapper as a resource for identifying contiguous forest and habitat refugia and connections to large parcels of protected land, for example, state parks.
Natural Resources: Land Use	Improve and Update Flood Plain and Wetlands Mapping	Frequently update floodplain and wetlands definitions and mapping as climate changes	The FEMA flood maps and the national wetlands inventory are currently available on the county website and will be regularly updated based on expanding floodplain areas.
Natural Resources: Land Use	Increase Sustainable Local Food Production	Sustainable and organic food production promotion, farmer's market promotion, proximity of population centers to agricultural centers	The county has actively supported farmers markets, in fact, in 2014 Orange County was granted $100,000 in funding to support farmers markets through promotional efforts, the creation a new winter and summer market, and to expand access to fresh local goods in lower-income areas. A schedule of markets across the county is readily available on the county website.
Natural Resources: Land Use	Increase Sustainable Local Food Production	Support increased agricultural production due to a longer growing season and increased precipitation; promote opportunities for sustainable, small	In order to facilitate funding via existing and potential sources the county provides an agricultural resource list on the county website. For example, the county has partnered with Cornell's Small Farms Program helping develop and grow small farm businesses.

Area	Strategy	Description	Examples
		scale and organic food production	
Natural Resources: Land Use	Increase Sustainable Local Food Production	Encourage back yard and rooftop vegetable gardens, community gardens and the preservation of productive agricultural lands, including vacant urban land	Provide resources for local and individual scale food production, for example, a pamphlet detailing more efficient yard use, e.g. the Smart Yards Guide. Develop a report detailing the possibilities for urban agriculture, especially in the Upper Hudson and Quassiack, the two most urban watersheds. A good model is the Prince George's County Urban Agriculture report.
Natural Resources: Land Use	Increase Sustainable Local Food Production	Conduct a food-shed mapping effort across the region to determine sources and quantities of locally produced food	Scenic Hudson has constructed this type of reporting for our region, including Orange County, Protecting Farms and the Region's Food Supply.
Natural Resources: Land Use	Address Invasive Species	Prevent, eradicate, and control invasive species; recover ecosystems and restore other assets adversely impacted	Possible interventions, in cooperation with Lower Hudson PRISM (www.lhprism.org) include signage and cleaning stations to ensure boaters clean their gear before moving between waterways; using reputable nurseries and seed sources; suppression management like selective logging and removal of ash trees with known emerald ash borers; and training of land stewards and citizens.

Natural Systems: Water

Area	Strategy	Description	Examples
Natural Resources: Water	Increase and Improve Stream, Groundwater, Reservoir, and Lake Monitoring	Support and enhance ongoing monitoring of various surface and subsurface water quality and quantity parameters	The county currently has a Stream Water Quality Monitoring program, as well as various strategies outlined in the Orange County Water Master Plan. The three watersheds with the highest percentage of agricultural land also have the highest stream density: North and South Wallkill and the Moodna. Therefore, focus should be placed in those areas, as well as in the Quassiack because of its high stream density. There are already several watershed plans focusing on these issues, and at least one more in development. Additional partnerships could be facilitated with watershed groups and non-profits to develop additional watershed plans with a focus on water quality and monitoring.
Natural Resources: Water	Monitor Illicit Discharges	Work with existing MS4s to inventory and address illicit discharges	Strategies for dealing with illicit stormwater discharges are proposed in the Orange County New York Stormwater Management Plan draft.
Natural Resources: Water	Reduce reliance on regional surface water for municipal water supplies	Develop alternative sources of water if algal blooms produce toxins or for some other reason water supplies have to be shut down	As recommended in the 2004 Orange County Open Space Plan municipalities should increase reliance on local groundwater water sources that are less expensive to treat and more sustainable.

Area	Strategy	Description	Examples
Natural Resources: Water	Improve Water Source Protection	Continue to identify and protect land in municipal water source watersheds and to plan to limit development where full protection is not possible	The county should be a resource to municipalities seeking to protect land in their water source watersheds. In 2018, the state Water Quality Improvement Project (WQIP) awarded over $103 million to municipalities to buy land in order *"to improve water quality, reduce the potential for harmful algal blooms (HABs), and protect drinking water across the state."*
Natural Resources: Water	Improve Water Source Protection	Encourage, develop, and or maintain intermunicipal agreements on source water protection	Update state regulations specific to Orange County municipalities, established to assure purity of municipal water supplies. Need info from Kelly about which have formal now, which are working on getting there, and which need it the most
Natural Resources: Water	Increase Stream and Wetland Restoration	Restore and protect riparian and wetlands to restore streams to natural state and revegetating banks, ideally using the groups of plants most likely to occur at each location	There are substantial grants available for municipalities and counties through the NYS DEC "Trees for Tribs" programs that focus on restoration of riparian areas through the planting of native young trees and shrubs along stream corridors. An Orange County example in the North Wallkill watershed is the Benedict Farm stream buffer restoration in Montgomery put in place by the Hudson River Estuary program with volunteer assistance.

Area	Strategy	Description	Examples
Natural Resources: Water	Reduce Impervious Surfaces	Encourage permeable surfaces; Increase landscape permeability	The county should build no additional parking with impermeable surfaces, when the need for replacement arises, replace impermeable with permeable surfaces and encourage all local governments within it to adopt a similar policy.
Natural Resources: Water	Hazardous Waste Management	Improve management of hazardous waste sites	There are over 100 remediation sites exist within the eight watersheds. These will require more rigorous monitoring procedures to account for predicted changes to water flow.
Natural Resources: Water	Improve Monitoring	Expand ability to predict drought and flood events by tracking soil moisture, streamflow, precipitation, groundwater levels, tide levels, well levels, reservoir levels, and weather forecasts	Investigate the acquisition of new technology and software available for hydrological measurement. More partnerships with the U.S. Geological Survey should be considered. Currently there are three real time monitoring stream flow stations: two on the Wallkill River and one on the Neversink River (in the Delaware watershed).
Natural Resources: Water	Manage algal blooms	Consider climate change in managing algal blooms; install treatment controls and set up toxin testing protocols to protect drinking water reservoirs and lakes.	Consider and act on the results of the state action plan to address algal blooms, which includes the Middletown-Monhegan Reservoir System in Orange County as a test site, and emulate if appropriate.

Infrastructure

Area	Strategy	Description	Examples
Infrastructure: Critical Facilities	Resilient Communications	Conduct communications audit to identify vulnerable communications infrastructure and make investments to ensure resilient communications during events	There was an interoperability board established in 2010. A project to upgrade equipment started in 2012, with a tower built and new equipment distributed in 2017. County should review current status of board activities, to assure plans are in place for necessary collaboration and coordination and the interoperability, resiliency and redundancy of equipment is assured.
Infrastructure: Critical Facilities	Resilient Facilities	Create a plan to address at-risk critical facilities, to identify and make investments to ensure resilient facilities during events	The 2018 county hazard mitigation plan should be review and updated and actions taken with regard to the plan should be cataloged. A timeline should be established for elevating and or flood proofing all facilities that must remain in floodplains.
Infrastructure: Critical Facilities	Resilient facilities	Require that new or renovated buildings follow flood-protection measures to accommodate projected sea-level rise -- as well as increase in storm intensity and severity -- over the structures' lifespan	Incorporation of actions to mitigate flood risk and enhance resiliency in municipal planning is encouraged, and the county should seek financial assistance for flood adaptation. For example, see the recommendations for City of Newburgh with coming sea level rise.

Area	Strategy	Description	Examples
Infrastructure: Culverts	Increase Culvert Resilience	Inventory culverts; especially ones the that jam/flood frequently in order to identify candidates for removal, repair, and retrofit; include consideration of flow and animal migration	An example: replacement of culverts along and repairing damaged banks along the Winding Brook was identified as a priority project to diminish flooding impact in the 2014 Town of Wallkill City of Middletown Natural Hazard Mitigation Plan.
Infrastructure: Dams	Increase Dam Resilience	Inventory dams; identify candidates for removal and repair and do so where appropriate; include consideration of flow and animal migration	A 2007 storm caused the Winona lake spillway to be breached, decreasing the size of the lake and causing substantial erosion downstream. The Quassaick Creek Management Plan identifies remediation as a priority action. In the Moodna watershed, the Beaver Dam Lake dam is currently being rehabilitated with county resources. The NYS DEC currently inventories dams and the county should work with the DEC to identify priority dams in need of repair or removal.
Infrastructure: Dams	Increase Dam Resilience	All dams, regardless of their hazard rating, should be inspected routinely and be improved to withstand stress put on them by storms the size of Hurricane Irene and larger.	Orange County has 70 intermediate or high hazard dams in 2017. Two were the only ones in the state listed as both high hazard and deficiently maintained: on Lake Tiorati Brook and on the Ramapo River. A systematic effort is needed to bring the county's dams into good repair, prioritizing those most deficient.

Area	Strategy	Description	Examples
Infrastructure: Dams	Increase Dam Resilience	Explore potential for Microhydro power on existing dams to decentralize and increase resiliency	A microgrid is a localized grouping of electricity sources and loads that normally operate connected to and synchronous with the traditional centralized grid (macrogrid), but can disconnect and function autonomously as physical and/or economic conditions dictate. The Highland Falls High Point Utility LDC proposes to draw upon hydro power from Buttermilk Falls to serve highland Falls, the Town of Highlands, and the West Point Military Academy.
Infrastructure: Design Standards	Implement watershed-friendly design standards	Follow design standards and building codes	The county's Watershed Design Guide recommends these strategies and works with local watershed groups to implement them. For example, the Quassaick Creek Watershed Plan specifies as a major goal implementing design standards that promote principles of resiliency and adaptability, such as specifying construction practices and regulations to diminish erosion and help assure streambank stability during storm events.
Infrastructure: Green systems	Increase Green Infrastructure Practices	To protect water supplies and reduce flooding, undertake urban area greening programs, such as rain gardens and tree planting, to make communities more resilient against heat waves	A resource for these types of projects is the Growing Green Cities: Urban Forests & Green Infrastructure for Health, Resilience & Sustainability program. Current projects in Orange County span multiple watersheds and include insulation of rain gardens and bioretention filters. Rain Gardens have been built in Black Rock Forest, Middletown, Greenwood Lake,

Area	Strategy	Description	Examples
		and to decrease stormwater runoff	Newburgh, Tuxedo Park, and Walden.
Infrastructure: Green systems	Increase Green Infrastructure Practices	Integrate green infrastructure and natural assets into transportation upgrades and retrofits through design standards and codes	A neglected shoreline between Waterstone Road and Greenwood lake was eroding due to runoff and was overgrown with invasive species. Native plants and biodegradable erosion control structures were used to filter the water and slow erosion as well as aquatic plantings to stabilize the shoreline.
Infrastructure: Green systems	Increase Green Infrastructure Practices	Green roofs, white roofs (paint), planted trees, green walls, urban greening at county facilities	The Cornell Cooperative Extension Orange County Rain Garden, a collaborative project between Orange County Soil & Water Conservation District and Cornell Cooperative Extension Master Gardeners, mitigates runoff from a large parking lot. Since only native plants are used it also serves as an educational garden for the public to learn about how rain gardens function and how to use native plants in garden design. |
Infrastructure: Historical and Cultural Sites	Increase Resiliency	Inventory and protect important historical or cultural sites that are at risk of coastal or inland flooding, storms,	Existing lists need to be revised to specify risks, and advance mitigation strategies for each. An example of one such list is in the county open space plan.

Area	Strategy	Description	Examples
		erosion, and wildfires	
Infrastructure: Renewable Energy	Inventory and increase Local Renewable Energy	Shift county facilities to renewable resources for electricity to build resilience to help keep power on during storms	In the Town of Wallkill the state funded the Backup Power for Critical Infrastructure Project to install back-up power sources at traffic signals near the Route 211 and Route 17 intersection in the Town of Wallkill, ensuring smooth traffic flow during outages, enabling residents to evacuate and easing roadway access for first responders. Solarize Hudson Valley, in close collaboration with NYSERDA, is helping to accelerate the long-anticipated widening of solar opportunities. The goal is to generate clean power, close by, and available to all income levels. In Orange County there are at least 33 solar farms currently in the permitting process with town planning boards. With county support, opportunities may arise from these or related future initiatives for county government.
Infrastructure: Renewable Energy	Increase Resiliency with Renewable Energy	Solar powered generators at critical facilities (battery storage) to build resilience to help keep power on during storms	

Area	Strategy	Description	Examples
Infrastructure: Roads and Bridges	Prepare and make roads and bridges more resilient	Repair roads that are vulnerable to flood events; reinforce rock-catchment barriers to prevent landslides from reaching roads; reinforce and adjust bridges to have a larger hydraulic opening to prevent flood damage from ice jams	In the 2021 revision of the Orange County Long Range Transportation Plan, achieving resiliency needs to be a priority with planning for it a requirement for approval of all road and bridge construction and repair.
Infrastructure: Shorelines	Increase Shoreline Resilience	Identify and promote sustainable methods for shoreline erosion control that will secure key infrastructure while enabling vital natural communities to exist and migrate landward as sea level rises	The county has already committed in its Stormwater Management Plan to reduction of pollutants in stormwater runoff, "in accordance with the most recent version of the New York State Standards and Specifications for Erosion and Sediment Control."
Infrastructure: Shorelines	Increase Shoreline Resilience	Identify and remove incentives for non-sustainable shoreline management methods, and create incentives for sustainable practices in shoreline management and erosion control	As part of the Hudson River Sustainable Shorelines Project, in Esopus in neighboring Ulster County "…a degraded bulkhead was replaced with softer stabilizing surfaces that still provided shoreline protection. A stone toe was placed at the high tide line and soft gabions positioned above it help hold the soil in place."

Area	Strategy	Description	Examples
Infrastructure: Shorelines	Increase Shoreline Resilience	Share best practices for fish friendly habitat options when shoreline construction/ reconstruction is necessary	Removing Strooks Felt Dam on Quassaick Creek would eliminate a first barrier for fish movement upstream from the Hudson River, restore over one mile of habitat for river herring and eel, improve fish passage and connectivity, and return river resiliency and natural functions.
Infrastructure: Transportation	Increase Transportation Resilience	Assess vulnerability of transportation systems to the combination of increased flows and rising sea levels	The Orange County Transportation Council staff is currently studying the transportation system's ability to accommodate variable and unexpected conditions and determine the vulnerability of the various transportation infrastructure assets located in the County as part of its current year unified work program. (For a vignette of travel to NYC from Orange County in the wake of recent hurricanes see: Transportation During and After Hurricane Sandy, p. 33)
Infrastructure: Transportation	Map Transportation Infrastructure and Improve Efficiency	Identify at-risk transportation: map transportation infrastructure that is vulnerable to repeated floods and/or landslides, and designate alternative travel routes for critical transportation corridors when roads must be closed because of natural hazards; Improve bus	Use existing transportation planning documents to develop a menu of alternative routes to major destinations. Create and maintain and interactive adaptable map, and communication plan for transit providers, to inform citizens in real time about transportation alternatives in the wake of disasters. Orange County Emergency Operations Center, assisted by a Transportation Task Force, currently provides service during emergencies but this

Area	Strategy	Description	Examples
		station/stop/routes and improve routes for efficiency in order to minimize risk to riders in the event of extreme weather	service could be enhanced with additional information.
Infrastructure: Transportation	Anticipate specific impacts to facilitate rapid response and when possible relocate and retrofit roads	Relocate or retrofit low-lying roads vulnerable to coastal or inland flooding. Many locations are identified in this report and/or the County Hazard Mitigation Plan.	Stockpile sandbags, sandbagging equipment, temporary damming devices, and related supplies in advance proximate to known vulnerable locations so that the county and localities can take appropriate action before the water levels rise to the point of flooding.
Infrastructure: Transportation	Improve Regional Transportation	Collaborate on largest regional transportation vulnerabilities and share planning, engineering, and monetary resources across municipalities to enhance regional resilience	Several of the strategies identified here are currently a part of the Orange County Long Term Transportation Plan, others can be included in the 2021 update.
Infrastructure: Transportation	Water Supply Resiliency	Assess demand and identify localized quality and supply issues.	The 2009 Orange County Water Master Plan identifies potential supply shortfalls for the City of Middletown and the villages of Goshen, Kiryas Joel, and South Blooming Grove. Persistent challenges appeared most likely in the latter two jurisdictions. Kiryas Joel is implementing a plan to access to NYC water, available to communities in the county by state law. Water quality is an additional issue in South Blooming

Area	Strategy	Description	Examples
			Grove, where a new filtering system is under active consideration.
Infrastructure: Transportation	Improve Stormwater Resiliency	Reduce amount of stormwater entering combined sewer overflows (CSOs) via infrastructure and other green practices	The City of Newburgh, in the Quassiak watershed, voted in September of 2017 to authorize a project to eliminate the discharge of 2.3 million gallons of raw sewage and polluted street water every year, by eliminating one of the city's combined sewer overflows (CSO). Their 2018 annual report is available here.
Infrastructure: Wastewater systems	Increase Wastewater System Resilience	Assess vulnerability of wastewater treatment plants to storm surges and flooding	The Newburgh Conservation Advisory Panel (CAC) has recommended a range of approaches to reduce demand on the city's water treatment plant to diminish the prospect of overflows during extreme weather.
		Develop a countywide disaster debris management plan with actions to dispose of or recycle materials (organic and artificial) efficiently after a disaster	The Orange County solid waste management plan should be amended and, informed by experience in recent disaster situations and federal guidelines, make provisions for post disaster debris management and disposal.

Public Health

Area	Strategy	Description	Examples
Public Health	Asthma interventions	Given expected increases in asthma rates, governments need to work with local health care providers to identify means of providing preventative care to affected populations	The Department of Health is partnering with Crystal Run Health Care and the Hudson Valley Asthma Coalition to implement a home health program for children newly diagnosed or recently hospitalized with asthma.
Public Health	Vector and infectious diseases	Continue to assess public health impacts of climate change and develop response plan with strategies to mitigate impacts.	Develop strategic partnerships with the NYS Health Department to prepare for the effects of climate change, particularly in the areas of infectious disease control and community preparedness.
Public Health		Implement awareness programs related to the public health impacts of climate change.	Draw upon materials on health impacts in NYSERDA's *Responding to Climate Change in New York* (ClimAID) for the development of printed and web based materials on health impacts, to be distributed electronically under the leadership of the county Health Department's community health outreach division and through school districts and general purpose local governments.

Public Engagement

Area	Strategy	Description	Examples
Public Engagement	Community Outreach	Develop outreach and education programs about the local threats posed by climate change, including annual public meetings in each subwatershed to listen to local adapation needs	In addition to the county as a whole, currently there are four climate smart communities in Orange County. Develop and deliver a tailored summary presentation for elected county, city, town and village local government officials to encourage and support efforts to encourage additional localities in Orange County to become certified climate smart communities.
Public Engagement	Community Outreach	Provide opportunities on county, local government, and watershed websites for residents to voice vulnerability and adaptation comments throughout the year	Launch a "100% prepared county campaign," beginning with a resolution of the county legislature endorsed by the county executive to have all municipalities formally adopting the Climate Smart Communities Pledge as a municipal resolution initiating each community's commitment to climate action. Use their model resolution as a template.
Public Engagement	Public Planning	Regularly update county and watershed level adaptation plans with community involvement	The Moodna Creek Intermunicipal Council meets regularly and is a collaborative mechanism for retaining focus and identifying updates needed for the creek's 2010 Watershed and Flood Mitigation Assessment Final Report.
Public Engagement	Community Outreach	Public education climate-related campaigns about pollution-reducing behaviors, local water resources, protecting water supplies, and promoting water	The Orange County Water Authority's Water Educators program brings an outstanding Water Conservation Education Program to school districts across Orange County. The program, offered free of charge, includes multiple sessions of NYSED-standards-based learning about

Area	Strategy	Description	Examples
		conservation measures for all water users, both municipal users and those on private wells	the water cycle, community water use, pollution and its prevention. The county should seek to extend this program to community organizations and citizens groups.
Public Engagement	Improve Access to Information	Create a website that details health risks exacerbated by climate change and provides information that helps residents prepare for and respond to drought, poor air quality, extreme heat, disease vectors, and other threats	Develop a page on the Orange County Water Authority website to present data on environmental health drawn from the state health department in an accessible manner, organized by water district and municipality. Provide accompanying easy guides for understanding this data. Encourage municipalities and watershed-based organizations to link to this data
Public Engagement	Improve Access to Information	Implement an educational campaign focused on engaging citizens, businesses and institutions on climate change resiliency practices and initiatives, including the locations and hours of cooling centers, the potential harm of standing water, evacuation routes, and best practices for dealing with power outages	Work with Woodbury Commons and other Weather Ready Nation Ambassadors (a NOAA program) to encourage businesses and not-for-profits in Orange County to seek this designation and then to help publicize the availability of information, facilities and other resources developed to assure effective disaster response through the Chamber of Commerce, foundations, and other non-governmental channels.
Public Engagement	Cleanups	Conduct regular stream and lake clean-ups	The Wallkill River Watershed Alliance's boat brigades document what's flowing into the river, and what's been left in its

Area	Strategy	Description	Examples
			waters and along its banks. During the trips, volunteers check on authorized outflows, and take note of ones with unknown sources. They've found litter on a sometimes massive scale, including hundreds of tires once placed for erosion control: 197 of those tires were recovered in 2017 and volunteers were recruited to pull just as many in 2018.
Public Engagement	Increase Access and Recreation	Increase public access to waterbodies, particularly in under-served areas; incorporate recreational water features in parks and plant trees in parks and along streets, especially in dense urban areas	Orange County, in cooperation with Ulster County and the Wallkill River Watershed Alliance, has received a small grant from the Hudson River Greenway to conceptualize, research and promote a new River Trail focused on in-water recreation (fishing, paddling and rafting opportunities etc.) in the river reach from the U.S. Fish and Wildlife Preserve on both sides of the NY/NJ border north through Orange County and into Ulster County stopping short of Sturgeon Pool just beyond the I-87 and Perrine Bridge crossings.
Public Engagement	Increase Air Quality Awareness	Air quality warnings and education	Create an "Environmental Health Metrics" space on the county Department of Health website to regularly report available measures, to include daily air quality indicators and trends, accompanied by easy to understand explanations and comparisons.

Area	Strategy	Description	Examples
Public Engagement	Increase Household Level Preparedness	Encourage residents to organize or participate in regular emergency preparedness, response, and recovery planning and training events; Educate residents about how to create a household preparedness plan and store of food, water, and other supplies (lanterns, bicycles, etc.) to use in case a flood or other hazard cuts off access to goods, services, and emergency responders	Further develop and enhance the county Emergency Management office's engagement with Ready.Gov and NY Prepare.Gov., including offering and encouraging residents to take courses offered under the citizens' preparedness course program and to obtain free NYS disaster preparedness kits. Encourage municipalities to link to the county health department page on "How to prepare for emergencies." Particular attention should be paid to the communities identified as most socially vulnerable to climate change above in the Ramapo and Upper Hudson watersheds, as wells as residential areas in floodplains.
Public Engagement	Increase Neighborhood Level Preparedness	Encourage neighborhoods to become familiar with residents who have skills and tools to assist others with special needs (e.g., elderly or disabled), should residents need to provide emergency response in the event that police and fire personnel cannot provide immediate assistance	According to FEMA, 46 percent of individuals expect to rely a great deal on people in their neighborhood for assistance within the first 72 hours after a disaster. The towns of Montgomery, Maybrook, and Walden have a Neighbors Helping Neighbors program. By resolution of the county legislature, commit the county to programming disseminating FEMA Neighbors Helping Neighbors materials and making available training with and through municipal government to involve and educate citizens about simple steps one can take to become more prepared.

Area	Strategy	Description	Examples
Public Engagement	Community Outreach	Develop outreach and education programs about the local threats posed by climate change, including annual public meetings in each watershed to listen to local adaptation needs	Participate in the FEMA "Preparathon" program organized on a watershed basis.
Public Engagement	Support Watershed Groups	Continue the significant support the county already provides for these groups	The Orange County Water Authority, the County of Orange, and others have researched and developed plans to help conserve and protect some of watersheds in the county.

Helping Residents During Emergencies

Area	Strategy	Description	Examples
Help Residents During Crisis	Provide Access to Safe Places	Provide public access to cool buildings during heat waves; send mobile cooling facilities into high risk neighborhoods such as dense urban places (heat island effect) and low-income areas; Distribute generators/air conditioners to at-risk residents during service disruptions/high heat days	There were sixteen designated warming and cooling centers in Orange County in 2018.
Helping Residents During Crisis	Provide Access to Safe Places	Maintain bus cooling systems for passengers	According to global research conducted by Bloomberg New Energy Finance, by 2040, municipal bus fleets are expected to transition to 80 percent electric.
Helping Residents During Crisis	Provide Access to Safe Places	Extended pool and park hours; Recreational water and shade features	
Helping Residents During Crisis	Prevent Access to Dangerous Places	Limit access to parks, lakes, and other outdoor recreation areas when natural hazards (e.g., algal blooms, wildfires, floods) pose risks to public safety	The NYS DEC listed eight Orange County locations as having Harmful Algae Blooms in 2018: Beaver Dam Lake, Brooke Lake, Masonic Lake, Orange Lake, Round Lake, Tuxedo Lake, Winding Hills Park Lake, and Masonic Creek. The county health department should advise citizens through its website and in host communities through local municipalities that the DEC advises: "Anyone using a

Area	Strategy	Description	Examples
			waterbody is advised to avoid direct contact with any discolored water and to report suspected HABs conditions to DEC by submitting a Suspicious Algal Bloom Report Form or by calling 518-402-8179.
Helping Residents During Crisis	Identify and Help Vulnerable Households	Provide homes with a window card to indicate if help is needed; have public safety officials or resident neighborhood response teams go door to door during extreme weather including heat and flooding events as well as during service disruptions; establish a voluntary list of residences that would be checked on during such events	Canvass the areas identified in the above assessment as vulnerable to efficiently identify people at risk for follow up and contact during at risk time periods.
Helping Residents During Crisis		Alert public during extreme heat events to power down unnecessary electronics in order to reduce strain on the grid and prevent blackouts, as well as take heat-related health precautions.	In collaboration with power companies the Orange County Department of Consumer Protection should advise consumers of incentives and opportunities to replace inefficient appliances and equipment. Organize all governments in the county to participate in seasonal and weather specific demand reduction initiatives.

Area	Strategy	Description	Examples
Helping Residents During Crisis	Utilize Media to Alert Residents	Use media outlets to increase awareness of risk associated with extreme heat; target at-risk populations, outdoor workers and those who exercise outdoors	Enhance use of social media, which is already being utilized by Orange County's Executive office and Emergency Management

Helping Local Governments

Area	Strategy	Description	Examples
Helping Local Governments	Increase local renewable energy sources	Help municipalities implement local zoning that is current and appropriately manages solar installations	New York State has a model solar zoning ordinance and the Orange County Department of Planning provides guidance regarding zoning for large scale solar installations. Zoning changes have been developed, or are being considered in Goshen, Minisink, Mount Hope, Warwick, Wawayanda, and Wallkill.
Helping Local Governments	Improve Land Use Planning	Prepare municipalities for the impacts of climate change by incorporating expected changes, such as more frequent flooding and heat waves, into building codes and land use decision-making processes	Sustainability and resiliency for local government facilities should be adopted as goals in planning documents and for capital budgeting, e.g. this has been done by revision of the Beacon City charter (Section 7.01.B).
Helping Local Governments	Improve Land Use Planning	Provide opportunities to local government leaders to be trained on existing regulations and about how to incorporate watershed level approaches into land use decision-making	One model in Orange County is the Moodna Creek Watershed Intermunicipal Council, formed by intermunicipal agreement in 2010. The council has both municipal and non-municipal members and includes representatives from 15 municipalities within the Watershed. The council and its committees will work cooperatively. Results include improved communication across municipal boundaries, increased access to financial support, and more effective solutions to water resource issues due to a

Area	Strategy	Description	Examples
			comprehensive watershed approach and coordination of organizational efforts.
Helping Local Governments	Improve Land Use Planning	Provide training on best management practices for minimizing flooding	The county can partner with the regional DEC office to host trainings for municipal leaders.
Helping Local Governments	Improve Land Use Planning	Encourage development setbacks from streamsides to protect people from flooding and to reduce property damage	The South Wallkill River Floodplain Benching project has and will continue to reduce and mitigate agricultural flooding.
Helping Local Governments	Improve Land Use Planning	Identify the places most at risk of flooding by modernizing floodplain maps to reflect not only historical but likely future flood patterns	The Orange County flood plain maps, updated through 2009, are available through FEMA.
Helping Local Governments	Improve Local Code	Develop model codes for water resource protection and climate change resilience	See the Zoning Code checklist in OCWA's Watershed Design Guide: Best Practices for the Hudson Valley (2014).
Helping Local Governments	Improve Local Code	Recommend standards that incorporate adaptability to climate change for new construction	See Local Law Provisions for Climate Change Adaptation for a range of suggestion for local zoning laws addressing adaptation for climate change.
Helping Local Governments	Improve Local Code	Encourage local regulatory measures for water resource protection, especially for drinking water, and	

Area	Strategy	Description	Examples
		stormwater reductions	
Helping Local Governments	Improve Local Code	Promote incentive billing for centralized water and sewer services to encourage conservation	The New York State Public Service Commission (PSC) approved a four-year rate plan for New York American Water (a private water provider) to move toward a goal set by the NYS DEC for all Long Island water suppliers to reduce water consumption by 15 percent to help ensure the long-term sustainability of the Long Island Aquifer. According to the conservation rate structure, as customers consume more water, the cost per gallon increases. The Village of New Paltz in Ulster County currently has a tiered systems whereby higher volume users pay more per gallon than lower volume users.
Helping Local Governments	Improve Stormwater Management	Help municipalities implement stormwater districts and to implement stormwater retrofits at identified sites and other appropriate locations	Cornell Cooperative Extension in Orange County is offers stormwater trainings designed to provide private and public sector engineers, architects, administrators, planners and consultants with up-to-date techniques for understanding, evaluating, designing and reviewing stormwater management plans and practices.
Helping Local Governments	Improve Stormwater Management	Incentivize stormwater management; increase maintenance of stormwater infrastructure, possibly through	The Orange County Water Quality Strategy and two watershed management plans call for the creation of a technical staff position with exclusive stormwater management responsibilities as crucial for elevating the priority of

Area	Strategy	Description	Examples
		outreach and training of municipal officials, contractors, and landowners	stormwater management for county government, municipalities businesses and land owners.
Helping Local Governments	Facilitate Septic System Maintenance	Develop program to encourage septic maintenance	Develop and disseminate by brochure and the water authority and health department websites materials similar to this (found on a commercial website).
Helping Local Governments	Improve Local Code	Help municipalities update local codes to require regular inspections and reporting on stormwater infrastructure	In New York State, "small municipal stormwater sewer systems (MS4s) that are located within the boundaries of a Census Bureau defined "urbanized area" are regulated under EPA's Phase II Stormwater Rule. MS4s are required to develop a stormwater management program that will reduce the amount of pollutants carried by stormwater during storm events to waterbodies to the "maximum extent practicable"."
Helping Local Governments	Improve Local Code	Help municipalities develop processes and requirements for project applicants to demonstrate projected water use and impacts as well as integrate water efficient landscaping standards	Water footprint methodologies have been developed to calculate the full amount of water utilized for the full cycle of projects.
Helping Local Governments	Increase Green Infrastructure Practices	Continue to promote appropriate use of green infrastructure	The NYS DEC lists twelve green infrastructure sites in Orange County on their Green Infrastructure Examples for Stormwater Management in the

Area	Strategy	Description	Examples
			Hudson Valley page.
Helping Local Governments	Identify Critical Areas/Needs	Encourage local level comprehensive planning focused on sustainability, help with natural resource inventories, vulnerability assessments, and adaptation strategies	The county has assisted Cornwall, Montgomery, and Blooming Grove in the development of natural resource inventories.

State Level Advocacy

There are several areas of importance that are outside the purview of counties, but these challenges cannot be faced without state partners. The state should be encourage to take action on:

- In order to protect wetlands, local leaders should work with with policy makers to reduce the minimum size of wetlands regulated by New York State.
- State agencies should conduct flood audits of critical state infrastructure such as hospitals, important road crossings, and wastewater treatment plants.
- Encourage the creation of a state climate change adaptation fund to help communities reduce loss of life and property damage both in advance of extreme weather and in disaster response.
- Encourage increased funding for county and local level comprehensive planning focused on sustainability, natural resource inventories, vulnerability assessments, and adaptation strategies (Think this exists now)
- Encourage state funding for infrastructure improvements that contribute to overall community resilience; advocate for expanding the eligibility of federal and state disaster-assistance funding to allow for the replacement or relocation of aging or vulnerable infrastructure before it fails

Implementation Tracking

In order to monitor progress on adaptation strategies, work plans need to be developed and include accountability mechanisms. Further funding should be sought to implement this plan, especially for highest-priority actions.

County staff should be directed and trained to develop their technical expertise and skills to prepare for and respond to climate change impacts. Climate impacts need to be factored into the planning of operations and the coordination of disaster response and recovery activities among first-responders, including public health, law enforcement, fire, and emergency medical services personnel. Activities and planning needs to be coordinated across county departments: align land use, hazard mitigation, transportation, capital improvement, and other plans so that they take into account climate change and work toward the same goals.

It is recommended that fiscal impacts be further documented: for example, conduct full fiscal impact studies of extreme weather and sea level rise scenarios to better inform and strengthen commitments from community leaders and elected officials.