RESILIENT NJ
NORTHEASTERN NEW JERSEY

CLIMATE HAZARDS ASSESSMENT

JUNE 2022

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NEW JERSEY

Image Source: City of Jersey City

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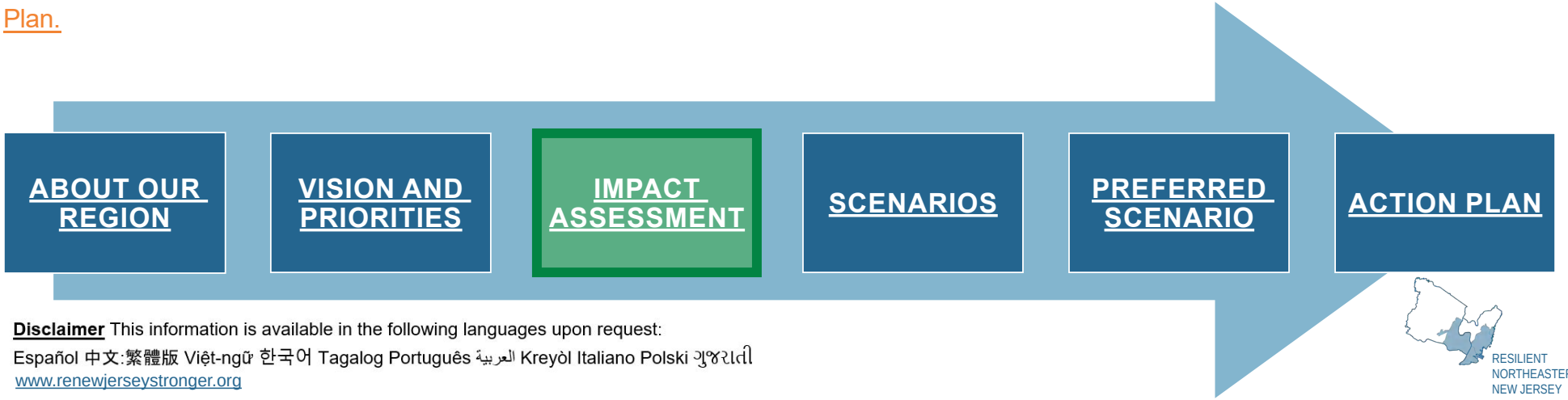
- BY EMAIL: ResilientNENJ@gmail.com
- BY SOCIAL MEDIA: @ResilientNENJ on Twitter & Facebook, @resilient_nenj on Instagram

Please visit our website at www.resilient.nj.gov/nenj to learn more about the program and what we've done so far.

The About Our Region report (released April 2021) shared the planning context, while the Vision and Priorities report (released October 2021) summarized what we had heard from the community so far. This Climate Hazards Assessment summarizes Resilient NENJ's findings, based on existing data and studies, about the possible current and future impacts to the region from climate-related hazards such as extreme heat, groundwater rise, and decreased air quality. This report includes an overview of flood impacts, while the separate Flood Impact Assessment summarizes the more detailed assessment that Resilient NENJ conducted to understand how flooding could affect the region under certain storm and tide conditions.

Resilient NENJ used community feedback, technical analyses, and findings from the Climate Hazards Assessment and Flood Impact Assessment to refine the possible courses of action, presented in the Scenario Development report, into recommendations for the Action Plan.



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JUNE 2022

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Thank you to the many community members, community-based organizations, agencies, and regional stakeholders that have contributed their time and expertise to the Resilient NJ process to date.

Resilient Northeastern New Jersey (Resilient NENJ) is developing a regional action plan to address current and future flood risks and improve quality of life in Jersey City, Newark, Hoboken, and Bayonne. The project is a partnership between the four cities, Hudson County, Ironbound Community Corporation, and HOPES CAP, Inc (the Region Team). Representatives from each sit on a Steering Committee that leads the project. Resilient NENJ is part of the Resilient New Jersey program, administered by the New Jersey Department of Environmental Protection (NJDEP) and funded by the U.S. Department of Housing and Urban Development (HUD).

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ABOUT THIS REPORT

Flooding is not the only climate-related hazard Northeastern New Jersey faces. Increasing global temperatures, radical shifts in precipitation and weather patterns, sea level rise, and correlated groundwater table rise will interact in complex ways to threaten the region with various additional hazards, including other (non-flooding) types of severe weather, various direct and indirect risks from groundwater rise, increased drought and threats to water supply, extreme heat, worsening air quality, invasive species and vector-borne illnesses, increased risk of wildfire, and ocean acidification.

This assessment summarizes the Resilient NENJ team's findings on how climate-related hazards affect the region today, how risk will evolve as climate change progresses into the future, and the types of impacts expected to people and places—whether to public health, provision of critical services, or the health and integrity of existing ecosystems and habitats the region's population depend on. The assessment both looks at how various climate hazards will directly affect the region (e.g. wildfire) and how climate hazards in other parts of the country will affect the region (e.g., how wildfire in other areas can affect air quality).

The Resilient NENJ team relied on existing publicly available data and studies to complete this assessment.

This assessment revealed the following key insights:

- Some of the most socially vulnerable communities in the state—and in some cases, the country—reside in Newark and Jersey City, both of which are important regional transportation and economic hubs. These communities also face extremely high urban heat, pollution, and proximity to hazardous waste.
- Rising global temperatures will increasingly affect Northeastern New Jersey with serious impacts to public health. Rising temperatures will generate dangerous heat, contribute to worsening air quality, potentially disrupt critical services, threaten water supply, water quality, and food supply as a result of drought, and increase the likelihood of wildfires. Some of these effects will be especially acute given the region's heavily urbanized landscape.
- High concentrations of hazardous materials and wastewater discharge throughout Northeastern New Jersey may pose a serious risk to public health and safety as groundwater levels rise. More attention and study are needed on this topic industry-wide.

This report concludes with a Climate Hazard Resilience Toolbox of potential approaches to address these various hazards which can be implemented at various scales, from site-specific to statewide actions. This Toolbox also informs clear action items and options incorporated into the Resilient Northeastern NJ Scenario Development Report.

1. CLIMATE SCENARIOS & HAZARDS

GLOBAL CLIMATE PROJECTIONS

Increasing global concentrations of greenhouse gas emissions (GHG) are driving increased temperatures, extreme and unpredictable precipitation patterns, sea level rise, and associated groundwater rise, which together will drive increased risk from multiple hazards.

The International Panel on Climate Change (IPCC) develops future climate change scenarios defined by the level of carbon in the atmosphere. “RCP 8.5” is considered the high-end scenario out of several Representative Concentration Pathways, or RCPs.

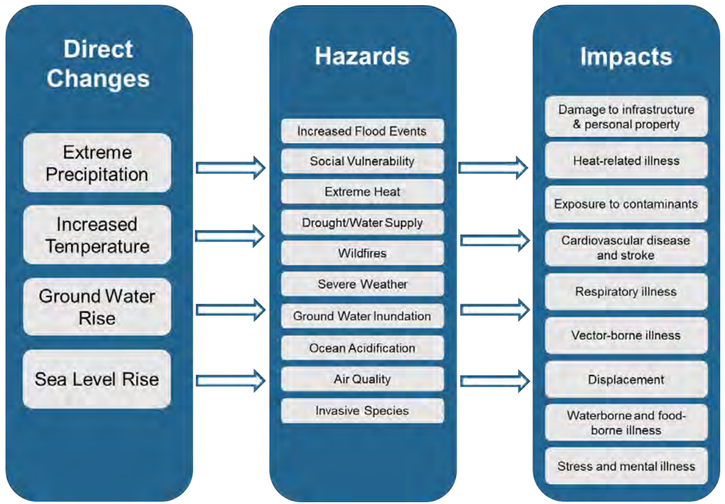
This is often referred to as the “business-as-usual” scenario, or the 90th percentile outcome if no substantive global policy is undertaken to curb greenhouse gas (GHG) emissions. This scenario is correlated with an average global temperature increase of approximately 4.9 degrees Celsius, or almost 9 degrees Fahrenheit.

More recently, the IPCC transitioned to using Shared Socioeconomic Pathways (SSPs) in place of RCPs to include various socioeconomic factors; however, most publicly available projections of future hazards are still based on the older RCP scenarios. The SSP equivalent of the RCP 8.5 scenario is SSP5-8.5.

The IPCC does not assign probabilities to any of its climate projection scenarios.

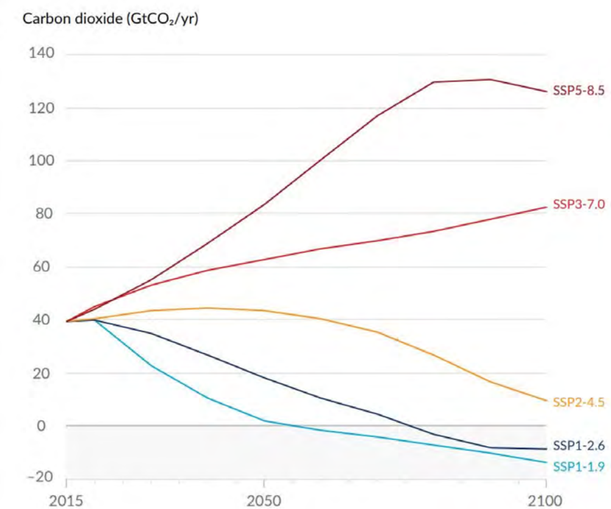
As such, there is considerable uncertainty and disagreement over the likelihood of an RCP/SSP5-8.5 outcome or any of the other outcomes.

Recognizing this uncertainty and Resilient NENJ’s planning needs, this climate hazard assessment uses the RCP/SSP5-8.5 scenario when looking at existing future projections of climate hazards.



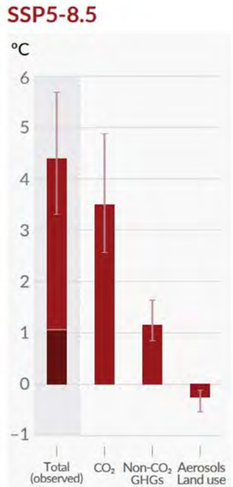
...AND FUTURE HAZARDS

Future Annual CO_2 Emissions (5 Scenarios)



Source: IPCC 2021: Climate Change 2021. The Physical Science Basis.

“Business-as-Usual” Emissions Contributions to Global Surface Temperature Increases



What does the “8.5” in RCP/SSP5-8.5 refer to? The numbers associated with these scenarios refer to the average global warming increase per square meter. For an RCP 8.5 or SSP5-8.5 scenario, this presumes an average global warming increase of 8.5 watts per square meter.

2. SOCIAL VULNERABILITY

SOCIAL VULNERABILITY AND RACIAL INJUSTICE

Northeastern New Jersey contains some of the most socially vulnerable communities in the state and nation. Social vulnerability refers to the degree to which people can expect to be challenged when faced with significant disruptions. A variety of socio-economic factors play a pivotal role in understanding challenges a community or household may experience.

For example, lower income households have fewer resources to adapt to changing and dangerous circumstances—whether by moving to areas or homes less exposed to risk, by retrofitting their homes to mitigate extreme heat, by having access to transportation to seek shelter in an emergency, by seeking out affordable health care to treat respiratory conditions exacerbated by poor air quality, or to financially recover from a destructive fire.

Historical exclusion and policies that have inequitably distributed resources have affected communities within certain demographics disproportionately, leaving them more vulnerable to disruptions. Examples of such communities include people of color, low-income populations, households with low English-speaking proficiency, and people with disabilities.

Very high rates of social vulnerability are concentrated in Newark and Bayonne, as well as western and southern Jersey City.

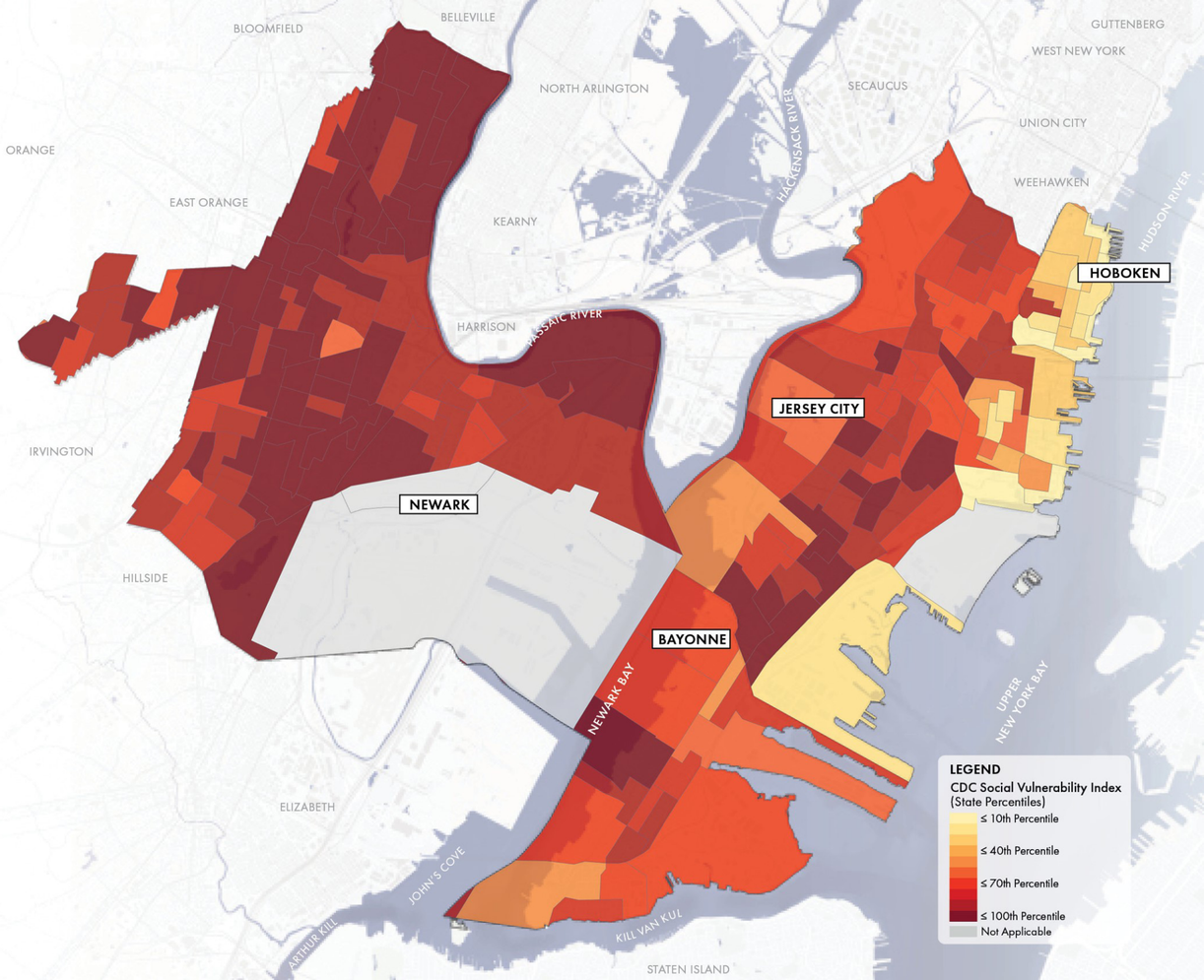
More than half of Newark consists of census tracts within the highest-ranking socially vulnerable communities in the nation. These communities are likely to experience the worst impacts from the hazards detailed in this assessment, and they are likely to experience many of them earlier.

This report looks at climate hazards in the context of social vulnerability to help understand people and places with the greatest risk and needs.

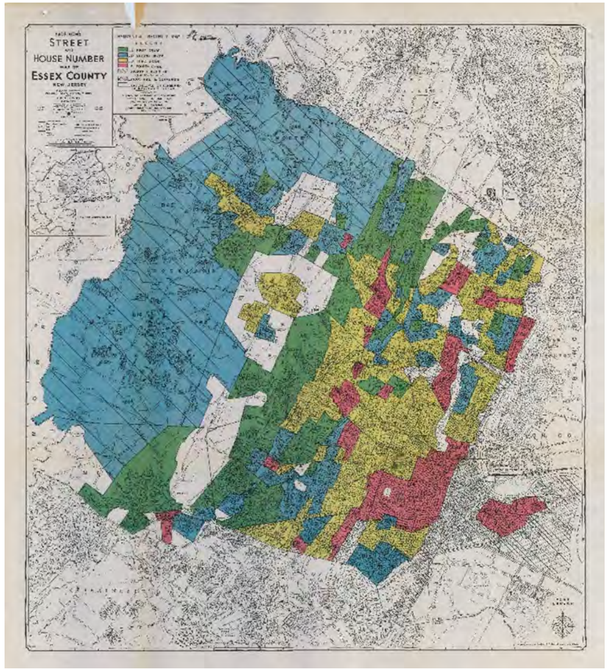
The CDC Social Vulnerability Index

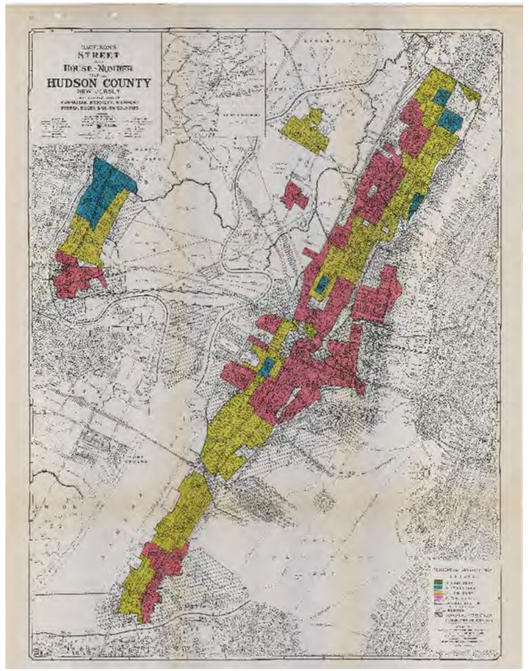
The Center for Disease Control and Prevention (CDC) produces a social vulnerability index at a more localized scale using census tract-level demographic data. The index is based on 15 social factors, including poverty level, unemployment, income, high school diplomas, aged 65+, aged 17 or younger, disability prevalence, single-parent households, minority status, English proficiency, multi-unit housing, mobile homes, crowding, vehicle ownership, and group quarters.

In the image to the right, census tracts are ranked based on their score compared to other census tracts in the state. Census tracts in deep red are amongst the most socially vulnerable census tracts in the state.



SOCIAL VULNERABILITY AND RACIAL INJUSTICE





Source: University of Richmond Digital Scholarship Lab, Mapping Inequality. https://dsl.richmond.edu/panorama/redlining/

Redlining and Historical Racial Inequities

Northeastern New Jersey has a notable history of racially discriminatory housing practices from the early- to mid-twentieth century, called redlining, whose effects can still be felt today. Most neighborhoods in Newark, Jersey City, Bayonne, and Hoboken were designated as Third and Fourth Grade residential security areas—neighborhoods subject to the most extreme forms of exclusionary planning and zoning practices.

Today, many of these same neighborhoods are classified by the CDC as amongst the highest-ranking socially vulnerable census tracts in the country—deep-rooted socio-economic dynamics that can be traced back to racially-charged housing segregation and its perpetuation of endemic poverty.

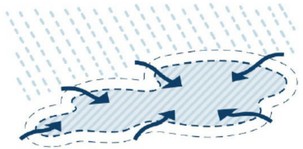
In addition to these demographic factors which contribute to low adaptive capacity to climate hazards, these neighborhoods also face greater physical exposure to hazards such as urban heat island, poor air quality, contaminated water, and the threats posed by proximity to hazardous materials: another legacy of twentieth century urban planning.

These geographic factors are no coincidence and can also trace their roots back to historical injustices, as marginalized and minority communities were previously forced to settle in areas facing chronic disinvestment and high industrial activity, even as the surrounding region came to depend on these areas as key economic and transportation hubs.

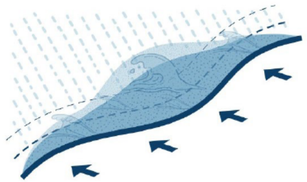
3. CLIMATE HAZARDS & THEIR IMPACTS

3a. FLOODING AND COASTAL STORMS

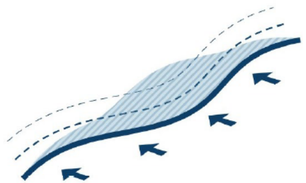
FLOODING: THE HAZARD AND EXPECTED RISKS



RAINFALL FLOODING



COASTAL STORM SURGE



TIDAL FLOODING

Sources of flooding that impact this region

Flooding already is a widespread issue in Northeastern NJ and is worsening with the combined effects of sea level rise and increasing intensity of rainfall.

Northeastern NJ is a coastal region and much of its land was formerly wetlands that were filled in, making it vulnerable to flooding from storm surge, as seen during Hurricane Sandy. The region is also densely populated with undersized drainage systems and increasing amounts of impervious surfaces (like concrete and asphalt paving), which contribute to flooding from rainfall.

Through Resilient NENJ, residents have reported flooding during heavy rainfall, and many shared the financial, physical, and emotional burdens that flooding has brought. Sea level rise can worsen rainfall, storm surge, and tidal flooding, and warming temperatures are expected to make rainfall more intense over time.

Resilient NENJ conducted a detailed assessment to understand the region's exposure to flooding and possible impacts if no action is taken. The results are explained at length in the separate Flood Impact Assessment report, and we provide a brief summary here.

The New Jersey Department of Environmental Protection (NJDEP) developed new flood models for use with the Resilient NJ program.

The models estimate the depths of flooding from rainfall and storm surge events similar to those that have occurred in the past and add sea level rise.

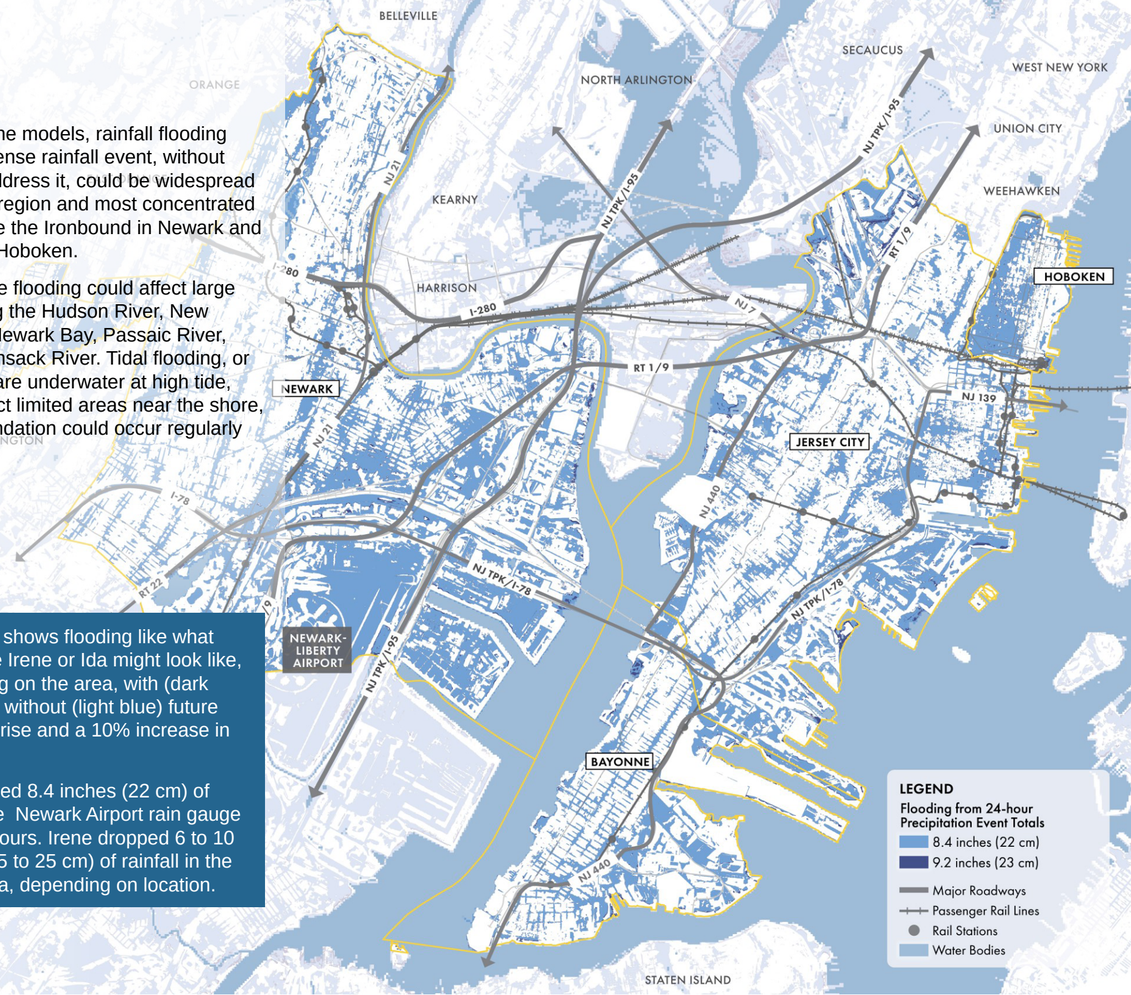
The rainfall models look at areal flooding and flash flooding with and without sea level rise, while the coastal flood model adds sea level rise on top of Hurricane Sandy high water marks.

These models are useful in highlighting potential flood-prone areas, comparing possible flood mitigation options, and prioritizing action. Many of the deepest areas of flooding based on the models align well with reported locations of flooding from community members. While the new models are valuable, they also have limitations, such as only showing us what flooding could look like from large events and using a rough estimate for the quantity of rainfall that drainage systems can store.

Areal flooding refers to widespread flooding that would occur from long duration rainfall, such as 24-hours. This is the type of storm used in the modeling for this map. This map shows what flooding would look like if heavy rain fell evenly across the whole area at the same time. In reality, different areas would likely flood at different times.

Based on the models, rainfall flooding from an intense rainfall event, without action to address it, could be widespread across the region and most concentrated in areas like the Ironbound in Newark and southwest Hoboken.

Storm surge flooding could affect large areas along the Hudson River, New York Bay, Newark Bay, Passaic River, and Hackensack River. Tidal flooding, or areas that are underwater at high tide, could impact limited areas near the shore, but the inundation could occur regularly



This map shows flooding like what Hurricane Irene or Ida might look like, depending on the area, with (dark blue) and without (light blue) future sea level rise and a 10% increase in rainfall.

Ida dropped 8.4 inches (22 cm) of rain at the Newark Airport rain gauge over 24 hours. Irene dropped 6 to 10 inches (15 to 25 cm) of rainfall in the study area, depending on location.

FLOODING – EXPECTED REGIONAL IMPACTS

Flooding has the potential to impact critical regional infrastructure, people and their homes and businesses, and valuable community spaces in the region. Although many actions are already underway to begin addressing flooding, significant risk remains, particularly from rainfall flooding.

Flooding can impact people and places in a variety of ways. For example, flooding can create structural damage that needs to be repaired (which takes up time and money, and causes significant stress), disrupt daily life by blocking transportation, or in extreme cases can cause injury or death. Impacts to travel or buildings can have reverberating impacts for businesses and people.

Resilient NENJ documented feedback from residents about flooding impacts in the Vision and Priorities and Flood Impact Assessment reports. Using the new flood models (described on the previous page), along with a baseline understanding of the people, places, and things throughout the region that may be impacted, the Resilient NENJ team quantified the range of impacts flooding could have on our region.

The team used methodologies developed by FEMA and USACE to quantify four types of impacts to buildings and the people, businesses, and services they house: direct physical damage, human impacts, business impacts, and loss of function. Results are summarized as Total Direct Losses, which are the total numbers shown in the bar chart on the right.

WHAT ARE THE POSSIBLE IMPACTS?

A flash flood event from heavy rainfall like Henri in 2021 (3 to 4 inches over two hours) region-wide has the potential to cause $2.7 billion in losses, while an Ida or Irene-like areal flood event is expected to cause $5.2 billion in losses. With the impacts of climate change, we could see $6 billion of potential losses in a future areal rainfall event and $31 billion in a future extreme storm surge event.

Areas with the biggest risk from rainfall flooding, including East Jersey City, Hoboken, and the Ironbound neighborhood of Newark, are each expected to incur more than $500 million in losses in a future rainfall event if no mitigation action is taken. These same areas, as well as the Dayton-Airport area in Newark, are also expected to have the highest losses in a future storm surge event, with losses in each of these areas expected to be more than $3.5 billion.

These loss estimates represent direct impacts to buildings and residents and do not consider reverberating economic losses, impacts to mobility, or the disproportionate effects these losses may have on under-resourced communities.

Overall, 280,000 residents are expected to have their homes exposed to either rainfall or coastal storm surge flooding, representing over 40 percent of the population in the region at large. Of these residents, half live in areas of high social vulnerability. In other terms, about a third of the residents in these most highly socially vulnerable areas are exposed to flooding.

Resilient NENJ studied possible flood impacts to critical assets, or places that play important roles in communities. The following page includes examples of possible impacts to critical assets. More detail is provided in the Flood Impact Assessment report.

Infrastructure:

- **Newark Liberty International Airport (EWR)** is currently exposed to both rainfall and storm surge flooding. Without action, areas of **Port Newark** could expect 14 feet of flooding during a future extreme storm surge event.

Emergency Response:

- The region is home to approximately **50 hurricane evacuation routes**, 40 miles of which may be exposed to at least 6 inches of flooding in the modeled future storm surge flood event. Six inches of flooding on a road is enough to damage vehicles, make routes impassable, and potentially pose serious threats to life safety.

Public Health:

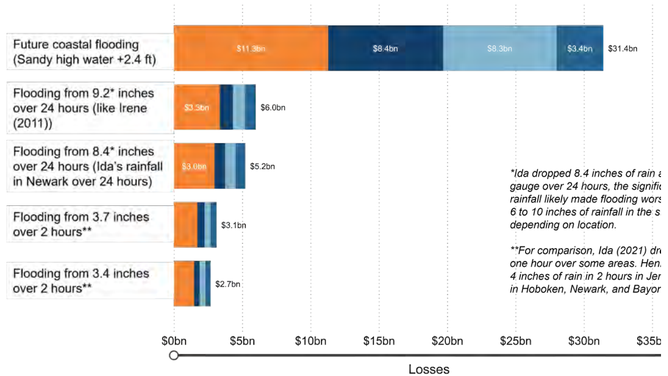
- **Columbus Hospital** in Newark is expected to be exposed to flooding due to both present and future major rainfall events.

Quality of Life:

- **Liberty State Park** is expected to experience flooding during heavy rainfall and extreme storm surge events, which will disrupt its use by the community and potentially cause ecological harm.

Ecosystem Health:

- **Combined sewer outfalls and known contaminated sites** are widespread through the region and flooding at these assets would negatively impact the community.



**Ida dropped 8.4 inches of rain a gauge over 24 hours, the signifi rainfall likely made flooding wors 6 to 10 inches of rainfall in the s depending on location.*

***For comparison, Ida (2021) dr one hour over some areas. Hen 4 inches of rain in 2 hours in Jer in Hoboken, Newark, and Bayor*

3b. SEVERE WEATHER (NON-FLOODING)

SEVERE WEATHER (NON-FLOODING) – THE HAZARD AND EXPECTED RISKS

Confidence is low on the overall impact climate change will have on severe thunderstorms and tornadoes. There is evidence to suggest that the number of days containing factors that could lead to severe weather will decrease, but when those factors do align, severe weather could be extreme. As ocean water temperatures warm, stronger hurricanes may be possible in northern latitudes. The number/ frequency of hurricanes/tropical storms with climate change is also low confidence, but there is evidence that storms rapidly intensify.

Models suggest that although it is less certain how wind speeds in the region may change, the frequency of severe storms and hurricanes with extreme winds is likely to increase across New Jersey. Additionally, current research supports the conclusion that warming ocean waters have the potential to strengthen the energy and thus intensity of tropical storm systems coming in from the Atlantic.

Further, greenhouse gas (GHG) emissions have the potential to reduce vertical wind shear, which serves as a natural barrier to hurricanes making landfall, potentially increasing the intensity of such storms if they make their way through New Jersey.

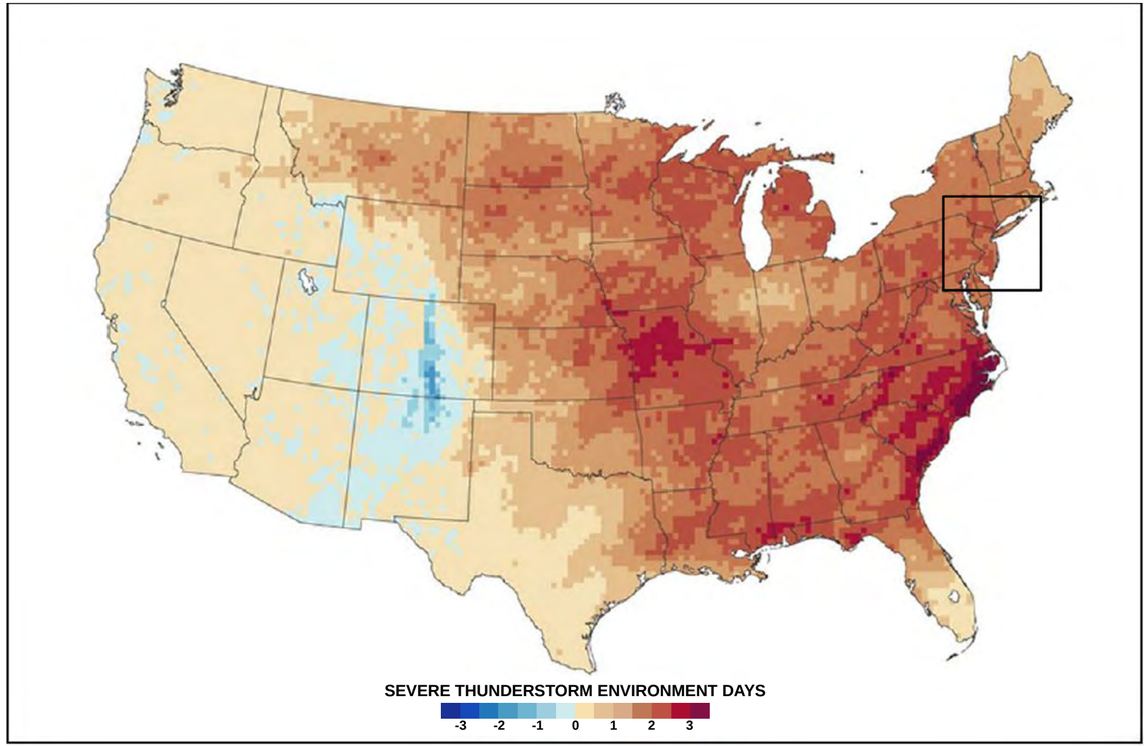
Snowfall in the region is likely to become less frequent over time as the snow season decreases in length. Nevertheless, there is a lack of data predicting the future frequency and intensity of nor'easters, freezing rain, and ice storms, though there is reason to believe the intensity of these storms may increase.

Increasing temperatures could lead to increased severity of thunderstorms, which may lead to more derechos (widespread, sustained windstorms) and tornadoes. As shown above, a 2007 study (Trapp et al) predicts an annual increase of 1-2 severe thunderstorm environment days in Northeastern New Jersey by the end of the century.

Severe Weather – Impacts

- **Residential buildings** are especially vulnerable to extreme wind events, due to greater use of wood and masonry in construction
  - **High-rise buildings**—common in Newark and Jersey City—are also highly vulnerable
- Critical facilities may sustain damage from high wind
  - In Newark, a 500-year wind-only event could impact operation of essential facilities such as emergency, medical, police, fire, and schools
- **Building and tree debris** from high wind are a danger to people, property, and utilities
- Higher frequency and severity of lightning-related events can be responsible for more **deaths, injuries, and property damage**. Being struck by lightning can cause heart damage, inflated lungs, brain damage and loss of consciousness, amnesia, paralysis, and burns
- **People over the age of 65 or without access to cars** may be especially vulnerable to severe weather events, as they could have difficulty evacuating or seeking medical attention
- Severe winter storms could cause **dangerous road conditions, power interruption, damage to roadways and waterways** due to salt application, and health risks—especially to **homeless and poor populations** lacking access to housing, proper insulation, or adequate heating

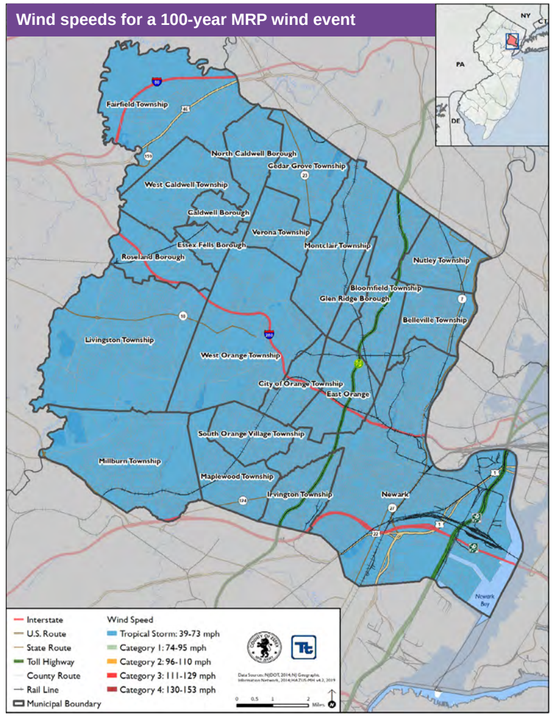
Predicted Change in Severe Thunderstorm Environment Days from 1962-1989 Period to 2072-2099 Period



Source: Trapp et al. 2007, adapted for the Essex County 2020 Hazard Mitigation Plan

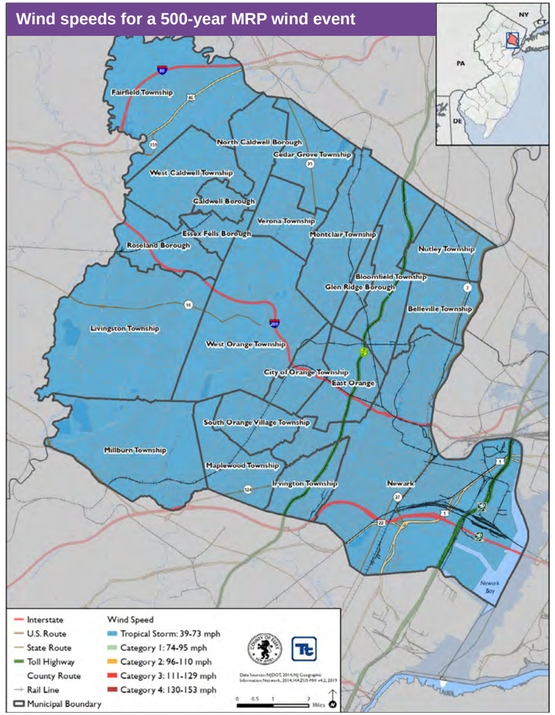
SEVERE WEATHER (NON-FLOODING) IMPACTS
Newark

In Essex County, a 100-year (1-percent annual chance) mean return period wind event wouldn't displace any households but could generate structural damages.



Source: Essex County 2020 Hazard Mitigation Plan

A 500-year (0.2 percent annual chance) mean return period wind event would displace 2 households, with none requiring temporary shelter, and would generate more substantial structural damages (up to $468.6M in replacement cost value distributed across all of Essex County).

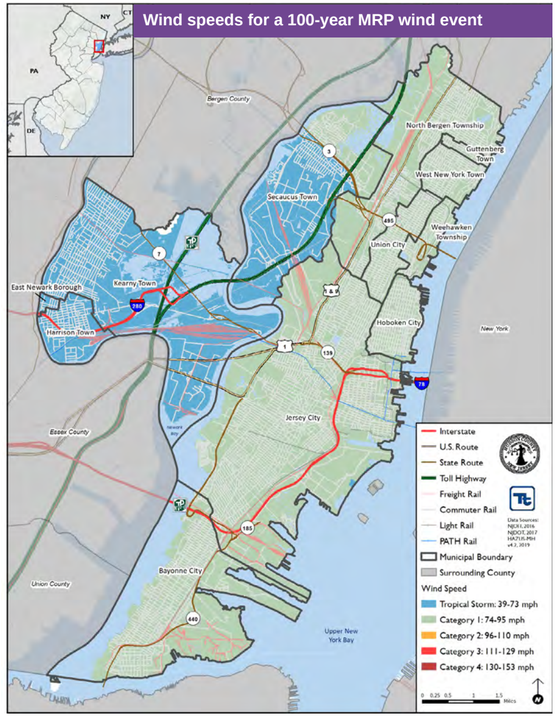


Source: Essex County 2020 Hazard Mitigation Plan

SEVERE WEATHER (NON-FLOODING) IMPACTS

JERSEY CITY, HOBOKEN AND BAYONNE

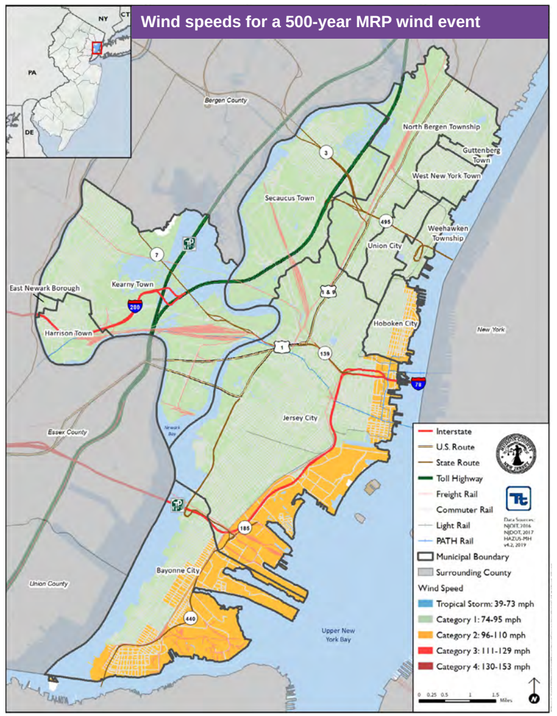
A 100-year (1-percent annual chance) mean return period wind event would displace less than 10 households each in Jersey City and Hoboken and generate up to $88.1M in structural damages across the county.



Source: Hudson County 2020 Hazard Mitigation Plan

A 500-year (0.2 percent annual chance) mean return period wind event would:

- Displace 43 households and require short-term shelter for 7 people in Bayonne
- Displace 194 households and require short-term shelter for 28 people in Hoboken
- Displace 303 households and require short-term shelter for 54 people in Jersey City
- Generate up to $697.8M in structural damages across the county



Source: Hudson County 2020 Hazard Mitigation Plan

3c. GROUNDWATER RISE & QUALITY

GROUNDWATER – THE HAZARD AND EXPECTED RISKS

The water table in an unconfined coastal aquifer will tend to rise at approximately the same rate as sea level rise. The 1:1 relationship between sea level rise (SLR) and water table rise will extend further inland in Northeastern New Jersey than the tidal influence on the water table.

The leading edge of the groundwater rise tends to advance ahead of flooding shown on coastal inundation maps.

Accounting for future sea level rise further extends the area of concern. There are very few data points for fluctuating groundwater—it's a costly process and requires additional modeling built off a network of well-water data.

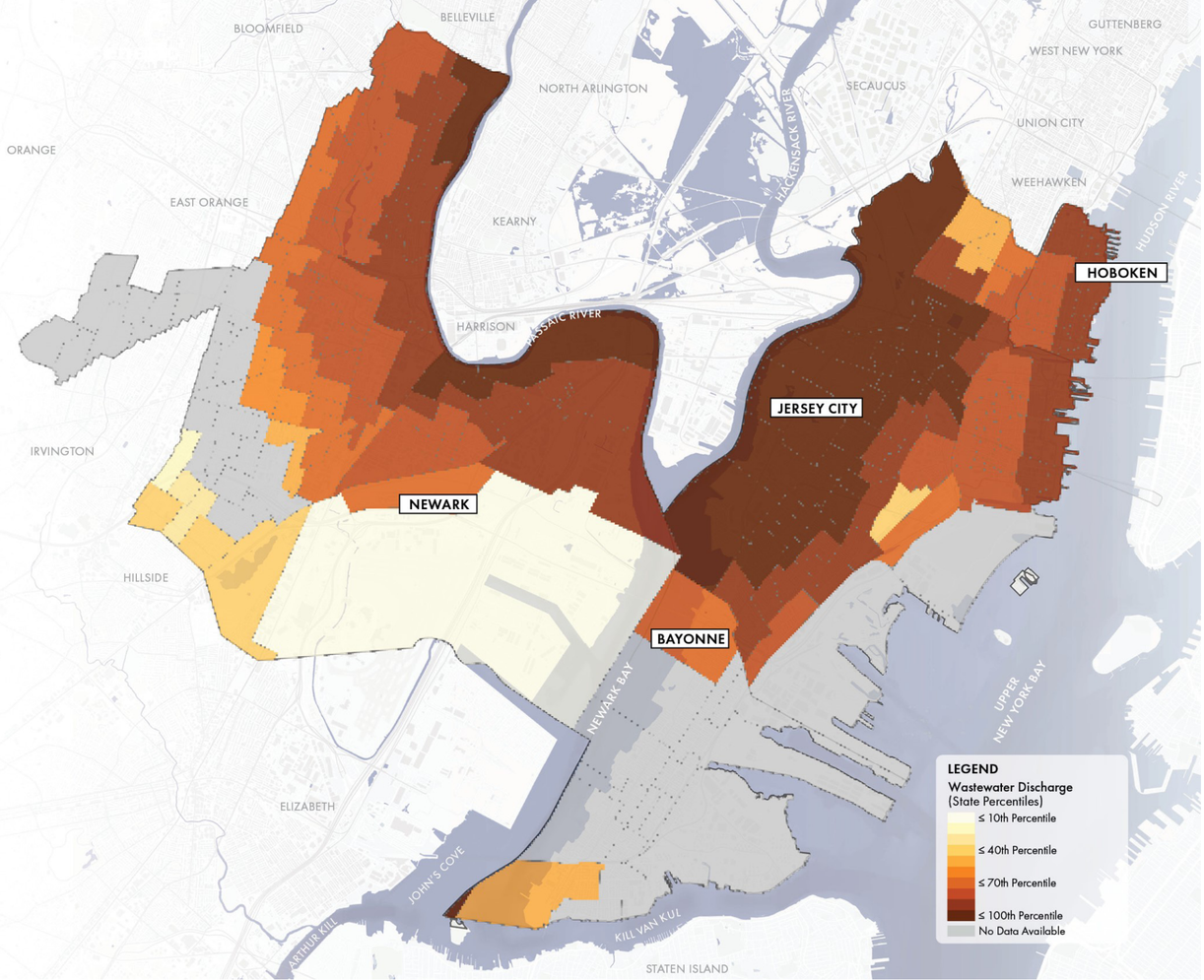
Rising groundwater levels will exacerbate the effects of several other climate change-generated processes, including drought, extreme precipitation and a strained water supply.

Impacts on individuals include increased basement flooding and septic systems filling up. For municipalities, impacts include higher corrosion rates of buried infrastructure, reduced storm water and wastewater system capacity, soil instability, soil contaminant mobilization, groundwater emergence and flooding and remobilization of contaminants into wastewater treatment facilities.

Areas of high wastewater discharge and shallow groundwater will increasingly be at risk of groundwater contamination

- Studies show that surface water carrying effluent can transport wastewater contaminants into shallow groundwater systems, even a great distance from outfalls. This risk is likely to increase in areas where depth-to-groundwater is decreasing due to sea level rise.
- Northeastern New Jersey has some of the highest concentrations of wastewater discharge in the state, especially in western Jersey City and parts of Newark. Many of these areas are also highly socially vulnerable. Data is lacking for Bayonne, however.

Saltwater Intrusion - Infrastructure and ecosystem risks, including speeding up the corrosion of infrastructure; damaging ecosystems in low-lying areas as soils become too salty to support crops and trees. Health risks including increasing chloride levels in drinking water. The World Health Organization suggests a safe level of chloride of 250 mg/L, but this is largely non-enforceable. Increased levels can lead to health impacts to pregnant women, infant mortality, and hypertension, and can trigger heavy metals in pipes to enter solution.



GROUNDWATER – THE HAZARD AND EXPECTED RISKS

Communities in Northeastern New Jersey have very high proximity to hazardous waste compared to the rest of the state and the nation

According to the Environmental Protection Agency, sources of hazardous waste range from industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids, gases, and sludges. Rising sea and groundwater levels can remobilize contaminants that were previously held in soils above the water table. Released contaminants can also enter aquifers and become concentrated plumes that may flow with groundwater.

Contamination of groundwater aquifers could limit their ability to serve as supplementary water supply sources in cases of prolonged drought. Remobilized contaminants can lead to contaminant plume spread and decrease water quality at partially remediated sites where contaminant levels in water had previously been improving. Contaminated groundwater can have notable impacts to coastal environments as it flows to the sea.

In areas with low depth-to-groundwater, tidal and rainfall conditions combined with sea level rise can lead to risk of groundwater emergence and flooding of basements and underground infrastructure, parks, open spaces, and even streets.

Given the slower movement of groundwater compared with surface water, this type of flooding may make a delayed appearance after a heavy downpour event and linger far longer after surface flooding has receded. If the affected groundwater source is contaminated, this poses an additional risk of sustained exposure to toxic water.

More study is needed to understand the extent and dynamics of these risks in Northeastern New Jersey. High priority needs include the following:

- A current water table elevation map for the region
- Projected future changes in depth-to-groundwater with sea level rise
- Evaluation of future drinking water needs and potential aquifers that could be affected
- A comprehensive contaminant source inventory that details depth and water-solubility of contaminants
- Additional groundwater modeling where high-risk conditions exist.

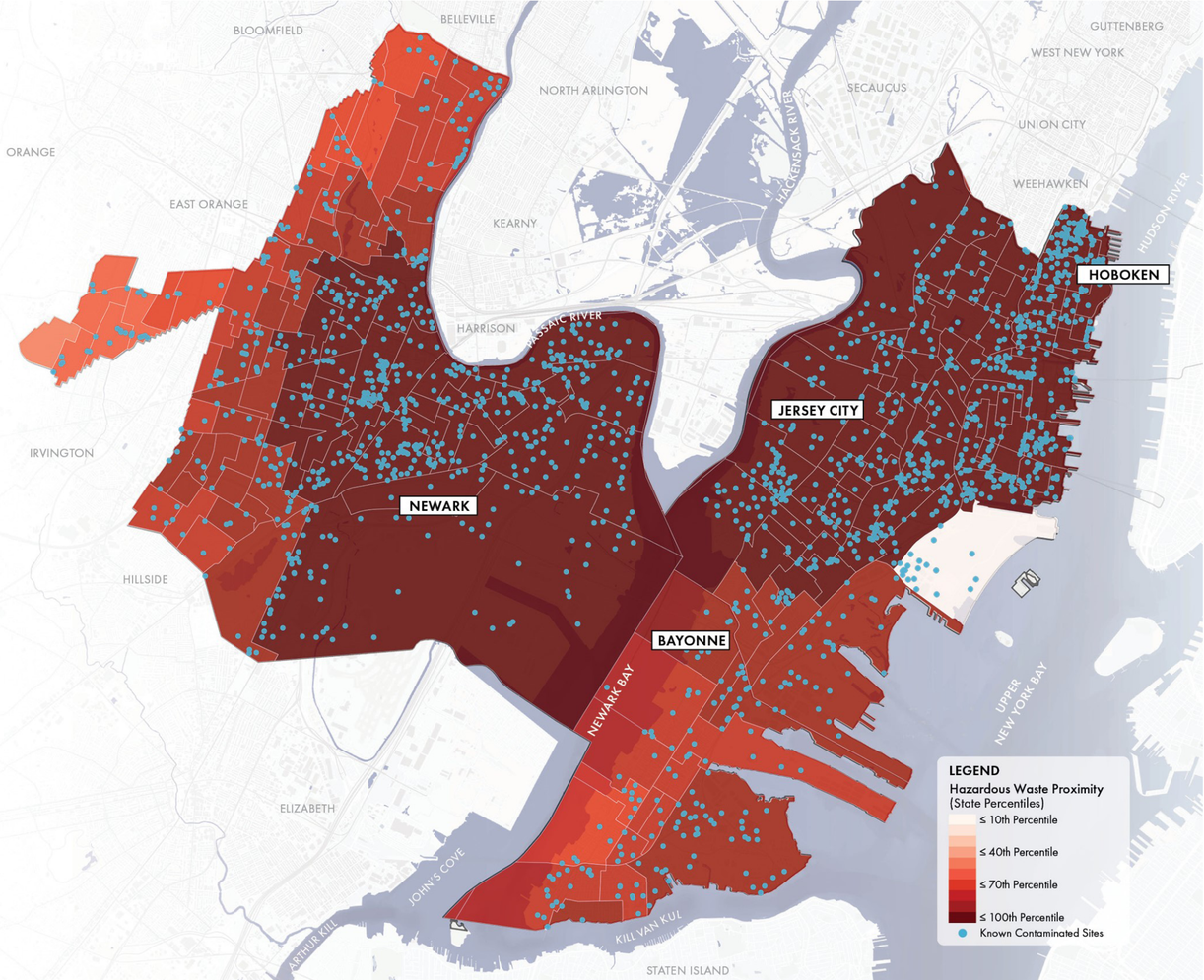
NENJ communities are also within high national percentiles for hazardous waste proximity

Bayonne is within the 90th national percentile

Hoboken is within the 99th national percentile

Jersey City is within the 97th national percentile

Newark is within the 94th national percentile



3d. DROUGHT & WATER SUPPLY

DROUGHT – THE HAZARD AND EXPECTED RISKS

Throughout the Northeast U.S., it is anticipated that droughts lasting 3-6 months or longer will significantly increase in frequency under a "business-as-usual" high emissions scenario and increase slightly in a low emissions scenario.[1]

Increasing average seasonal temperatures, combined with projected changes in seasonal precipitation patterns, are likely to increase the duration and incidence of prolonged dry periods in the Northeastern New Jersey region. Although a slight increase in average annual precipitation is expected, the region will experience much of this as more intense extreme rainfall events, not unlike what the region experienced in September 2021 with the remnants of Hurricane Ida.

Nevertheless, dry periods between these more intense rainfall events—especially in hotter summer months—are likely to increase, leading to more evapotranspiration (release of moisture from open water, soils, and plants) and reduced soil moisture, and ultimately to more frequent and prolonged droughts (though not necessarily more intense).

While average rates of winter precipitation are likely to increase slightly throughout the region, much of this will be in the form of rainfall instead of snow. The Northeast U.S. has experienced notable reductions in snow pack since 1970, causing peak streamflow to be 7-14 days earlier than in the past.

Reduced spring snowmelt, without significant increased precipitation, will further exacerbate drier soil conditions and low streamflow and groundwater baseflow in the warmer months.

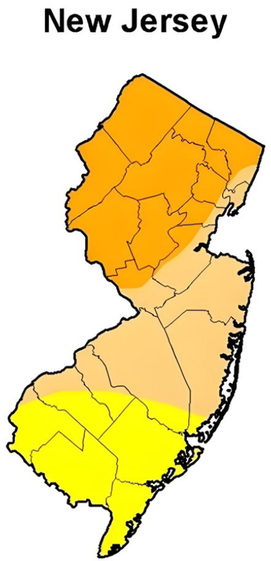
	2010-2039		2040-2069		2070-2099	
Community	**Change in Maximum Relative Summer Humidity**	**Change in Potential Evapotranspiration (Grass)**	**Change in Maximum Relative Summer Humidity**	**Change in Potential Evapotranspiration (Grass)**	**Change in Maximum Relative Summer Humidity**	**Change in Potential Evapotranspiration (Grass)**
Bayonne	0.4%	+1.3 inches	-1.3%	+2.6 inches	-2.2%	+3.9 inches
Hoboken	-0.3%	+1.3 inches	-1.1%	+2.6 inches	-1.9%	+3.9 inches
Jersey City	-0.3%	+1.3 inches	-1.2%	+2.6 inches	-2%	+3.9 inches
Newark	-0.5%	+1.3 inches	-1.5%	+2.5 inches	-2.5%	+3.9 inches

Site-specific annual multi-model mean derived from 18 downscaled CMIP5 (Climate Model Intercomparison Project) models. RCP 8.5 scenario. Source: https://climate.northwestknowledge.net/MACA/tool_summarymaps2.php

Recent Drought Events in the Region

From October 2016 to April 2017, New Jersey experienced its worst drought conditions since 2002-2003, with moderate to severe drought affecting both Essex and Hudson County. Prior to that, Essex County was included in USDA drought-related disaster declarations in earlier 2016 and 2015.

Higher incidence of drought is likely to be correlated with drier soil conditions. While projections are scarce, lower future summer humidity and higher rates of evapotranspiration help inform understanding in the absence of modeling.



(Released Thursday, Jan. 12, 2017)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	72.01	37.85	0.00	0.00
Last Week 1/3/2017	0.00	100.00	72.01	37.85	0.00	0.00
3 Months Ago 10/11/2016	37.88	62.12	55.33	3.38	0.00	0.00
Start of Calendar Year 1/3/2017	0.00	100.00	72.01	37.85	0.00	0.00
Start of Water Year 9/27/2016	15.12	84.88	53.92	0.00	0.00	0.00
One Year Ago 1/12/2016	81.26	18.74	1.32	0.00	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Miskus
NOAA/NWS/NCEP/CPC

DROUGHT – EXPECTED REGIONAL IMPACTS

Northeastern New Jersey, being primarily within the Passaic and Hackensack water regions, draws most of its water supply from surface water from outside of the region (e.g., the New Jersey Highlands region), making it more immediately vulnerable to the effects of drought; drought affects surface water more quickly than groundwater.

Shorter intervals between drought events could hamper the recovery of reservoir levels or aquifer storage, such that sequential moderate droughts could severely stress water supply in the region.

A Together North Jersey 2013 study indicates that Newark, for example, could approach or reach the capacity of its reservoirs in the future with anticipated population growth by 2035, though further evaluation is needed to assess capacity accounting for all water contracts*.

As increased incidence of drought threatens surface water supply, Northeastern New Jersey may come to rely increasingly on groundwater.

Increased periods of dry and heavy wet conditions can lead to increased release and mobilization of contaminants, such as arsenic, especially in the bedrock region around the Newark basin. As groundwater tables rise due to sea level rise, the risk of arsenic and other types of contamination seeping into the water supply will increasingly risk water quality—especially with likely increased dependence on groundwater for drinking water supply.

Saltwater intrusion into aquifers from sea level rise will further limit groundwater's ability to provide an alternative to surface reservoirs—especially in areas where wells are over-pumped (more in Section 3c: Groundwater Rise & Quality).

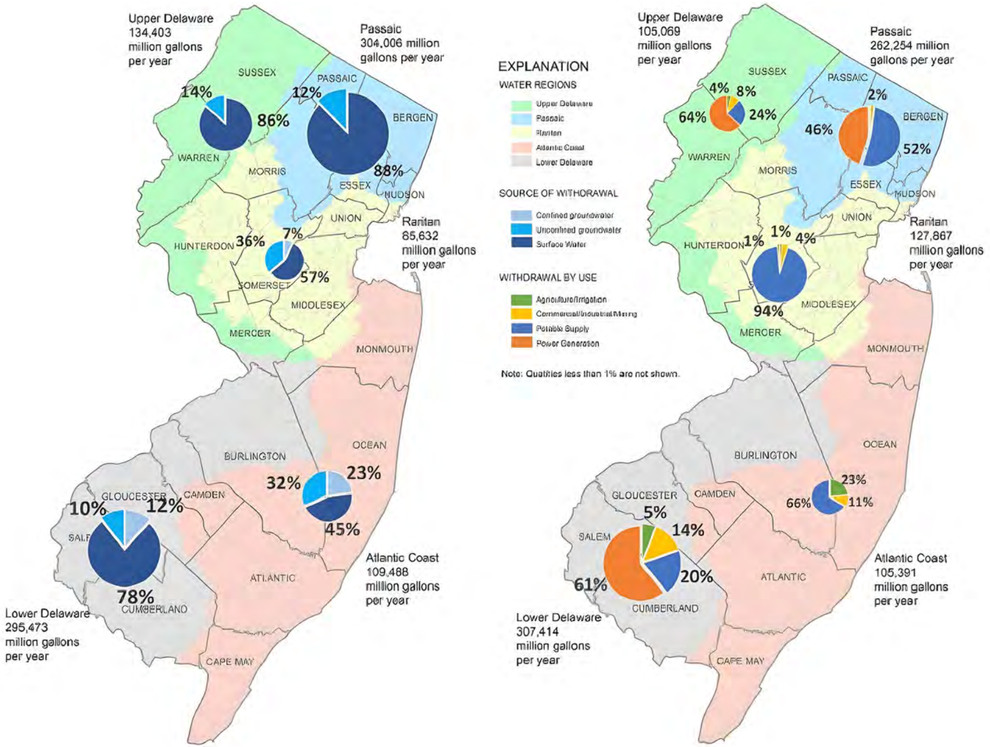
Higher rates of groundwater pumping will have implications both for water quality and increased risk of land subsidence (or ground sinking)—especially in the sandy coastal soils. This can damage infrastructure and exacerbate local sea level rise flooding.

As temperatures become warmer (and as growing seasons lengthen), demand for water will increase. People and animals will require more to remain healthy and cool. Further, the economic demand for hydropower, livestock, and agriculture rises with population growth and increasing energy demand. Combined with drought-generated changes in streamflow and discharge, this could lead to water supply shortages, especially during times of drought.

Reduced availability of potable water could generate serious public health impacts, including higher incidence of heat-related illness, waterborne diseases, recreational risks, limited food availability, and overall lower quality of life—all exacerbated by indicators of social vulnerability such as age or limited ability to seek essential resources. The 2017-2022 New Jersey Water Supply Plan estimates that even assuming currently-approved levels of public drinking water supplies (i.e., not accounting for reductions in natural resource capacity due to drought), anticipated rates of population growth could cause a deficit in projected drinking water availability of up to -9.0 mgd (million gallons per day) in Bayonne, Hoboken, and Jersey City as early as 2030-2035.

Water supply shortages could also impact critical utilities such as power generation and availability. Water supply is essential for power plant cooling as well as thermoelectric power generation. Reduced availability of water could intensify challenges posed by higher electricity demand and increase the risk of service failure.

*Learn more in the Together North Jersey 2013 Water Resources Baseline Topic Report, which notes limitations of the study and recommends additional evaluations on reservoir capacity.



Average annual source of water withdrawal by water region, 1990-2015 (left) and average annual use of water by water region, 1990-2015 (right)

Source: NJDEP 2017, New Jersey Water Supply Plan 2017-2022

3e. EXTREME HEAT

EXTREME HEAT – THE HAZARD AND EXPECTED RISKS

By the mid-21st century, approximately 70-percent of summers in the Northeast U.S. are expected to be hotter than the warmest summers to date, and New Jersey is warming at a faster rate than the rest of the Northeast U.S..

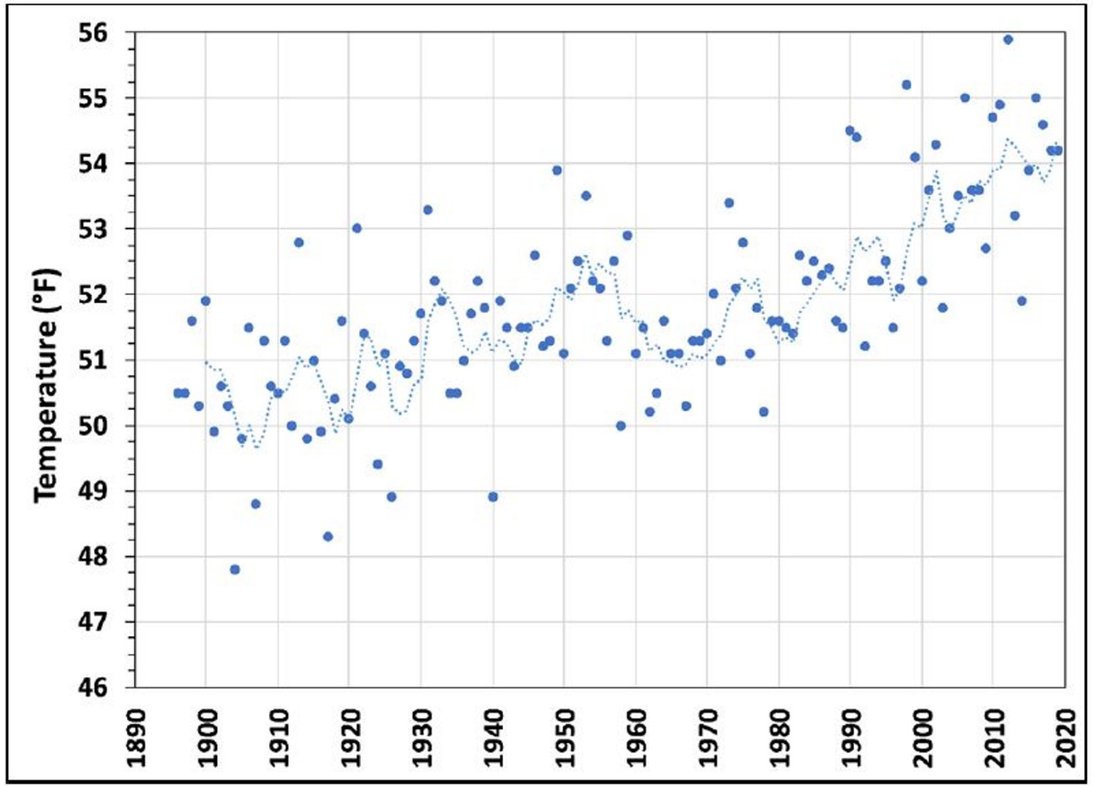
In a “business-as-usual” (RCP 8.5) greenhouse gas emissions scenario, average summer temperatures in the Northeastern New Jersey region are projected to increase—as high as 9.6 degrees F in some areas—by the end of the century. Parts of the region will see between as many as 66 more days per year with temperatures rising above 90 degrees F, resulting in more frequent and intense heatwaves, or prolonged periods of extreme heat. These heatwaves are increasingly affecting larger and larger areas.

Average winter temperatures will also increase in the region—as much as 9 degrees F in some areas—by the end of the century, resulting in less intense cold waves and reduced snow accumulation. This has implications for seasonal runoff.

For example, New Jersey’s 2016 water supply drought was in part caused by historically low summer streamflow due to record low winter snowfall accumulation. In the longer term, this could also have impacts to groundwater recharge, further exacerbating drought risk.

Historical Trends – Increasing Temperatures

Since 1895, annual average temperatures in New Jersey have increased by 3.5 degrees F. The graph below displays 12-month average air temperatures in New Jersey from 1895-2019. Points represent average annual temperatures, with the dashed line representing 5-year averages of those points



Source: NJDEP: Division of Science and Research. (2020). Climate Change in New Jersey: Temperature, Precipitation, Extreme Events, and Sea-Level Rise. Original data from the Office of the New Jersey State Climatologist 2020 (http://climate.rutgers.edu/stateclim_v1/nclimdiv/).

EXTREME HEAT – THE HAZARD AND EXPECTED RISKS

Future Annual Days with Heat Index ≥ 90°F

	Historical Simulation (1971-2000 mean)	2010-2039		2040-2069		2070-2099	
Community	**Annual Days**	**Annual Days**	**% Increase**	**Annual Days**	**% Increase**	**Annual Days**	**% Increase**
Bayonne	24 days	41.4 days	+72.5%	65.6 days	+173.3%	90.3 days	+276.3%
Hoboken	21.2 days	38.1 days	+79.5%	61.7 days	+191.0%	86.8 days	+309.4%
Jersey City	21.4 days	38.5 days	+79.9%	62.1 days	+190.2%	87.3 days	+307.9%
Newark	25.9 days	43.7 days	+68.7%	67.7 days	+161.4%	92.2 days	+256.0%

Site-specific annual multi-model mean derived from 18 downscaled CMIP5 (Climate Model Intercomparison Project) models. RCP 8.5 scenario. Source: https://climate.northwestknowledge.net/MACA/tool_summarymaps2.php

Future Average Seasonal Temperatures

	Historical Simulation (1971-2000 mean)		2010-2039		2040-2069		2070-2099	
Community	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
Bayonne	35.2 deg F	75,2 deg F	38.1 deg F	77.9 deg F	40.9 deg F	81.1 deg F	44.1 deg F	84.6 deg F
Hoboken	35 deg F	75 deg F	37.9 deg F	77.7 deg F	40.7 deg F	80.9 deg F	44 deg F	84.4 deg F
Jersey City	34.6 deg F	74.8 deg F	37.5 deg F	77.5 deg F	40.3 deg F	80.8 deg F	43.6 deg F	84.2 deg F
Newark	34.1 deg F	74.5 deg F	37 deg F	77.2 deg F	39.8 deg F	80.5 deg F	43.1 deg F	84.1 deg F

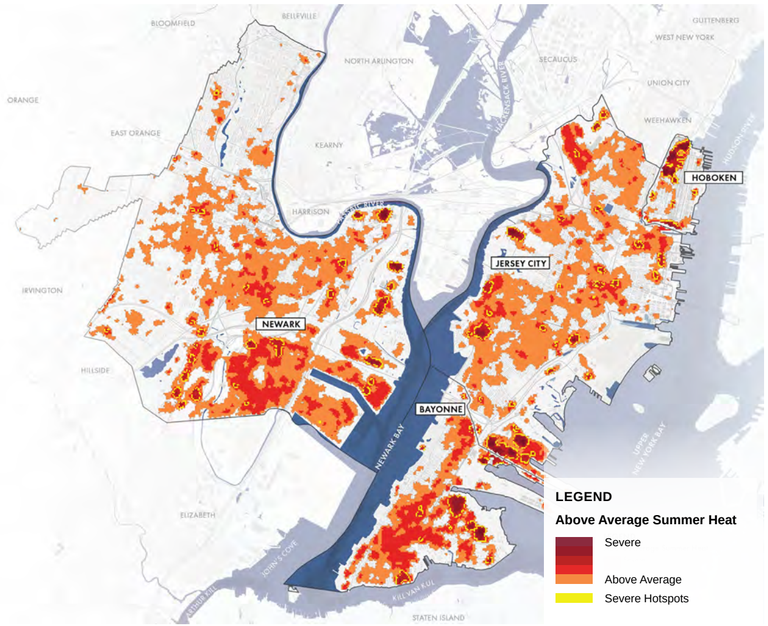
EXTREME HEAT AND URBAN HEAT ISLAND

Extreme heat and urban heat islands are exacerbated by increased urbanization, as large expanses of asphalt and concrete and the loss of forests and open spaces can trap heat and pollution due to the “urban heat island” effect. Much of the Northeastern New Jersey region consists of high levels of asphalt, brick, and concrete. High concentrations of traffic congestion and heavy use of air conditioners can compound the problem in densely populated areas—especially in neighborhoods with low concentrations of green space.

Above-Average Summer Heat Hotspots in Northeastern New Jersey

Approximately 36-percent of the total Northeastern New Jersey study area experienced above-average summer heat temperatures in 2020 and 2021. These areas are likely to expand and experience more severe and prolonged heat in the future.

Hotspots of especially severe summer heat are concentrated in central Bayonne, the area around Greenville Yard, western Jersey City, pockets of Hoboken, the area around Oak Island Yard in Newark, as well as pockets of eastern Newark. Although many of these hotspots are industrial, residential areas experiencing severe heat averages in eastern Newark and western Jersey City overlap with areas of high social vulnerability.



Increased frequency and intensity of heatwaves will impact the region in a multitude of ways, including:

- Increased incidence of heat stress could result in a 55-percent increase in **heat-related mortalities** in the New York metropolitan region by the 2050s (compared to the 1990s). Children, the elderly, the sick, and the poor are especially vulnerable to health impacts including heat stroke, dehydration, and other dangerous conditions
- Strain on **water supply**, especially during periods of drought
- Lower yields of **agricultural products in other areas**, leading to cascading economic impacts and stresses in Northeastern NJ
- Increased **air pollution**, as increased heat alters the chemical and physical processes that moderate and transport pollutants, especially ground-level ozone (O3) and particulate matter with a diameter less than 2.5 micrometers (PM2.5) (such as methane). This will have additional health impacts, as detailed in **Section 3f: Air Quality**
- Exacerbation of **wildfire risk**, as detailed in **Section 3h: Wildfire**. This also has implications for regional air quality
- Warmer temperatures also allow certain **insect species** to survive year-round and may cause other species to migrate north. This may result in increased incidence of vector-borne diseases such as Lyme disease, as further detailed in **Section 3g: Invasive Species & Vector-Borne Illness**
- Decreased winter snowfall accumulation due to increased temperatures has implications for **seasonal runoff**. For example, New Jersey’s 2016 water supply drought was in part caused by historically low summer streamflow due to record low winter snowfall accumulation. In the longer term, this could also have impacts to groundwater recharge, further exacerbating drought risk
- Environmental risk to existing **habitats and wildlife**, threatening the health of already-scarce existing green space in the region
- Prolonged periods of extreme heat can cause significant damage to **transportation infrastructure**, generating service disruptions and potential risks to health and safety. Heatwaves can cause thermal expansion of bridge joints and paved roads, threaten the integrity of some types of pavement (e.g., softening, rutting, or migration of liquid asphalt), and can accelerate deterioration of steel, asphalt, coats, and sealants. Thermal expansion of metal rail tracks could cause them to bend and buckle under stress, resulting in “sun kinks” or track misalignments which could dangerously increase incidences of derailment. Under extreme heat conditions, trains must reduce their speed to minimize heat stress, with further impacts to disruption of service
- Heatwaves can also make waiting for public transportation potentially dangerous, if cooling stations and adequate shading is not available
- Heatwaves are known to cause **widespread power outages** or blackouts, as they coincide with peak electricity demand and power plant inefficiencies. These could have widespread impacts to functionality and operations of critical services, businesses, and telecommunications, while making residences, schools, and other indoor areas potentially unsafe, especially for senior populations, people with existing health conditions or disabilities, and households that do not have access to or cannot afford air conditioning and adequate power redundancy by shutting off any existing air conditioners as well as refrigerators.
- Increased temperatures are also likely to contribute to **worsening water quality** due to environmental impacts such as increased frequency and intensity of algal blooms or dying off of important microorganisms

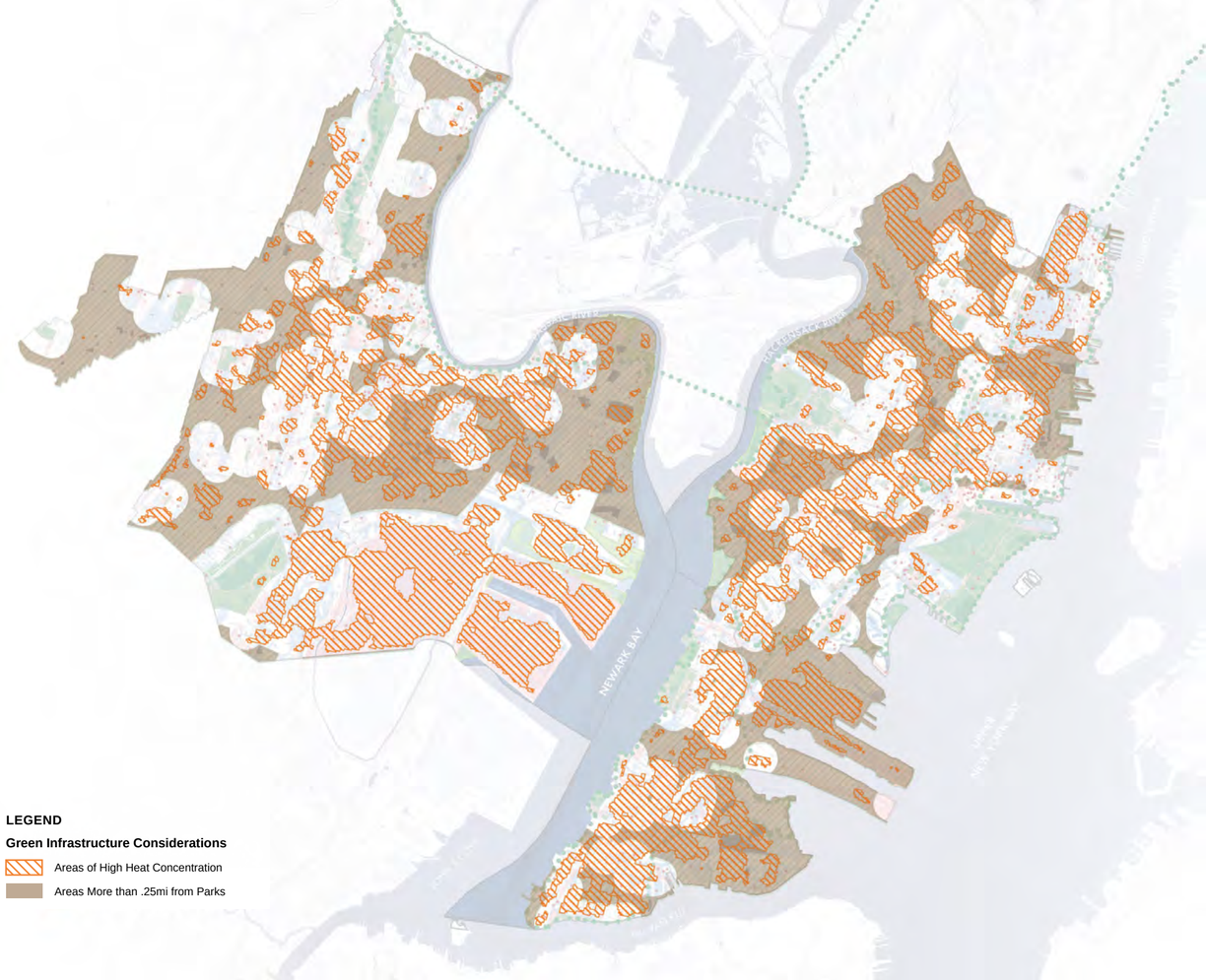
EXTREME HEAT AND URBAN HEAT ISLAND

- **Wooden residences** and other buildings are especially susceptible to direct damage due to extreme heat, as the wood can capture excessive moisture, causing the wood to expand and crack, which can lead to various types of leaks. Heat impacts to the roof and floor of wooden buildings can result in ventilation failure which, during a heatwave, could exacerbate risk of heat exhaustion or even suffocation for inhabitants. Over the long-term, extreme heat could severely damage a building's foundations.
- Heatwaves can result in **systemic failure of hospitals**. Hospitals are likely to experience a surge in patients during heatwave events due to increased incidence of cardiovascular failure, dehydration, and heat exhaustion, in addition to secondary health effects caused by increased temperatures including increased incidence of asthma and respiratory conditions due to poor air quality and wildfires as well as vector-borne diseases such as West Nile Virus. This can stress hospital capacity, which may find itself unable to cope especially when paired with increased likelihood of power outages interrupting essential services, staff shortages due to health impacts, impacts to hospital access due to heat stress on roadways, as well as potential long-term structural impacts of heat on the hospital building itself
- Rarely, heatwaves can cause **electrical circuit shortages and fires**
- Depending on the level of **toxic materials and organic waste** in hazardous waste sites and/or landfills, there is precedent of extreme heat causing spontaneous combustion during heatwave events. This could lead to dangerous fires, severe air pollution, and other unexpected effects
- Heatwaves can also affect **wastewater treatment**, as extreme heat can result in dramatic increases in excessive sludge aging, which can increase the amount of solids and lead to deteriorating solids quality in the wastewater effluent. Heatwaves can also lead to odor control issues with wastewater infrastructure. In addition to effluent-related issues, heatwaves can also directly impact operations at pump stations due to structural heat stress as well as energy stress and the potential for power outages and higher energy costs. Should any of these issues result in systemic operational failure, this could result in disastrous consequences, especially if paired with high tides blocking outfalls or a sudden bout of heavy rainfall leading to backed-up combined sewer overflow flooding and/or environmentally damaging discharges
- Increased energy consumption will also translate to **increased costs** to residents and businesses, as well as even higher urban heat island effect due to high usage of air conditioners

Urban Heat Island and Access to Green Space

Access to urban green space can mitigate many of the worst effects of extreme heat by tempering localized ambient and land surface temperatures, providing shade canopies, providing additional cooling via evapotranspiration of plants, and improving air quality, which can deteriorate during heatwaves.

Nevertheless, most census tracts within the Northeastern New Jersey region—many of which are also within areas currently experiencing above-average summer heat—have a very low density of green space by their total area, indicating a lack of distributed and connected urban green spaces. Instead, most green space in Northeastern New Jersey is concentrated within several major parks.



3f. AIR QUALITY

AIR QUALITY – THE HAZARD AND EXPECTED RISKS

The two major sources of climate change-related air pollution—ground-level ozone (haze or smog) and PM2.5 (particulate matter, or aerosols)—are already a serious problem in Northeastern New Jersey, likely the cause of widespread "invisible" health effects, especially for the elderly and people with pre-existing health conditions, such as asthma.

Human-related activities are a major source of both ozone and PM2.5, and poor regional air quality is substantially exacerbated by other climate hazards including extreme heat, wildfires, and drought.

High levels of ground-level ozone are caused by a combination of high temperatures, especially heatwaves and urban heat island, and direct emissions from things like motor vehicles, industrial activity, and gas stations.

High levels of PM2.5 are largely a consequence of increased incidence of wildfires, increased levels of dust due to droughts, and higher temperatures leading to increased evaporation of substances like sea salt, ash, and organic materials.

Additionally, concentrations of aeroallergens such as pollen, mold, and dust mites are highly likely to increase with climate change due to warmer winter temperatures, precipitation change, and increased greenhouse gas emissions.

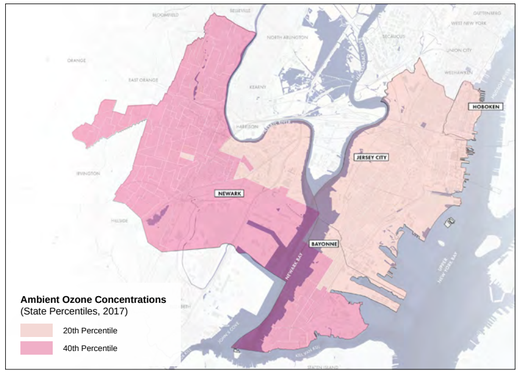
Increased frequency of severe weather events can also generate power outages which can disrupt indoor air regulation, leading to health issues such as mold and bacteria growth or carbon monoxide poisoning from use of portable generators.

Present-Day Ambient Ozone and PM2.5 Concentrations in Northeastern New Jersey

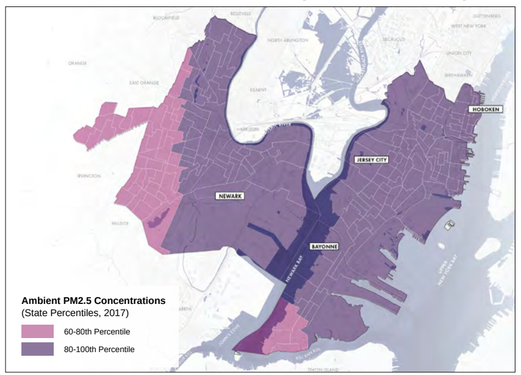
Compared to the rest of the state, Northeastern New Jersey has extremely high ambient PM2.5 concentrations, with census tracts mostly within the 80th to 99th percentile range.

Ozone concentrations are lower relative to the rest of the state but can still pose serious health issues—especially in urban areas, where increasing urban heat island can capture ground-level ozone. In general, higher PM2.5 concentrations are correlated with proximity to the New York-Newark metropolitan area, while ozone levels tend to be higher in more rural/suburban areas (known as the "ozone paradox").

Ambient Ozone Concentrations (State Percentiles)

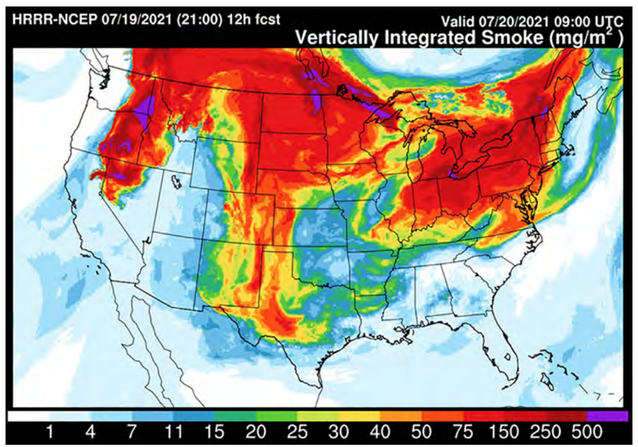


Ambient PM2.5 Concentrations (State Percentiles)



Western Wildfires and Air Quality in Northeastern New Jersey

In addition to increased risk of regional wildfires contributing to PM2.5 pollution, even wildfires from the Western U.S. can cause indirect PM2.5 impacts in Northeastern New Jersey. July 2021 showed how a record-breaking fire season can cause poor regional air quality, as demonstrated in the below figure. The Jetstream caught and transported smoke downstream across the continent. High pressure can also cause the smoke to settle at ground level.



AIR QUALITY – EXPECTED REGIONAL IMPACTS

To the extent that such impacts occur where large numbers of people are exposed, which is more likely to be the case for ozone and pollen than for smoke from wildfires, additional adverse health effects due to poor air quality can be anticipated in tandem with increasing temperatures and other environmental changes.

People with existing asthma, allergies, and other respiratory diseases may be especially vulnerable to respiratory impacts, leading to increased respiratory and cardiovascular health problems and, consequently, a greater number of premature deaths.

Across the combined areas of Essex, Hudson, and Union Counties, 8.1-percent of the adult population and 8.0-percent of the child population have asthma, putting them at higher risk.

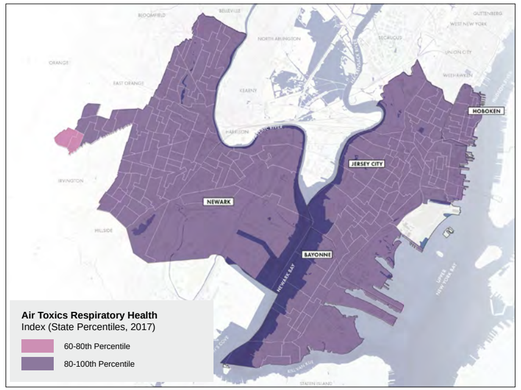
Socially vulnerable areas and communities with a history of redlining and segregation typically experience higher levels of air pollution, owing to a variety of factors such proximity to industrial uses and limited green space. These effects are exacerbated by higher prevalence of urban heat island in these neighborhoods, which captures ground-level ozone and contributes to stagnant air. Such communities also tend to have less access to medical care and health insurance, increasing the health risks posed by poor air quality.

Aside from health-related impacts, air pollution can also lead to other issues such as reduced visibility, affecting mobility and increasing the risk of motor vehicle accidents, as well as direct damage to crops and forests with environmental and agricultural implications.

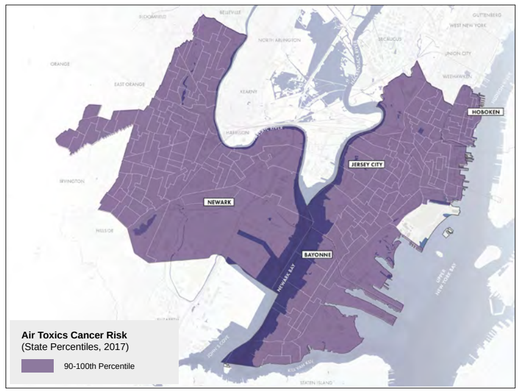
High Present-Day Health Risks

Nearly the entire Northeastern New Jersey region is currently at the highest level of risk for cancer and respiratory health impacts due to air toxics, compared to the rest of the state. The entirety of the region is within the 90th-99th percentile of air toxics cancer risk compared to the rest of New Jersey. This points to a high likelihood that “invisible” health effects of poor air quality are already widespread amongst vulnerable populations. As New Jersey does not currently participate in the CDC’s national data gathering for publicly-available asthma prevalence data, there are significant data gaps that make it difficult to determine the full toll of present-day impacts.

Air Toxics Respiratory Health Index (State Percentiles)



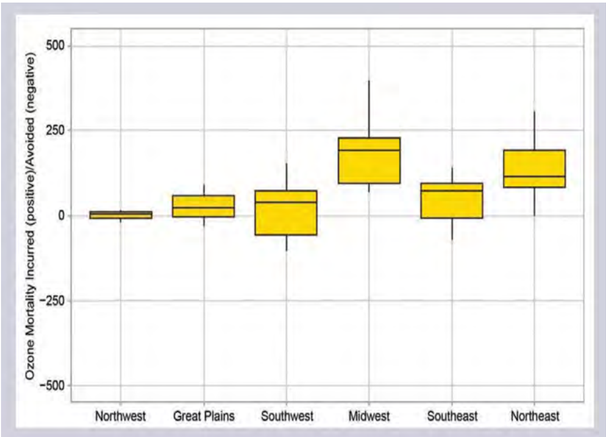
Air Toxics Cancer Risk (State Percentiles)



Increasing Ozone-Related Mortality in the Region

A 2016 study by the US. Global Change Research Program concludes that by the 2030s, premature deaths in the Northeast U.S. due to excess ozone-related effects will see a notable increase as a result of higher expected summer (May through September) average maximum daily 8-hour ozone (parts per billion) compared to the year 2000. Higher ozone concentrations will also lead to increased emergency and hospital visits due to asthma and other respiratory conditions as well as missed days of school.

Projected Chancge in Ozone-Related Premature Deaths



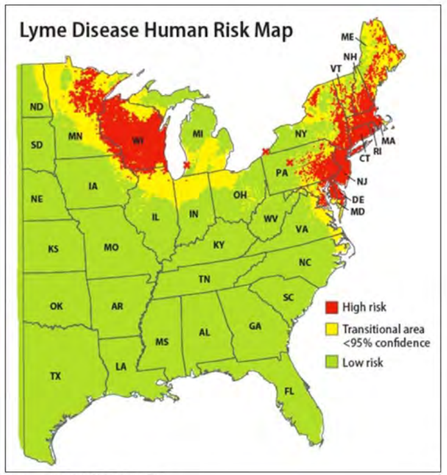
Source: U.S. Global Change Research Program. (2016). The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment.

3g. INVASIVE SPECIES & VECTOR-BORNE ILLNESS

INVASIVE SPECIES & VECTOR-BORNE ILLNESS – THE HAZARD AND EXPECTED RISKS AND IMPACTS

As temperatures increase, Lyme disease and West Nile Virus will increasingly become a threat with longer seasonal periods.

Warmer average future winter temperatures are likely to elongate tick season in Northeastern New Jersey, as ticks carrying Lyme disease emerge at temperatures above 45 degrees F. New Jersey is already considered to be at high risk of Lyme disease—nationally, NJ ranked 2nd in 2017 for highest number of confirmed cases. Incidence of reported Lyme disease in New Jersey increased by 8.8% between 2007 and 2019, and this risk is expected to continue to go up. While posing a lower risk to urban than rural populations, studies indicate that Lyme disease is a growing threat to urban areas as well.



Source: Yale School of Public Health, 2013
Note (1): All of Essex County located in a high risk area.

Broader Ecosystem Impacts of Invasive Species

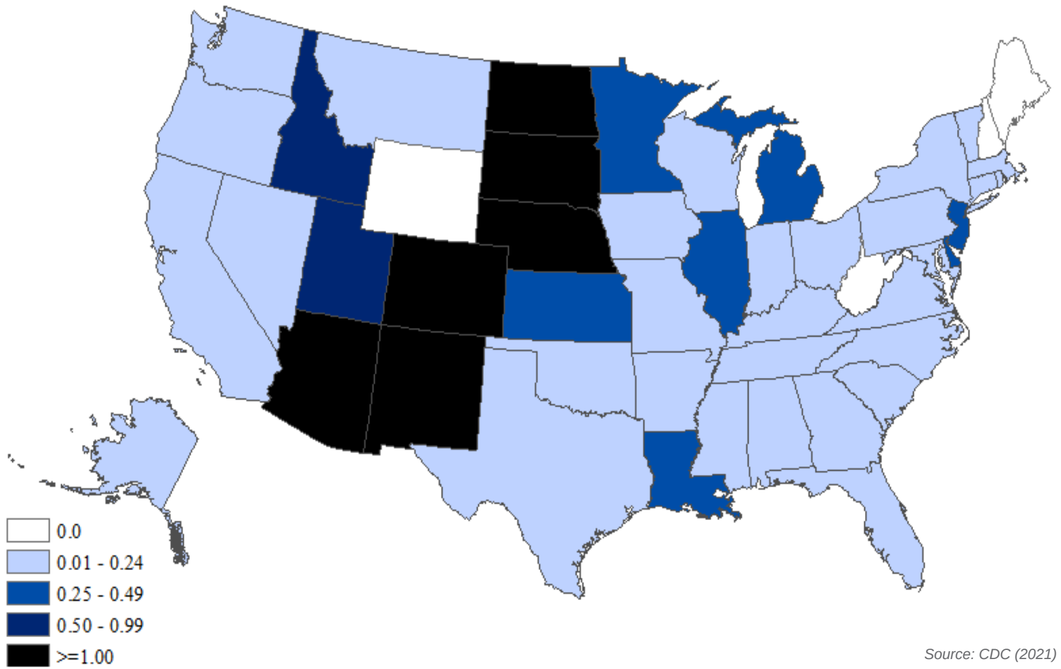
In addition to creating more favorable environments for species such as Lyme-carrying ticks and Asian Tiger mosquitoes that can cause vector-borne illnesses, increasing temperatures can also facilitate the introduction of other invasive species with environmental impacts that could have other long-term implications.

For example, warmer temperatures will likely cause certain species of insect pests to mature more quickly, grow their population, and migrate into new habitats. In southern New Jersey especially, outbreaks of species like the Southern pine beetle could threaten New Jersey's forests. This has implications for Northeastern New Jersey as well, as trees stressed due to these infestations could serve as fuel sources, increasing wildfire risk with negative impacts to regional ecology and air quality.

Extreme heat and drought can also stress numerous existing habitats in Northeastern New Jersey, including at large urban parks such as Liberty State Park, with ecosystem impacts and changes to the water cycle that have the potential to enable invasive pests and weeds. Certain water-borne invasive species can also directly cause deterioration of infrastructure, including dams.

Additionally, warming temperatures combined with higher frequency of heavy rainfall-generated ponding could facilitate a growth in the Asian Tiger mosquito population in Northeastern New Jersey, widely considered to be the most invasive species of mosquito. These mosquitos are common carriers of the West Nile Virus (WNV). In recent years, New Jersey has experienced late-summer WNV seasons with record-high outbreaks. WMV can cause neuroinvasive diseases such as meningitis, encephalitis, and acute flaccid paralysis. On rare occasions, this has resulted in human fatalities.

West Nile Virus Neuroinvasive Disease Incidence (per 100,000 population), 2021



Source: CDC (2021)

3h. WILDFIRE

WILDFIRE – THE HAZARD AND EXPECTED RISKS

Projected higher temperatures and increased frequency of drought are likely to increase the length of the wildfire season in Northeastern New Jersey in the future.

In the peak season, most wildfires are caused by lightning and severely exacerbated by dry soil conditions. However, human-caused fires are more common in the earlier and later portions of wildfire season. In New Jersey, most wildfires are caused by humans, and they do not always trace their source to dry vegetation in forested areas; in heavily-urbanized Northeastern New Jersey, other ignition sources such as electrical lines, circuits, or substations can also cause fires—especially during heatwaves or during water shortages, which could limit power plant cooling. Combined with a high density of buildings, some parts of the region have a surprisingly high concentration of wildfire fuel. Further, as more of New Jersey's population expands into rural areas, wildfires are more likely to be triggered at wildland-urban interfaces, where most wildfires tend to begin.

Increased frequency and severity of extreme weather events will increasingly disrupt tree growth and regeneration, which can alter the wildfire landscape, including at the wildland-urban interfaces as well as large urban parks. Longer dry and hot seasons can be catalytic for wildfires as well as the migration of insects and invasive species. As insect populations expand, higher rates of insect infestations could provide increased fuel sources. Severe thunderstorm environment days are also likely to increase in frequency with climate change, and these events often serve as triggers for wildfires.

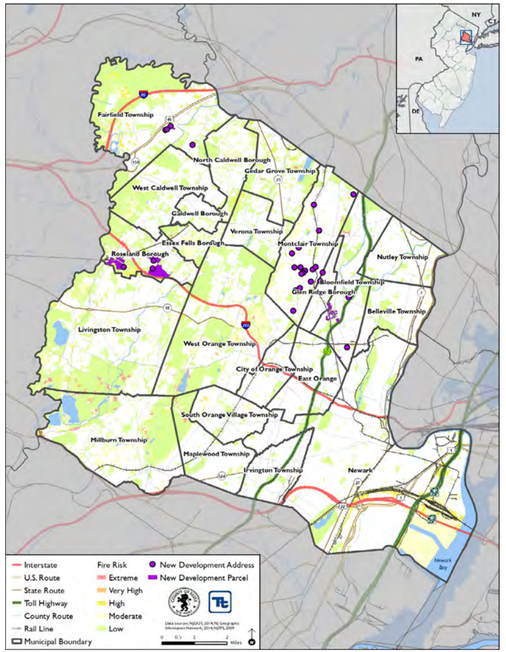
Potential future increases in high wind—associated, for example, with increased frequency of extreme storm events—could also exacerbate the spread of fires.

	Historical Simulation (1971-2000 mean)		2010-2039		2040-2069	
Community	**"High" Danger**	**"Extreme" Danger**	**"High" Danger**	**"Extreme" Danger**	**"High" Danger**	**"Extreme" Danger**
Bayonne	20.2 days	2 days	22.7 days	3.1 days	26.7 days	4.6 days
Hoboken	20.1 days	1.8 days	22.5 days	2.9 days	26.4 days	4.3 days
Jersey City	21.1 days	1.9 days	23.4 days	3 days	27.4 days	4.5 days
Newark	19.3 days	1.5 days	22.2 days	2.5 days	26.4 days	3.8 days

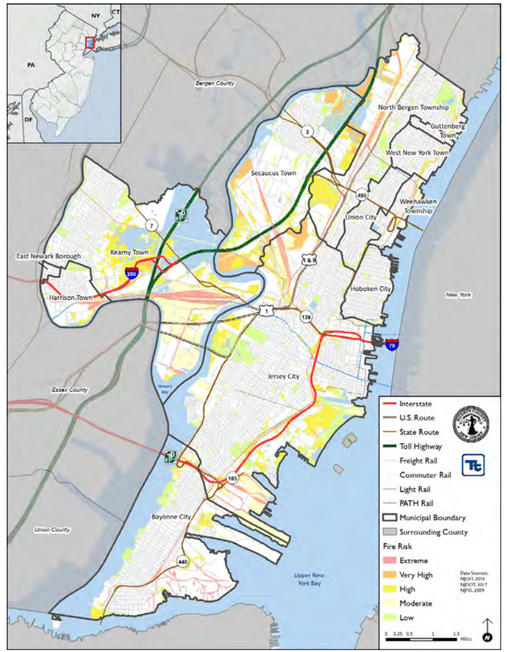
Site-specific annual multi-model mean derived from 18 downscaled CMIP5 (Climate Model Intercomparison Project) models. RCP 8.5 scenario. Fire danger evaluation based on National Fire Danger Rating System (NFDRS). Source: https://climate.northwestknowledge.net/MACA/tool_summarymaps2.php

Wildfire Fuel Risk in Northeastern New Jersey

Urban areas can have surprisingly high concentrations of wildfire fuel and possible ignition sources. Maps provided in the 2020 Essex and Hudson County Hazard Mitigation Plans reveal large areas of low-to-moderate hazard in Hoboken and Newark, though neither have much land exposed to high-to-extreme risk. Parts of Jersey City are at especially high levels of wildfire risk, especially in and around Liberty State Park. Bayonne has a mix.



Source: Hudson County 2020 Hazard Mitigation Plan



Source: Hudson County 2020 Hazard Mitigation Plan

WILDFIRE – EXPECTED REGIONAL IMPACTS

Despite its highly urbanized nature, increasing wildfire risk in Northeastern New Jersey threatens loss of life as well as the destruction of public and private property.

The nonprofit First Street Foundation produces a wildfire tool called Risk Factor. This tool predicts that nearly 29-percent of homes in Hoboken and 28-percent of homes in Bayonne could face some risk of wildfire in the next 30 years.

Wildfires can impact transportation and/or utility services; in Jersey City, approximately 22-percent of critical infrastructure facilities could be at risk by the 2050s.

Wildfires also threaten regional ecological impacts with destruction of forests, brush, grasslands, and field crops. Urban parks such as Liberty State Park will face an increasingly high wildfire fuel risk, especially as increased frequency and duration of drought hazard generate drier soil conditions.

Increased fire risk could also strain existing fire department capacity and put firefighters at greater risk, compounded by higher risk of heat exhaustion.

Large-scale fires can also increase the probability of other hazards, especially flash floods and mudflows, by drastically altering the landscape and soil conditions. Wildfires can leave the soil unable to absorb rainfall until vegetation is restored, which can take up to five years after a wildfire event.

Such fires can also increase the incidence of damage from debris from flash floods and mudflows that may follow.

As further detailed in **Section 3f: Air Quality**, wildfire smoke also has serious implications for air quality. Even higher levels of wildfire risk in areas as proximate as southern New Jersey (the Pine Barrens region) or as far away as western US and Canada can negatively impact Northeastern New Jersey's air quality as smoke is carried upwind across vast distances.

First Street Foundation's 2022 Wildfire Modeling

First Street Foundation—a nonprofit research and technology organization based out of New York—recently released a wildfire model to estimate current and future risk of wildfires reaching properties across the United States, called Fire Factor. Fire Factor uses a behavioral wildfire model based on 100 million simulated wildfire events based on historic fire ignition locations. They use data on existing fire fuel and vegetation (from the U.S. Forest Service) as well as predicted heat and wind/weather conditions to generate probabilities at a highly granular scale. **It is important to note that First Street's modeling of future temperature and precipitation patterns is based on the IPCC's RCP 4.5 greenhouse gas emissions scenario—a lower-impact scenario than the "worst-case" RCP 8.5 scenario used elsewhere in this assessment.**

Community	Present-day wildfire risk	Wildfire risk projected 2041-2050				
	Total Properties at Risk	Total Properties at Risk	Residential (Minor Risk)	Commercial (Minor Risk)	Critical Infrastructure (Minor Risk)	Social Facilities (Minor Risk)
Bayonne	1,726 (12% of total)	3,878 (27% of total)	2,864 (27.8% of homes)	236 (20.5% of commercial)	8 (12% of facilities)	8 (16.7% of facilities)
Hoboken	4,521 (24.7% of total)	5,307 (29% of total)	4,335 (28.8% of total)	305 (40.1% of commercial)	5 (17.9% of facilities)	26 (44.8% of facilities)
Jersey City	5,023 (9.2% of total)	7,681 (14% of total)	5,003 (13.1% of homes)	632 (14.2% of commercial)	28 (22.2% of facilities)	29 (12.4% of facilities)
Newark	812 (1.5% of total)	2,703 (5% of total)	1,808 (6.2% of homes)	207 (3.8% of commercial)	14 (7.3% of facilities)	23 (5.1% of facilities)

Source: First Street Foundation, Risk Factor. (2022). https://riskfactor.com/. RCP 4.5 scenario.

3i. OCEAN ACIDIFICATION & THREATS TO MARINE LIFE

OCEAN ACIDIFICATION – THE HAZARD AND EXPECTED RISKS AND IMPACTS

As increasingly acidic ocean pH levels threaten marine life along the coast, Northeastern New Jersey could experience ecological impacts to its estuarine habitats as well as potential longer-term economic stresses.

Higher levels of carbon dioxide in the atmosphere have been leading to increased acidity of ocean waters. Since the mid-18th century, the ocean has absorbed about 30% of global emissions, causing ocean pH levels to drop by 0.1. At current rates of greenhouse gas emissions, pH levels are projected to drop another 0.3-0.4 pH to a level of between 7.7 and 7.8 by the end of the century—resulting in the most acidic ocean conditions in 20 million years.

Coastal acidification is exacerbated by several additional processes, including local changes to (naturally acidic) freshwater rivers given changes in precipitation, temperatures, and erosion patterns, as well as higher concentrations of runoff from pollution and fertilizers which could lead to algal blooms, further increasing acidification.

The broad continental shelf (NES) defining the Mid-Atlantic region experiences especially extreme seasonal ocean temperature variation, which could exacerbate ocean acidification. Higher acidity levels can significantly reduce the populations of shellfish, including scallops and surf clams, which make up approximately two-thirds of New Jersey's commercial fishing revenues.

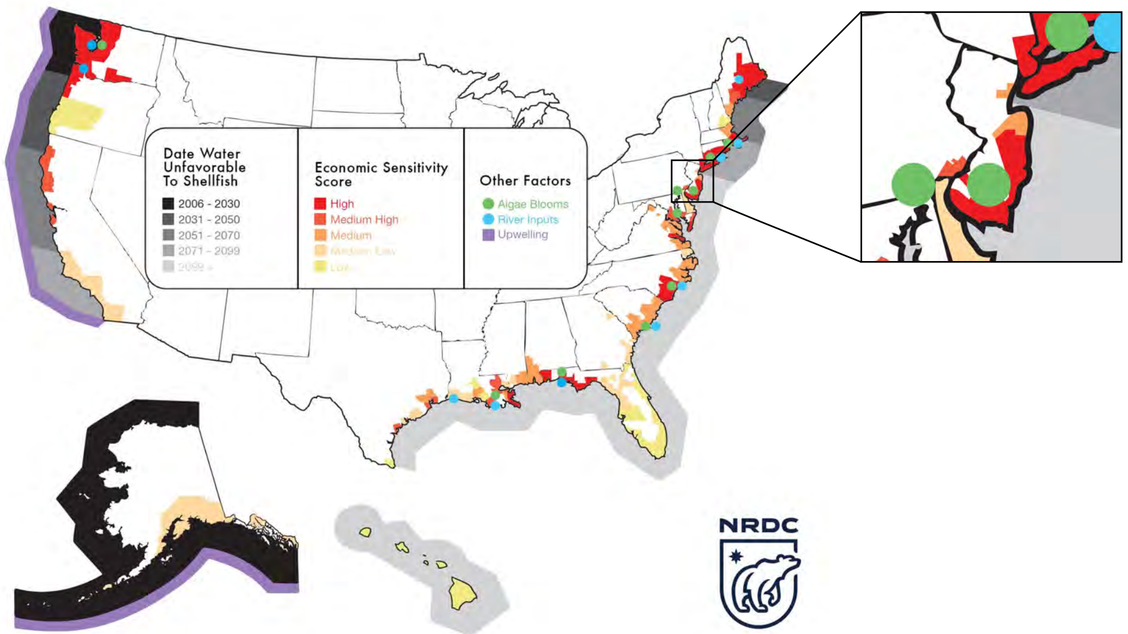
High acidity levels in estuarine areas—such as the New York-New Jersey Harbor Estuary—can also lead to loss of wetlands and eelgrass with impacts to crabs and hard-shell clams, which also account for much of the commercial fishing industry.

These ecological effects are likely to be felt acutely at coastal parks and open space in the region, such as Liberty State Park in Jersey City. Negative impacts to these ecosystems are also likely to reduce natural protection from coastal storm surge and erosion.

In addition to directly affecting peoples' livelihoods—largely in other parts of the state—the long-term consequences of loss of marine species could have broader economic implications for Northeastern New Jersey, especially for any port facilities (such as the Global Marine Terminal at Port Jersey) dependent on maritime economic activity, as well as for businesses, residences, and community services, who may be at the receiving end of increased marine food prices, potentially compounded by any additional food shortages caused by the agricultural impacts associated with drought and water supply issues.

Regional Economic Sensitivity to Ocean Acidification

According to the National Resources Defense Council (NRDC), although the majority of economic impacts affecting commercial fishing-dependent communities will be concentrated in southern New Jersey, parts of Northeastern New Jersey around Newark Bay could still experience impacts of medium economic severity. In the northernmost part of New Jersey, water could start becoming unfavorable to shellfish earlier than the rest of the state—as early as 2071.



4. CLIMATE HAZARD RESILIENCE TOOLBOX

CLIMATE HAZARD RESILIENCE TOOLBOX

There are many possible solutions that can be implemented to address climate-related hazards considered by Resilient NENJ.

Resilient NENJ developed this climate hazard-related toolbox that describes solutions included in the five categories in the Resilient NENJ Action Plan: physical and nature-based solutions; policy and governance solutions; outreach, education, and capacity building; service and program development or enhancement; and emergency preparedness and response.

The toolbox is not intended to be inclusive of all possible solutions; it helps communicate the types and range of solutions possible. The related Flood Resilience Toolbox is included in Appendix C of Resilient NENJ's Vision and Priorities report and is available as a stand-alone document on the Resilient NENJ website.

The toolbox helped the team identify solutions used in the development of the scenarios outlined in Resilient NENJ's Scenario Development Report. The toolbox summarizes key information about each solution including:

- A description of the tool
- Existing example applications of the tool
- Types of hazards the tool addresses
- Scale of the intervention (individual site, multiple sites, etc.)
- Possible co-benefits (benefits other than reduced flooding)

Legend

Hazards

- Extreme Heat
- Air Quality
- Drought & Water Supply
- Wildfire Risk
- Groundwater Rise & Quality
- Severe Weather
- Ocean Acidification
- Vector-Borne Illness

Co-Benefits

EDUCATIONAL ECONOMIC RECREATIONAL ECOLOGICAL

Level of Effort

Scale of Implementation

Site-Specific Neighborhood Municipality

Region State

OUTREACH, EDUCATION, AND CAPACITY BUILDING

Action – Develop and Distribute Accessible Information & Educational Materials

Tools

Multilingual outreach and education campaign designed to reach as many communities as possible (especially environmental justice communities) focused on public health risks and mitigation options associated with:

- Extreme Heat
- Air Quality
- Lyme Disease Protection
- West Nile Virus Protection
- Groundwater Rise & Quality
- Severe Weather
- Ocean Acidification

Scale of Implementation

- Neighborhood
- Municipality
- Region
- State

- Start a drought response outreach program with detailed guidelines (e.g., California Drought Response Outreach Program for Schools (DROPS))

Co-Benefits

EDUCATIONAL

Examples of Ongoing Efforts

- The NJ Water Savers program supports comprehensive public education about water conservation, efficient landscaping and irrigation practices, home water audits and indoor water saving techniques, and appropriate school curricula materials
- The New Jersey Watershed Ambassadors Program is a community-oriented AmeriCorps program that raises awareness on water-related issues

OUTREACH, EDUCATION, AND CAPACITY BUILDING

Action – Invest in Community Engagement to Understand Local Needs

Tools

- Implement a public health hotline system for extreme heat to alert public health officials of high-risk or distressed individuals, tied to public programs to assist with residential heat mitigation
- Invest in comprehensive community engagement to understand where long-term and "invisible" health effects of pollution are already taking effect. Based on this, identify high-priority areas for immediate intervention
- Host the National Weather Service SKYWARN Storm Spotter training
- Work with teachers to help educate children on the risks of severe weather
- Determine areas high in Lyme contraction and convert them into "tickscapes," areas less livable for tick communities, while accounting for potential negative ecological, stormwater, or urban heat island side effects. Some options to explore include keeping areas mowed and trimmed at edges, repairing stone walls and sealing cracks, keeping firewood piles away from frequently traveled areas, and using mulch or stone to create borders

Scale of Implementation

Neighborhood | Municipality | Region | State

- Conduct community engagement to increase awareness of localized social and economic impacts of:
  - Ocean Acidification
  - Changes to Water Supply Levels and Projected Future Demand

Co-Benefits

EDUCATIONAL

Examples of Ongoing Efforts

- The NJDEP Office of Environmental Justice runs the Community Collaborative Initiative (CCI), a place-based partnership that works closely with local communities on a variety of environmental issues.

OUTREACH, EDUCATION, AND CAPACITY BUILDING

Action – Build Partnerships & Establish Working Groups for Collective Action

Tools

- Establish municipal-level working groups to advance specific actions related to:
  - Extreme Heat and Urban Heat Islands
  - Ground Ozone/Aerosol Health Risks
- Partner with the American Water Works Association (AWWA) to explore statewide industry-standard approaches to water conservation
- Engage communities in the National Groundwater Monitoring Network to maintain and better understand groundwater systems
- Build partnerships with the research and academic community to support statewide ocean acidification initiatives
- Coordinate training within communities to create a local career-pipeline for foresters and fire management workers

Scale of Implementation

Neighborhood | Municipality | Region | State

Co-Benefits

EDUCATIONAL

Examples of Ongoing Efforts

- New Jersey Sea Grant and NOAA Ocean Acidification Program (OAP) partnership prioritizes and invests in regional ocean/coastal acidification research
- The Southward Environmental Alliance will host its 2nd Environmental Justice Summit where local community members and officials have panels and discuss various important environmental challenges

PHYSICAL AND NATURE BASED SOLUTIONS

Action – Invest in Ecosystem-Based Adaptation Projects to Address Multiple Climate Hazards

Tools

Expand urban green space to:

- Address environmental justice issues
- Improve community health

Decrease Surface Temperatures

Ameliorate Poor Air Quality

Mitigate Flash Flooding

Large-scale forest stand improvement (FSI) projects including enhancing native habitats, removal of additional brush/debris/dead leaves, tick tubes, and monitored localized burnings

Minimize Tick Presence & Remove Invasive Species

Reduce Wildfire Fuel and Increase Forest Health

Scale of Implementation

Neighborhood

Municipality

Region

State

Implement watershed-based management habitat restoration, sustainable agroforestry practices, and planting of native species to:

Protect Water Resources, Improve Groundwater Recharge and Quality

Decrease Forest Fire Risk

Implement integrated water resources management (IWRM) practices in future water supply infrastructure, such as conjunctive seasonal use of surface water and groundwater

Maintain surface water wetlands and lakes to decrease contaminated recharge

Large-scale projects and initiatives to conserve and protect marine life vulnerable to ocean acidification

Co-Benefits

EDUCATIONAL

RECREATIONAL

ECOLOGICAL

Examples of Ongoing Efforts

- NJ National Resources Conservation Service (NRCS) offers financial and technical assistance to landowners for FSI projects
- NJDEP Green Acres Program conducts land acquisitions as well as loans/ grants to nonprofits for acquisition and conservation purposes
- Hudson County Urban Forestry Initiative
- Jersey City Tree Canopy Assessment – Urban Environmental Green Infrastructure Design Plan
- Hoboken Green Infrastructure Strategic Plan
- The City of Newark's Adopt a Catch Basin Program can help clear standing water that serve as mosquito breeding grounds

PHYSICAL AND NATURE BASED SOLUTIONS

Action – Site-Specific Plans for Prioritized Aging Infrastructure and Hazardous Sites

Tools

- Conduct a comprehensive vulnerability assessment of:
  - Electrical, Transportation, Water, and Conveyance Infrastructure to Heat Stress
  - Water Main Networks for Vulnerabilities and Breakages
  - Hazardous Waste Sites and Need for Remediation of Contaminated Plumes Through Full or Partial Soil Removal

Scale of Implementation

Site-Specific

Municipality

- Prioritize capital improvement projects to replace and/or renew deteriorating and inefficient pipelines and supply assets
- Use best management and practices and monitor land in wellhead protection areas for expenditure of contaminants
- Remove combustible material from sites during building processes and create “defensible spaces” around buildings
- Increase open, lit spaces to discourage tick community growth

Co-Benefits

EDUCATIONAL

ECOLOGICAL

Examples of Ongoing Efforts

- NJDEP recently launched a Water Infrastructure Investment Plan (WIIP) to fund water-related capital improvement projects, including through NJ Water Bank-issued green bonds
- NJDEP’s Capacity Development (CapDev) program is specifically designed to identify and address water systems with technical, managerial, or financial deficits
- NJDEP Office of Environmental Justice’s Community Collaborative Initiative (CCI) works to remediate brownfield sites
- Hoboken Water Main Replacement Program
- Newark Lead service line replacement program
- Jersey City Lead Free JC Program
- Jersey City is undertaking a Climate Vulnerability Assessment for priority assets

POLICY AND GOVERNANCE

Action – Enforce Existing Regulations and Pursue Higher Standards

Tools

- Ensure all municipalities and the state are aspiring to or in line with federal and international higher standards, including:
  - 2021 federal U.S. Department of Labor Occupational Safety and Health Administration (OSHA) standards, including inspection guidance for heat-related hazards, in line with the National Emphasis Program (NEP) on heat inspections (effective April 2022)
  - 2021 International Energy Conservation Code (IECC) on energy efficiency and performance as well as spot-ventilation, isolation, and insulation of electrical and mechanical heat systems
  - Federal EPA air quality standards
  - World Health Organization (WHO) Global Air Quality Guidelines
  - 2018 International Residential and Plumbing Codes water conservation and efficiency standards
  - 2018 International Green Construction Code water conservation and efficiency standards

Scale of Implementation

Municipality

State

- Establish new regulations and ordinances
  - Require new public or publicly-funded buildings and facilities (such as transportation terminals or bus stops) to include outdoor heat mitigation features such as canopy cover or photovoltaic (PV) shade canopies, water-based cooling stations, or cool pavements
  - Implement load restrictions for older roads, bridges, and rail to reduce traffic on vulnerable transportation infrastructure which might experience material stress
  - Conservation subdivision ordinances to ensure water-efficient landscaping, e.g., requiring retainment of wooded areas or requiring a certain percentage of low water-use plants be used in design
  - Adopt statewide regulatory amendments needed to require American Water Works Association (AWWA) water loss audits and meet other benchmarks
  - Streamline SOPs and processes to obtain a Water Allocation Permit for Reclaimed Water for Beneficial Reuse (RWBR)
  - Mandate routine water supply asset condition assessments
  - Expand Groundwater Quality Standards to include a broader list of contaminants
  - Stricter zoning laws to create overlay zones that protect any water within the 1- 5- or 10- year time of travel zones
  - Require tougher fireproofing and fire safety regulations on homes, and restrict development in fire-prone areas to decrease areas referred to as “Wildland Urban Interfaces”

Co-Benefits

ECOLOGICAL

Examples of Ongoing Efforts

- 2021 NJ Stormwater Rule that requires municipalities to update their Stormwater Control Ordinances (SCOs) to require green infrastructure be included with new development. Model ordinances are provided
- State Emission Statement rule that establishes regulations for the annual reporting of air contaminant emissions from stationary sources to help with the monitoring of the state’s progress toward the mandatory emissions reduction protocols
- NJ Air Quality State Implementation Plan (NJ) regulations
- New Jersey’s existing statewide water quality standards, assessments, monitoring, and watershed-based plans and programs to reduce total maximum daily loads
- Enforce landlord regulations for provision of window and door screen protections to tenants (mosquito protection)
- Regulations on design of water conveyance and holding structures to minimize potential for mosquito habitats

POLICY AND GOVERNANCE

Action – Enhance Regional Planning and Coordination

Tools

- Expand regional coordination to collaborate on:
  - Fire Protection in New Jersey and Fire-Prone Areas in Surrounding States
  - Programs Associated with Reclaimed Water for Beneficial Reuse (RWBR)
  - Development of a Regional Drought Early Warning System (DEWS) that Includes NJ
  - Updated Strategic Management Plan for Invasive Species Reflecting Best Available Data on Climate Change-Related Impacts
  - Create Integrated Mosquito Management (IMM) Plans Including Surveillance, Removal of Larvae and Pupae, and Monitoring Control Systems to Mitigate Risk of Outbreaks
  - Identify Key Stakeholders and Advance Ocean Acidification Initiatives
  - Regional Goals to Support Local Planning for Better, Accessible, Equitable Public and Multi-Modal Transportation Infrastructure.

Scale of Implementation

Region

State

- Create a contaminant source inventory that details depth and water-solubility
- Consider making New Jersey a reclamation state to allow state and regional coordination around federally-funded water supply management infrastructure projects

Co-Benefits

ECONOMIC

RECREATIONAL

Examples of Ongoing Efforts

- 2017-2022 New Jersey Water Supply Plan
- 2015 New Jersey Energy Master Plan to improve resiliency of energy infrastructure

SERVICE AND PROGRAM DEVELOPMENT

Action – Incentivize Private Actors to Implement Retrofits and Sustainable Practices

Tools

- Explore implementing incentives programs to:

Install Noncombustible Screens Over Vents and Safe Storage Propane Tanks in Homes. Remove Combustible Materials from Sites

Encourage Structural Water Conservation Retrofits, Water Audits, Low-Flow Plumbing Retrofits and Efficient Appliances, and Limited Irrigable Acreage

Encourage Widespread Property Retrofits, New Construction, and Landscaping Features with Heat Mitigating Strategies Such as the NYC Green Roof Tax Abatement

Reduce Private Car Owner Vehicular Emissions

Explore Public-Private Partnerships to start or Expand Bike Share Programs

Scale of Implementation

Region

State

- Incentivize hazardous site remediation efforts that include elimination of stagnant water sources and/or maintenance/drainage of surface water to prevent mosquito growth
- Explore cost-share programs and technical assistance programs to landowners to undertake forest and wildlife improvement practices

Co-Benefits

ECONOMIC

RECREATIONAL

Examples of Ongoing Efforts

- NJ Water Savers: drinking water conservation pilot program with residents and industries throughout New Jersey
- NJDEP's Residential Rainwater Harvesting: Provides tools to community members to harvest rainwater for use.
- Rutgers Water Resources Program: State-wide grant program tackling New Jersey's water conservation challenges

SERVICE AND PROGRAM DEVELOPMENT

Action – Undertake Robust Monitoring and Modeling Efforts Using Industry-Standard Technology

Tools

- Use community science tools to forecast and monitor risk and impacts at a localized scale, tied to community alert systems and other resources:
  - Extreme Heat and Urban Heat Island
  - Ground Oone/Aerosol Health Risks
  - Flooding
- Integrate best-available data on future climate, population, and land use trends into ongoing monitoring and modeling efforts using cutting-edge technology:
  - Air Quality Monitoring
  - Water Reservoir Modeling and Drought Monitoring
  - High Resolution Rapid Refresh to Forecast on Smaller Grid

Scale of Implementation

- Municipality
- Region
- State

- Conduct physical and financial audits to collect data on resource consumption:
  - Water Losses and Efficiency
- Conduct additional modeling to address critical data gaps:
  - Rising Groundwater Levels and Contaminant Source/Trajectory
  - Predict Changes in Ocean Carbon Cycles, Ocean Acidification Monitoring
  - Future Risk Projections and Modeling
  - Municipal-Level West Nile Virus Risk Modeling

Co-Benefits

- EDUCATIONAL

Examples of Ongoing Efforts

- NJDEP conducts surface water reservoir system modeling using RiverWare and similar software for the Hackensack/ Passaic River and Raritan River Basins
- NJDEP maintains extensive ambient and drought monitoring networks
- The Southward Environmental Alliance in Newark's Air Quality Monitoring Project identifies areas with high pollution levels to establish "Clean Air Zones"
- In 2021, Sustainable Jersey City mobilized 45 community members to collect temperature and air quality data points across Newark and Jersey City (and Elizabeth)

SERVICE AND PROGRAM DEVELOPMENT

Action – Prioritize Equitable Investments in Public Programs to Reach/Assist Under-Resourced Populations

Tools

- Initiate public programs to distribute critical risk-mitigating resources (alongside installation assistance), especially to environmental justice and other economically vulnerable communities:
  - Air Conditioners, Clean Energy Technologies and Transportation Subsidies
  - Soil Moisture/Rain Sensors and Smart Controllers for Irrigation Efficiency
  - Water Quality Test Kits, Emergency At-Home Water Filtration Systems
  - Sprays, Window and Door Screen Protections, Tickscape Resources

Scale of Implementation

Neighborhood

Municipality

State

- Set up public health monitoring and screening programs that are accessible to everyone (including undocumented people) to help identify exposure to adverse health conditions in environmental justice communities:
  - Mobile Mammography and Other Cancer Screening with On-Site Medical Services, Assistance in Obtaining Subsidized Health Insurance
  - Localized Monitoring of Water Quality Conditions, Especially in High Hazardous Waste Proximity Sites

Co-Benefits

ECONOMIC

Examples of Ongoing Efforts

- NJ Department of Community Affairs help administer the Low-Income Home Energy Assistance Program (LIHEAP), a federally funded program to help low-income families and individuals meet home heating and cooling costs.

EMERGENCY RESPONSE AND PREPAREDNESS

Action – Develop Hazard-Specific Emergency Response Plans Using National Best Practices

Tools

- Develop and/or update municipal-scale response and/or contingency plans with clear actions to address specific extreme events, including:
  - Heatwaves
  - Water Supply Emergencies and Severe Food Shortages
  - Aquifer Contamination and/or Hazardous Plumes
  - Severe Wildfire Smoke
  - West Nile Virus Seasonal Outbreaks

- Review existing plans and procedures to ensure they align with national best practices:
  - Streamline Existing Drought and Water Supply Emergency Management Procedures
  - Ensure Redundancy In Early Warning and Public Communication Systems
  - Incorporate Integrated Mosquito Management for Post-Flood Response

Examples of Ongoing Efforts

- New Jersey statewide regulations that require all water allocation permit holders to submit updated Water Conservation and Drought Management Plans (WCDMPs)
- NJDEP encourages all households to make an emergency plan in the event of any severe weather disaster and offers guidance to citizens to realize them
- NJDEP provides a worksheet and technical guidance for Wastewater Systems Emergency Response Plans

Scale of Implementation

Neighborhood | Municipality | State

Co-Benefits

ECONOMIC

EMERGENCY RESPONSE AND PREPAREDNESS

Action – Invest in Accessible Shelters, Cooling Stations, and Resilience Hubs

Tools

- Identify high-priority areas to expand the scope and concentration of universally accessible community centers for provision of relief and resources during extreme events:
  - Cooling, Electricity/Wi-Fi During "Brown-Outs," Potable Water Distribution
  - Well Air-Filtrated Spaces with Electricity and Wi-Fi for Poor Air Quality Days
  - Potable Water Distribution
  - Shelter, Potable Water and Food During Severe Weather

Scale of Implementation

Neighborhood

Municipality

- Work with local civic groups and mutual aid networks to encourage and support establishment of multi-purpose “resilience hubs” that can serve as both shelters/cooling stations while also providing additional community resources, capacity building, and space for civic organizing and advocacy to advance action
  - Support Education and Organizing Around Health Risks and Actions/Policies to Mitigate
  - Preparedness Capacity Building, Trained Community Disaster Response Network
  - Support Education Around Increasing Risks, Organize Cleanups of Stagnant Water Sources

Co-Benefits

ECONOMIC

Examples of Ongoing Efforts

- Most municipalities have started to implement cooling centers on extreme heat days in dense urban areas
- Newark submitted a BRIC application in 2021 to implement a resilience hub at Ann Street School in the Ironbound neighborhood

BIBLIOGRAPHY

BIBLIOGRAPHY

Abbinett, Jessica et al. *Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation*. Climate and Health Program, Centers for Disease Control and Prevention. https://www.cdc.gov/climateandhealth/docs/HeatResponsePlans_508.pdf

Aeroqual. (2021, February 16). *People Power – Air Quality Mitigation Strategies for Communities*. https://www.aeroqual.com/blog/air-quality-mitigation-strategies-for-communities

Agostini, Paola. (2011, August). *Guide to Best Practices for Ocean Acidification Research and Data Reporting*. European Commission Research & Innovation. https://www.iaea.org/sites/default/files/18/06/oa-guide-to-best-practices.pdf

Arizona Department of Health Services. (2021, September). *Extreme Heat Incident Annex*. Arizona Department of Health Services. https://www.azdhs.gov/documents/preparedness/emergency-preparedness/response-plans/extreme-heat-incident-annex.pdf

Barr, Janine. (2020, September 2). *Opportunities to Address Ocean Acidification Impacts in New Jersey*. Rutgers NJ Climate Change Resource Center. Opportunities-to-Address-Ocean-Acidification-Impacts-in-New-Jersey.pdf (rutgers.edu)

Bhatia, Udit et al. (2016, November). *Mitigation and Adaptation Strategies for Public Health Impacts of Heatwaves for Town of Brookline*, MA. Sustainability and Data Sciences Lab Northeastern University. https://thrivingearthexchange.org/wp-content/uploads/2016/03/Brookline_Heatwaves_SDS-2.pdf

C40 Climate Leadership Group. (2021, November). *How to Adapt Your City to Extreme Heat.* C40 Knowledge. https://www.c40knowledgehub.org/s/article/How-to-adapt-your-city-to-extreme-heat?language=en_US

California Department of Public Health, Vector-Borne Disease Section. (2010, August). *Best Management Practices for Mosquito Control in California.* Mosquito Vector Control Association of California. https://www.contracostamosquito.com/PDF/BMPforMosquitoControl_08_10.pdf

Center for Climate and Energy Solutions. (2017, November). *Resilience Strategies for Extreme Heat.* Center for Climate and Energy Solutions. https://www.c2es.org/wp-content/uploads/2017/11/resilience-strategies-for-extreme-heat.pdf

Centers for Disease Control and Protection. (2022, May 5). *Mosquito Control in a Community*. Centers for Disease Control and Prevention. Mosquito Control in a Community | Mosquitoes | CDC.

Centers for Disease Control and Protection. (2022, January 11). *West Nile Virus Neuroinvasive Disease Incidence by State 2021*. https://www.cdc.gov/westnile/statsmaps/preliminarymapsdata2021/incidencestate-2021.html.

Centers for Disease Control and Protection: Agency for Toxic Substances and Disease Registry. (2022, March 15). *CDC/ATSDR Social Vulnerability Index.* https://www.atsdr.cdc.gov/placeandhealth/svi/index.html.

City of Hoboken. (2021, December 2). *Hoboken Announces New Partnership with Weather and Climate Security Platform*. https://www.hobokennj.gov/news/hoboken-announces-new-partnership-with-weather-and-climate-security-platform.

Clef, Michael. (2007). T*he Recommendations of the New Jersey Invasive Species Council to Gov Jon S.Corzine*. New Jersey Strategic Management Plan for Invasive Species. https://www.nj.gov/dep/njisc/docs/Final%20NJ%20Strategic%20Management%20Plan%20for%20Invasive%20Species%2011.09.pdf.

Congressional Research Service. (2022, February 8). *Drought in the United States: Science, Policy, and Selected Federal Authorities.* https://crsreports.congress.gov/product/pdf/R/R46911

Congressional Research Service. (2022, March 23). *FEMA Hazard Mitigation: A First Step Toward Climate Adaption*. https://crsreports.congress.gov/product/pdf/R/R46989

211 New Jersey. *Utility Assistance Programs*. https://www.nj211.org/utility-assistance-programs.

Davis, R. E. and Novicoff, W. M. (2018). The *Impact of Heat Waves on Emergency Department Admissions in Charlottesville, Virginia, U.S.A*. Int J Environ Res Public Health 15(7). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6068980/.

Ding, Y. and Y. Peng. (2009, April). *Contaminant Transport in Coastal Aquifers.* Submitted to NJDEP Division of Science, Research and Technology. https://www.nj.gov/dep/dsr/coastal/coastal-aquifers-report.pdf.

Dunlap, Lauren and Wibbenmeyer, Matthew. (2021, August 18). *Wildfires in the United States 102: Policy and Solutions. Explainer.* https://www.rff.org/publications/explainers/wildfires-in-the-united-states-102-policy-and-solutions/

Environmental Defense Fund. (2020, January 20). *Policies to Reduce Pollution and Protect Health.* https://www.edf.org/airqualitymaps/oakland/policies-reduce-pollution-and-protect-health

Essex County Sherriff's Office and Essex County Office of Emergency Management. (2020). *County of Essex All Hazard Mitigation Plan: 2020 Update.* https://www.essexsheriff.com/oem/all-hazard-mitigation-plan/.

FEMA Department of Homeland Security. (2021, October 28). *FEMA Announces Initial Initiatives to Advance Climate Change Resilience.* https://www.fema.gov/press-release/20211028/fema-announces-initial-initiatives-advance-climate-change-resilience.

FEMA Department of Homeland Security. (2013, January). *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards.* https://www.fema.gov/sites/default/files/2020-06/fema-mitigation-ideas_02-13-2013.pdf.

First Street Foundation: Risk Factor. (2022). https://riskfactor.com/.

Frumhoff, P.C., J. J. McCarthy, J. M. Melillo, S. C. Moser, and D. J. Wuebbles. 2007. *Confronting climate change in the U.S. Northeast: Science, impacts, and solutions.* Pages 1–160 Synthesis report of the Northeast Climate Impacts Assessment (NECIA). UCS Publications, Cambridge, MA.

Gioiella, Filomena et al. (2020, April 11). *Mitigation Strategies for Reducing Air Pollution.* Environmental Science and Pollution Research. https://link.springer.com/article/10.1007/s11356-020-08647-x#Sec12

Heat Adaptation Workgroup. (2013, October). *Preparing California for Extreme Heat: Guidance and Recommendations.* California Climate Action Team. https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CCHEP-General/CDPH-EPA-2013-Preparing-CA-for-Extreme-Heat_ADA.pdf.

Holst, Eric. *4 Ways the Right Policies Can Help us Confront Wildfires.* Environmental Defense Fund. https://www.edf.org/climate/4-ways-right-policies-can-help-us-confront-wildfires.

Hubbard, L. E., Keefe, S. H., Kolpin, D. W., Barber, L. B., Duris, J. W., Hutchinson, K. J., and Bradley, P. M. (2016). *Understanding the hydrologic impacts of wastewater treatment plant discharge to shallow groundwater: Before and after plant shutdown.* Environmental Science: Water Research & Technology. https://pubs.er.usgs.gov/publication/70174047.

Hudson County Office of Emergency Management. (2020). *2020 Hazard Mitigation Plan.* https://www.hcnj.us/roads-and-public-property/emergency-management/hazard-mitigation-plan-2/.

Intergovernmental Panel on Climate Change (IPCC). (2021). *Climate Change 2021: The Physical Science Basis.* https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

Kemper Count IGCC EIS. (2009, November). *Pollution Prevention and Mitigation Measures*. https://netl.doe.gov/sites/default/files/environmental-policy/eis-kemper-draft/12_Chapter-5.pdf.

Magill, B. (2014, July 31). *Derailments May Increase as 'Sun Kinks' Buckle Tracks.* Climate Central. https://www.climatecentral.org/news/climate-change-warp-railroad-tracks-sun-kinks-17470.

Municipal Finance and Construction Element. *The New Jersey Water Bank – NJWB*. New Jersey Department of Environmental Protection. https://www.nj.gov/dep/dwq/mface_njeifp.htm

National Association of Counties: Community Services Division of the County Services Department. (2007, July). *Air Quality Improvement Guide for Local Governments*. https://www.naco.org/sites/default/files/documents/AQ_Factsheet%20-%20Air%20Quality%20Improvement%20Guide%20for%20Local%20Governments.pdf

National Integrated Drought Information System. *Drought Early Warning*. https://www.drought.gov/about/drought-early-warning#:~:text=Drought%20early%20warning%20systems%20(DEWS,with%20the%20impacts%20of%20drought.

National Integrated Drought Information System. *Midwest Drought Early Warning System Strategic Action Plan*. https://www.drought.gov/sites/default/files/2021-11/2021%E2%80%932024_MW_StrategicPlan.pdf

Natural Pest Repellants. *How to Tickscape Your Yard*. https://naturalpestrepellents.com/blog/Tickscaping-your-yard/

BIBLIOGRAPHY

Natural Resources Defense Council. *Newark Drinking Water Crisis*. https://www.nrdc.org/newark-drinking-water-crisis.

Natural Resources Defense Council. (2012, April). *Ready or Not: An Evaluation of State Climate and Water Preparedness Planning*. https://www.nrdc.org/sites/default/files/Water-Readiness-full-report.pdf.

Neumann, Brad. (2019, October 8). *Local Government Strategies to Protect Groundwater*. Michigan State University Extension. https://www.canr.msu.edu/news/local_government_strategies_to_protect_groundwater

New Jersey Future. (2018, July). *A Review of New Jersey Water Bank Financing for Green Infrastructure Projects*. New Jersey Future. NJFutureWaterBankFinancingReport.pdf

New Jersey Future. (2021). *New Jersey Green Infrastructure Municipal Toolkit.* NJ Stormwater Rules | New Jersey Green Infrastructure Municipal Toolkit (njfuture.org)

NJDEP. (2018, December 13). *Beneficiary Mitigation Plan for the Volkswagen Mitigation Trust*. https://www.state.nj.us/dep/vw/BMPfinal.pdf

NJDEP. *Emergency Response Preparedness/ Planning Guidance and Best Practices*. https://www.nj.gov/dep/dwq/pdf/guidance_erp.pdf.

NJDEP. (2020). *New Jersey Scientific Report on Climate Change*. https://dspace.njstatelib.org/xmlui/handle/10929/68415.

NJDEP. *New Jersey Water Supply Plan 2017-2022*. https://www.nj.gov/dep/watersupply/pdf/wsp.pdf

NJDEP. (2021, May). *Soil and Soil Leachate Remediation Standards for the Migration to Ground Water Exposure Pathway*. https://www.nj.gov/dep/srp/guidance/rs/bb_migration_gw.pdf

NJDEP: Bureau of Environmental Analysis, Restoration and Standards. (2022, March 9). *Ground Water Quality Standards*. https://www.state.nj.us/dep/wms/bears/gwqs.htm

NJDEP: Division of Science and Research. (2020). *Climate Change in New Jersey: Temperature, Precipitation, Extreme Events, and Sea-Level Rise*. https://www.nj.gov/dep/dsr/trends/Climate%20Change.pdf.

NJDEP: Division of Water Supply and Geoscience. (2022, January 27). *The Case for Water Conservation in New Jersey*. https://www.state.nj.us/dep/watersupply/conserve.htm.

NJDEP: Green Acres Program. (2022, April 29). *Green Acres Mission*. https://www.nj.gov/dep/greenacres/index.html.

NJOEM. (2018). *2019 New Jersey State Hazard Mitigation Plan*. https://nj.gov/njoem/mitigation/2019-mitigation-plan.shtml.

NJ Spotlight News. (2017, May 5). *Interactive Map: NJ Water Systems Out of Compliance with Federal Standards.* https://www.njspotlightnews.org/2017/05/17-05-04-interactive-map-unfit-to-drink-nj-water-systems-out-of-compliance-with-federal-standards/.

NOAA: National Integrated Drought Information System. (2022, May 25). *New Jersey*. https://www.drought.gov/states/new-jersey/.

Northjersey.com. (2017, May 8). *Many parts of New Jersey face stressed drinking water supplies*. https://www.northjersey.com/story/news/2017/05/08/new-jersey-has-many-stressed-drinking-water-supplies/310316001/.

NYC Office of the Mayor. (2020, May 15). *Mayor de Blasio Announces COVID-19 Heat Wave Plan to Protect Vulnerable New Yorkers*. Official Website of the City of New York. https://www1.nyc.gov/office-of-the-mayor/news/350-20/mayor-de-blasio-covid-19-heat-wave-plan-protect-vulnerable-new-yorkers

Pierre, Jeffrey. (2021, December 16). *After A Year of Deadly Weather, Cities Look to Private Forecasters to Save Lives*. NPR WNYC. https://www.npr.org/2021/12/16/1064590315/after-a-year-of-deadly-weather-cities-look-to-private-forecasters-to-save-lives

Plumer, Brad and Schwartz, John. (2021, May 19). *These Changes Are Needed Amid Worsening Wildfires, Experts Say. The New York Times*. https://www.nytimes.com/2020/09/10/climate/wildfires-climate-policy.html.

Rozell, D. J. (2020). *Coastal resiliency groundwater considerations*. Groundwater, 58(6), 877–881. https://doi.org/10.1111/gwat.13035

Serban, A. (2019, October 19). *The Impact of Heat Stress in Firefighter Fatalities.* Honeywell. https://sps.honeywell.com/us/en/support/blog/safety/the-impact-of-heat-stress-in-firefighter-fatalities.

Stafford, Kirby. (2007). *Tick Management Handbook. The Connecticut Agricultural Experimentation Station*. Tick Management Handbook (tickdiseases.org)

State of California. (2022). *Drought Response Outreach Program for Schools*. https://www.waterboards.ca.gov/water_issues/programs/grants_loans/drops/

State of California: California Drought Action. (2022). *Dry Start to 2022 Marks Third Year of Drought*. https://drought.ca.gov/#:~:text=Governor%20Newsom%20signed%20a%20package,and%20quality%2C%20and%20support%20wildlife.

State of California: Forest Management Task Force. (2021, January). *California's Wildfire and Forest Resilience Action Plan*. https://fmtf.fire.ca.gov/media/cjwfpckz/californiawildfireandforestresilienceactionplan.pdf.

State of Oregon. (2019, November). *Governor's Council On Wildfire Response: Report and Recommendations*. https://www.oregon.gov/osp/Docs/GovWildfireCouncilRpt-FinalRecs.pdf.

State of Oregon Department of Land Conservation and Development. (2021). *Oregon Climate Change Adaptation Framework*. https://www.oregon.gov/lcd/CL/Documents/2021_CLIMATE_CHANGE_ADAPTATION_FRAMEWORKandBlueprint.pdf.

Stormwater. (2021, June 7). *New Jersey Invests $122 Million in Water Infrastructure Through Green Bonds. Stormwater*. https://www.stormh2o.com/green-infrastructure/press-release/21225763/new-jersey-invests-122-million-in-water-infrastructure-through-green-bonds.

Sustainable Jersey Climate Change Adaptation Task Force (CATF). (2011). *New Jersey Climate Change Trends and Projections Summary*. https://www.sustainablejersey.com/fileadmin/media/Media___Publications/Publications/2011-09-26_SJ_CATF_CC_Impacts_Summary_final.pdf.

The Groundwater Foundation. (2022). *In Your Community*. Groundwater Foundation. https://www.groundwater.org/action/community/community.html

The Groundwater Foundation. (2022). *Wellhead Protection*. Groundwater Foundation. The Groundwater Foundation : Take Action : In Your Community : Wellhead Protection

Together North Jersey. (2013, May). *Water Resources Baseline Topic Report)*. Prepared for NJ Future. https://cms.jerseywaterworks.org/wp-content/uploads/2019/08/Water-Formatted-Upload.pdf

The Trust for Public Land. (2022, March 15). *Heat Severity – USA 2021*. https://www.arcgis.com/home/item.html?id=cdd2ffd5a2fc414ca1a5e676f5fce3e3.

Trapp, R. J., Diffenbaugh, N. S., Brooks, H. E., Baldwin, M. E., Robinson, E. D., and Pal, J. S. (2007). *Changes in severe thunderstorm environment frequency during the 21st century caused by anthropogenically enhanced global radiative forcing*. https://www.pnas.org/doi/abs/10.1073/pnas.0705494104.

True New Jersey: Politics. (2022, January 20). *NJ to get $1B to Address Flooding, Climate Change after Hurricane Ida. Here's where it goes.* https://www.nj.com/politics/2022/01/nj-to-get-1b-to-address-flooding-climate-change-after-hurricane-ida-heres-where-it-goes.html.

United States Senator for California Dianne Feinstein. (2021, May 26). *New Bill Would Reduce Risk for Catastrophic Wildfires, Increase Preparedness*. https://www.feinstein.senate.gov/public/index.cfm/press-releases?ID=D42BB61B-4F08-4E66-BD95-55E5EF32A463.

University of California MERCED. *Multivariate Adaptive Constructed Analogs (MACA) Datasets*. https://climate.northwestknowledge.net/MACA/tool_summarymaps2.php.

University of South Carolina: Hazards Vulnerability & Resilience Institute. *BRIC Data*. https://sc.edu/study/colleges_schools/artsandsciences/centers_and_institutes/hvri/data_and_resources/bric/bric_data/index.php.

University of South Carolina: Hazards Vulnerability & Resilience Institute. *SoVI 2010-14 Data*. https://sc.edu/study/colleges_schools/artsandsciences/centers_and_institutes/hvri/data_and_resources/sovi/sovi_data/index.php.

US Department of Agriculture: *Climate Hubs. Dealing With Drought*. https://www.climatehubs.usda.gov/dealing-drought

US Department of Agriculture: Forest Service. (2017). *Safe and Effective Wildfire Response*. https://www.fs.usda.gov/managing-land/fire/response.

US Department of Environmental Protection. (2016, August). *What Climate Change Means for New Jersey*. https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-nj.pdf.

BIBLIOGRAPHY

US Department of the Interior: Office of Congressional and Legislative Affairs. (2020, March 4). *The Impact of Invasive Species on Bureau of Reclamation Facilities and Management of Water Resources in the West*. https://www.doi.gov/ocl/invasive-specieswater-resources.

US Department of Labor. (2021, September 20). *OSHA National News Release. US Department of Labor*. https://www.osha.gov/news/newsreleases/national/09202021

US Environmental Protection Agency. (2022, April 1). *EJScreen: Environmental Justice Screening and Mapping Tool*. https://www.epa.gov/ejscreen.

US Environmental Protection Agency. (2021, November 2). *Air Data: Air Quality Data Collected at Outdoor Monitors Across the US*. https://www.epa.gov/outdoor-air-quality-data.

US Environmental Protection Agency. (2021, July 15). *Adapting to Heat. EPA*. https://www.epa.gov/heatislands/adapting-heat#:~:text=Programs%20that%20install%20cool%20or,system%2C%20particularly%20during%20heat%20waves

US Geological Survey: Groundwater and Streamflow Information Program. *Groundwater Monitoring*. https://www.usgs.gov/programs/groundwater-and-streamflow-information-program/groundwater-monitoring.

US Global Change Research Program. (2018). *Fourth National Climate Assessment (NCA4)*. https://www.globalchange.gov/nca4.

White House Statements and Releases. (2021, September 21). *FACT SHEET: Biden Administration Mobilizes to Protect Workers and Communities from Extreme Heat. The White House*. https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/20/fact-sheet-biden-administration-mobilizes-to-protect-workers-and-communities-from-extreme-heat/

Wildfire Today. (2021, July 19). *Wildfire smoke forecast, July 20, 2021*. https://wildfiretoday.com/2021/07/19/wildfire-smoke-forecast-july-20-2021/.

Williamson, T. N., Nystrom, E. A., and Milly, P. C. (2016). *Sensitivity of the projected hydroclimatic environment of the Delaware River basin to formulation of potential evapotranspiration*. Climatic change, 139(2), 215-228. doi: 10.1007/s10584-016-1782-2.

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