RESILIENT NJ
RESILIENT RARITAN RIVER AND BAY COMMUNITIES

APPENDIX O:

ADDITIONAL CLIMATE HAZARDS ASSESSMENT

August 12, 2022

Table of Contents

Each hazard's section includes projections and impacts. A toolkit of approaches to address these hazards has been distributed separately

RARITAN RIVER AND BAY COMMUNITIES

Key Points

This appendix summarizes desktop research on regional trends and vulnerabilities to various climate hazards in Raritan River and Bay Communities, not inclusive of flood risk (as this is covered by Resilient NJ).

Next steps to follow will include:

- Refining analysis based on Steering Committee feedback
- Integrating this assessment and toolbox into the Action Plan and future engagement materials

Key insights from this analysis include:

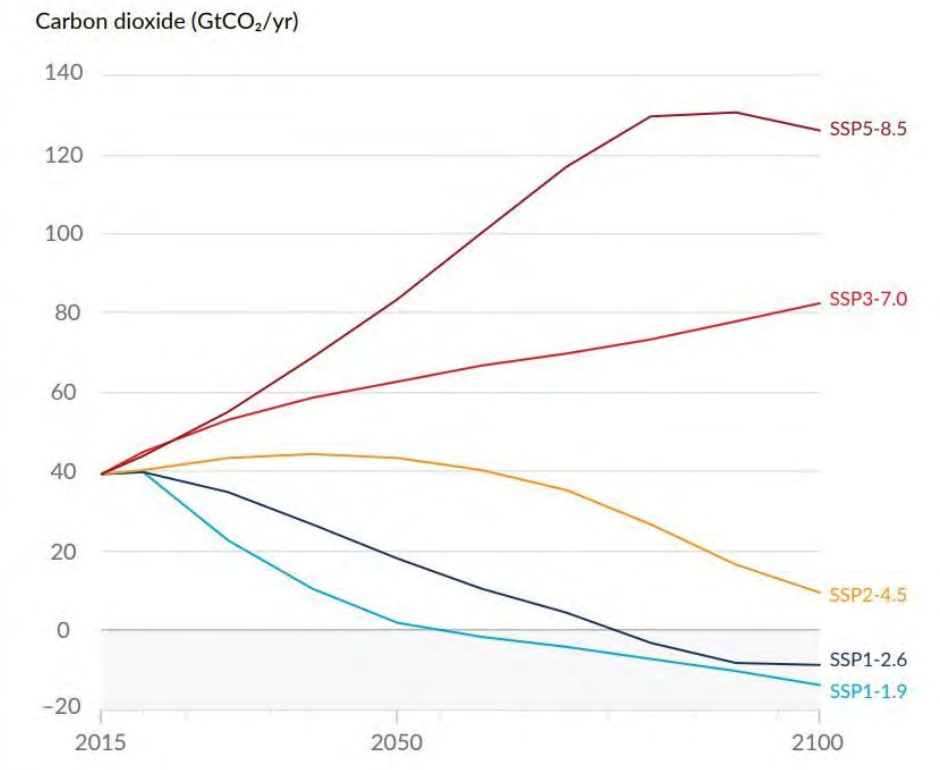
- Some of the most socially vulnerable communities in the state—and in some cases, the country—reside in Perth Amboy and Carteret. They live in areas of high urban heat, pollution, and proximity to hazardous waste
- Rising global temperatures will have an increasingly acute localized effect on RRBC with 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/food supply as a result of drought, and increase the likelihood of wildfires. Localized urban heat island will be especially acute in the more heavily urbanized parts of the region, such as parts of Carteret and Perth Amboy
- High concentrations of hazardous materials and wastewater discharge throughout RRBC can pose a serious risk to public health and safety as groundwater levels rise

Clear action items flowing from this analysis include:

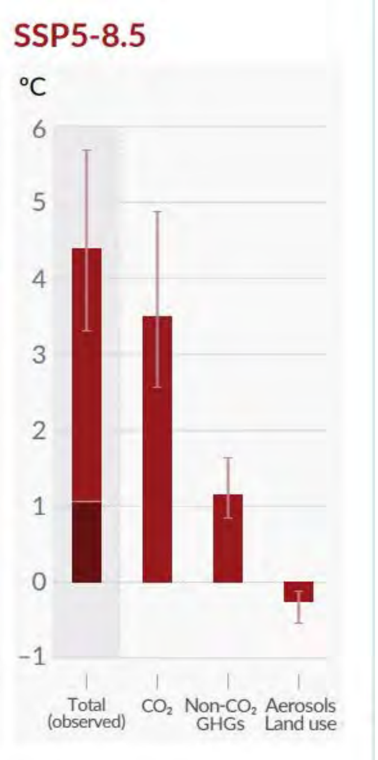
- Conducting thoughtful and targeted outreach and engagement to generate a clear picture of how vulnerable communities in RRBC are already feeling the impacts of climate change, sometimes in “invisible” ways—as well as what policy priorities and resources they require to adapt and improve quality of life
- Invest in additional data generation and modeling to fully understand localized future projections—especially for rising groundwater levels, for which data is severely lacking
- Collaborate with trusted civic groups, community leaders and organizers, and artists to educate and help build capacity in communities vulnerable to the worst and most immediate impacts of these hazards

We are currently on track for a “business-as-usual” greenhouse gas emissions scenario

Future Annual CO_2 Emissions (5 Scenarios)



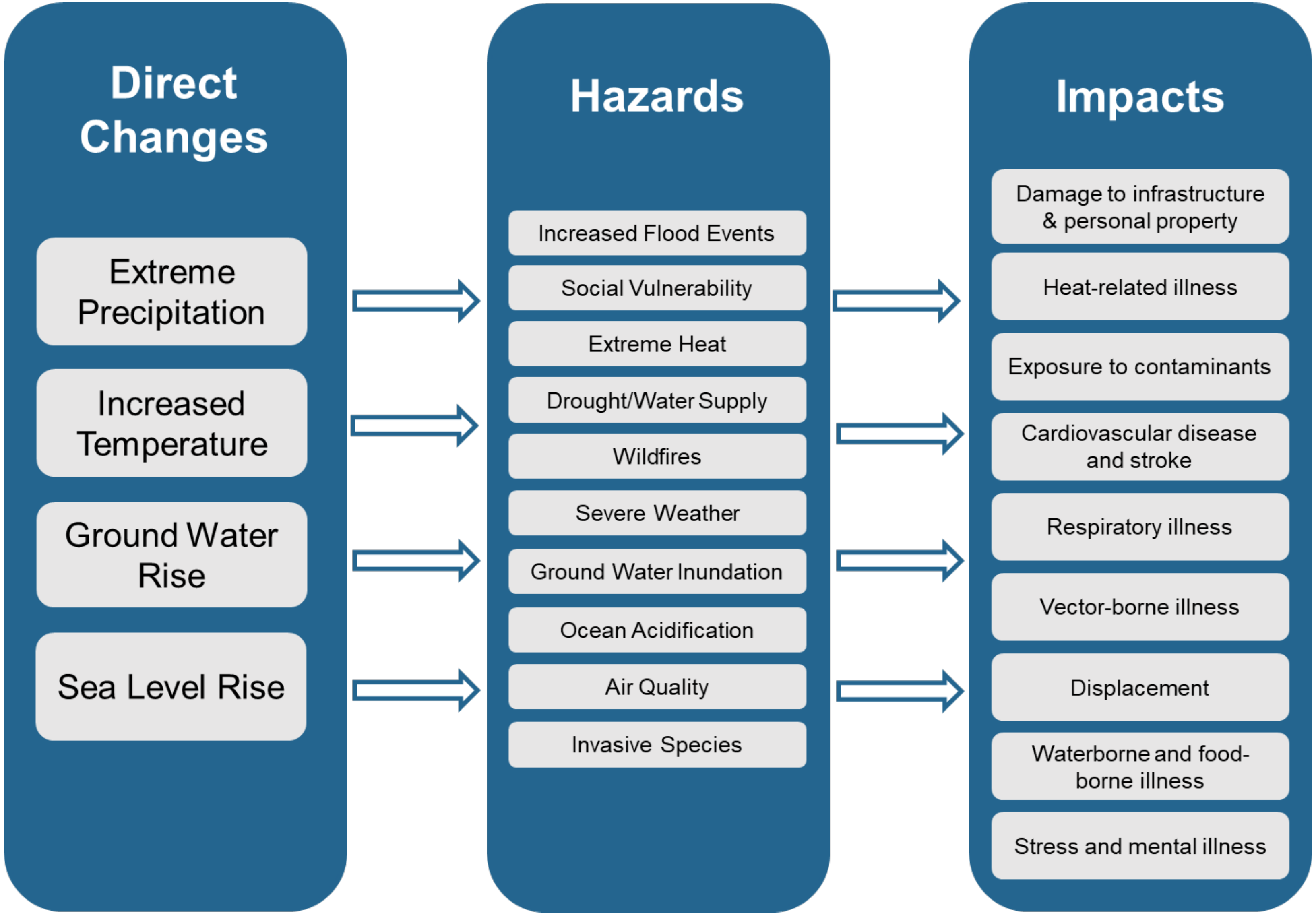
Business-as-Usual Emissions Contributions to Global Surface Temperature Increases



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

- The **International Panel on Climate Change (IPCC)** develops future climate change scenarios defined by the level of carbon in the atmosphere
- **RCP8.5** is the high-end, “business-as-usual” scenario (out of several Representative Concentration Pathways), understood as the **90th percentile outcome** if no substantive global policy is undertaken to curb greenhouse gas emissions
- 8.5 refers to an average **global warming increase of 8.5 watts per square meter**
- This is considered the **“baseline” scenario** for planning purposes, though there is some uncertainty and disagreement over whether it under- or over-estimates future emissions and temperature increases
- More recently, the IPCC transitioned to using **Shared Socioeconomic Pathways (SSPs)** in place of RCPs to include various socioeconomic factors, but most existing models rely on the older RCP scenarios

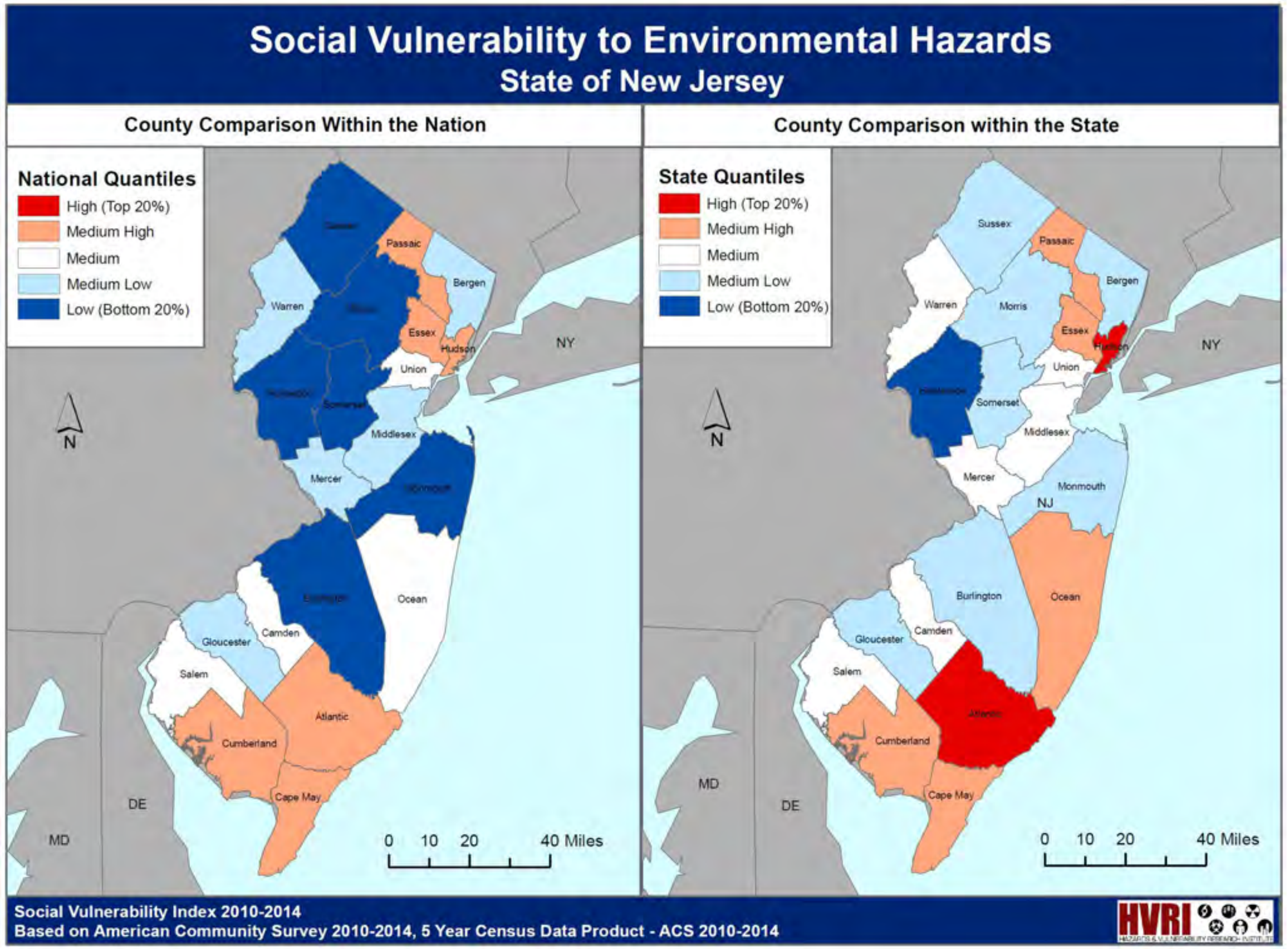
Impacts of Climate Change on Weather



RARITAN RIVER AND BAY COMMUNITIES

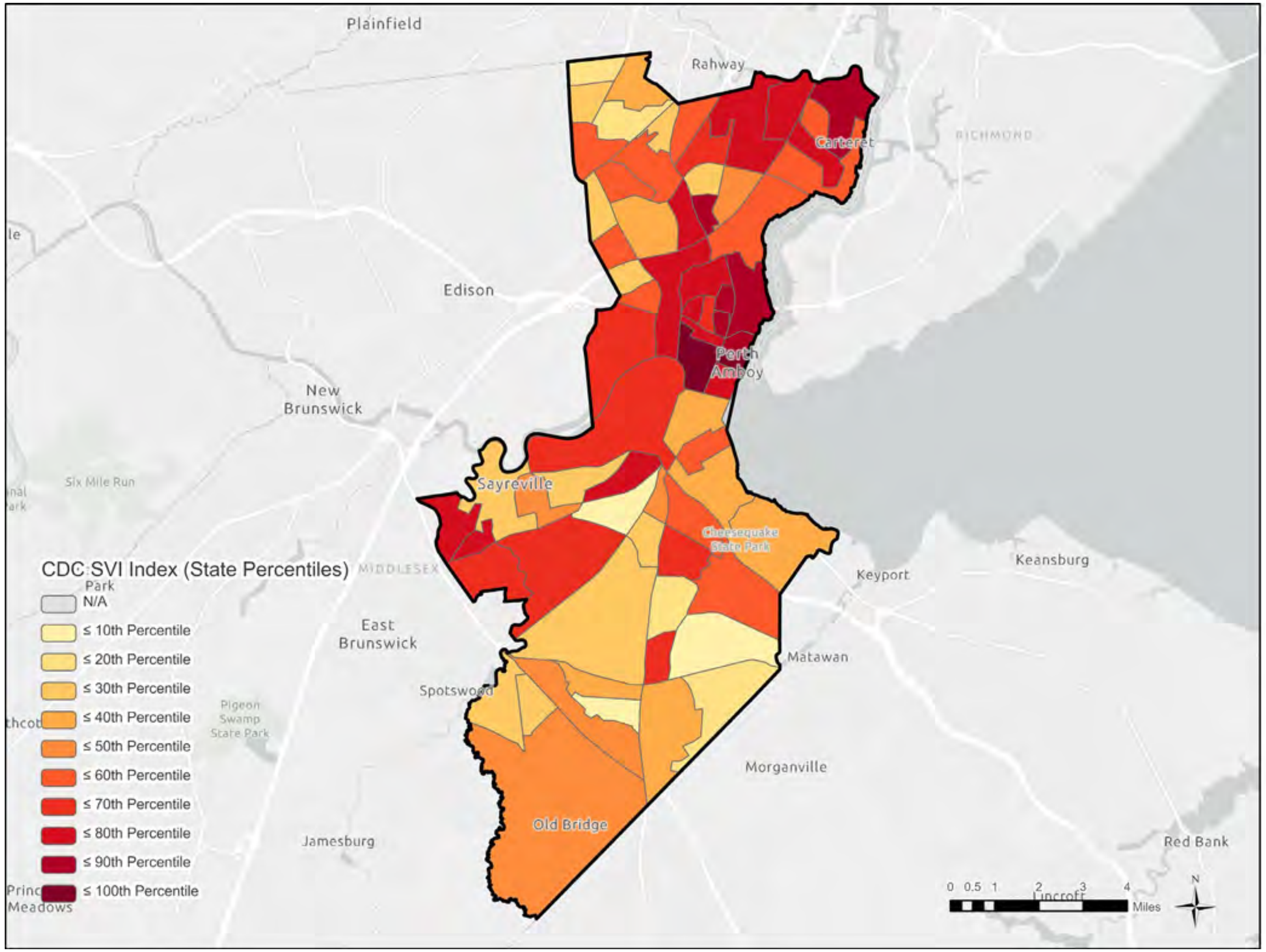
SOCIAL VULNERABILITY

Hazards under an RCP8.5 scenario won't affect everyone equally. Social vulnerability is key to understanding impacts



- A variety of socio-economic factors play a pivotal role in understanding the degree of impact a community or household may experience as a consequence of environmental hazards
- For example, poorer households are less likely to have the resources to adapt to changing and dangerous circumstances—whether by moving to areas less exposed to risk, or to recover from an extreme event
- Higher rates of social vulnerability have often been correlated with factors including wealth, race and ethnicity (as marginalized communities have often been subject to historic inequities and struggle to achieve representation in decision-making processes), English-speaking proficiency, age, and health factors
- The University of South Carolina social vulnerability index (SoVI) produces scores at the county level across the country based on these, and other, factors
- Middlesex County scores relatively low in social vulnerability on aggregate, but has many highly socially vulnerable pockets—especially in more urban areas

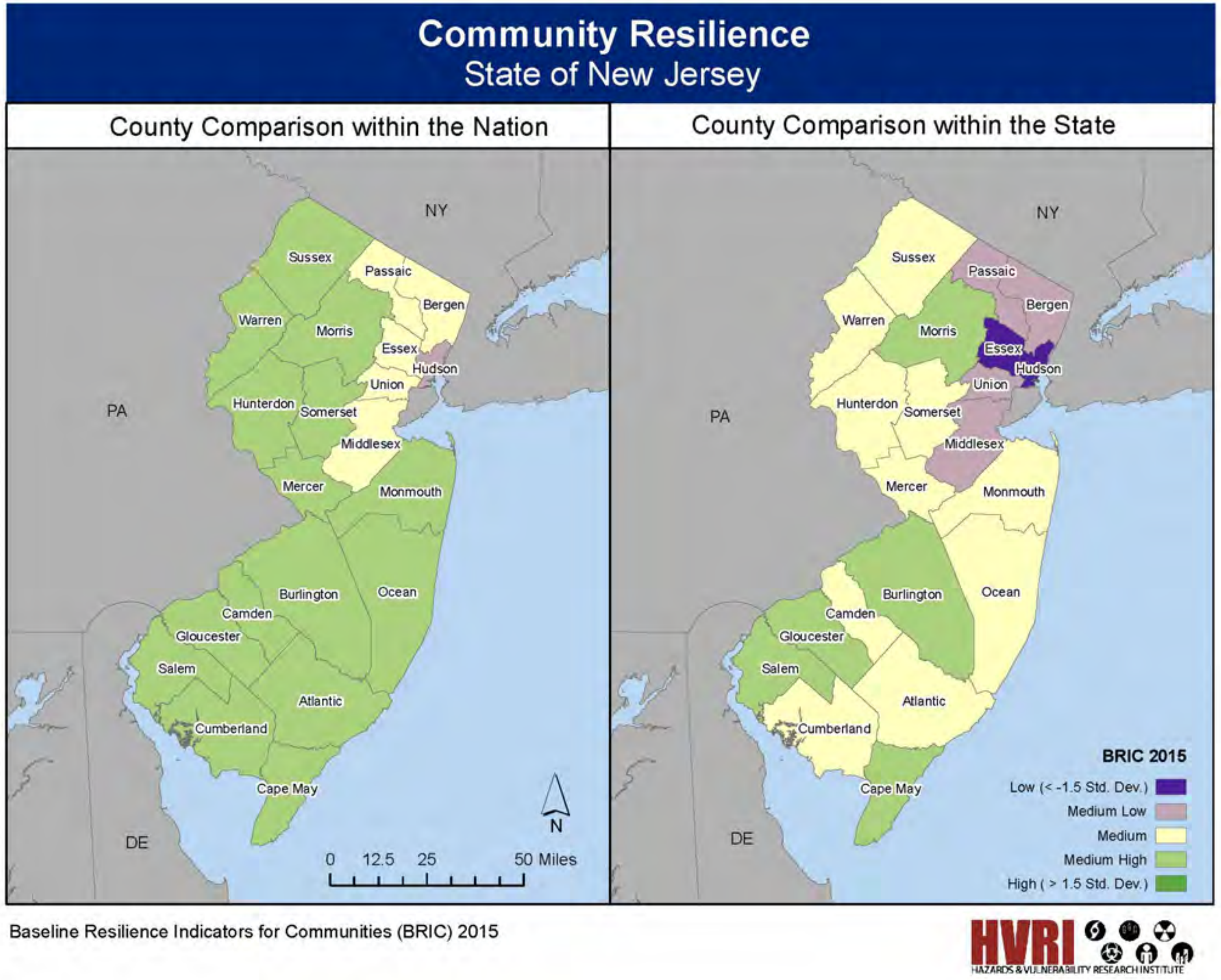
Highly socially vulnerable communities are concentrated in Perth Amboy and Carteret



Source: CDC/ATSDR Social Vulnerability Index (SVI) (2018)

- The CDC produces a social vulnerability index at a more localized scale using census tract-level demographic data
- This index is based on 15 social factors, including poverty level, unemployment, income, high school diploma, age (old and young), disability prevalence, single-parent households, minority status, English proficiency, type of housing, and vehicle ownership
- Census tracts are ranked based on their score compared to other census tracts in the nation. Census tracts in deep red on the map displayed here are amongst the most socially vulnerable census tracts in the country
- Pockets of very high social vulnerability can be found in Perth Amboy and Carteret as well as parts of Sayerville
- These communities are likely to experience the worst impacts from the hazards detailed in the assessment, and they are likely to experience many of them earlier

Higher levels of social vulnerability are correlated with lower levels of community resilience

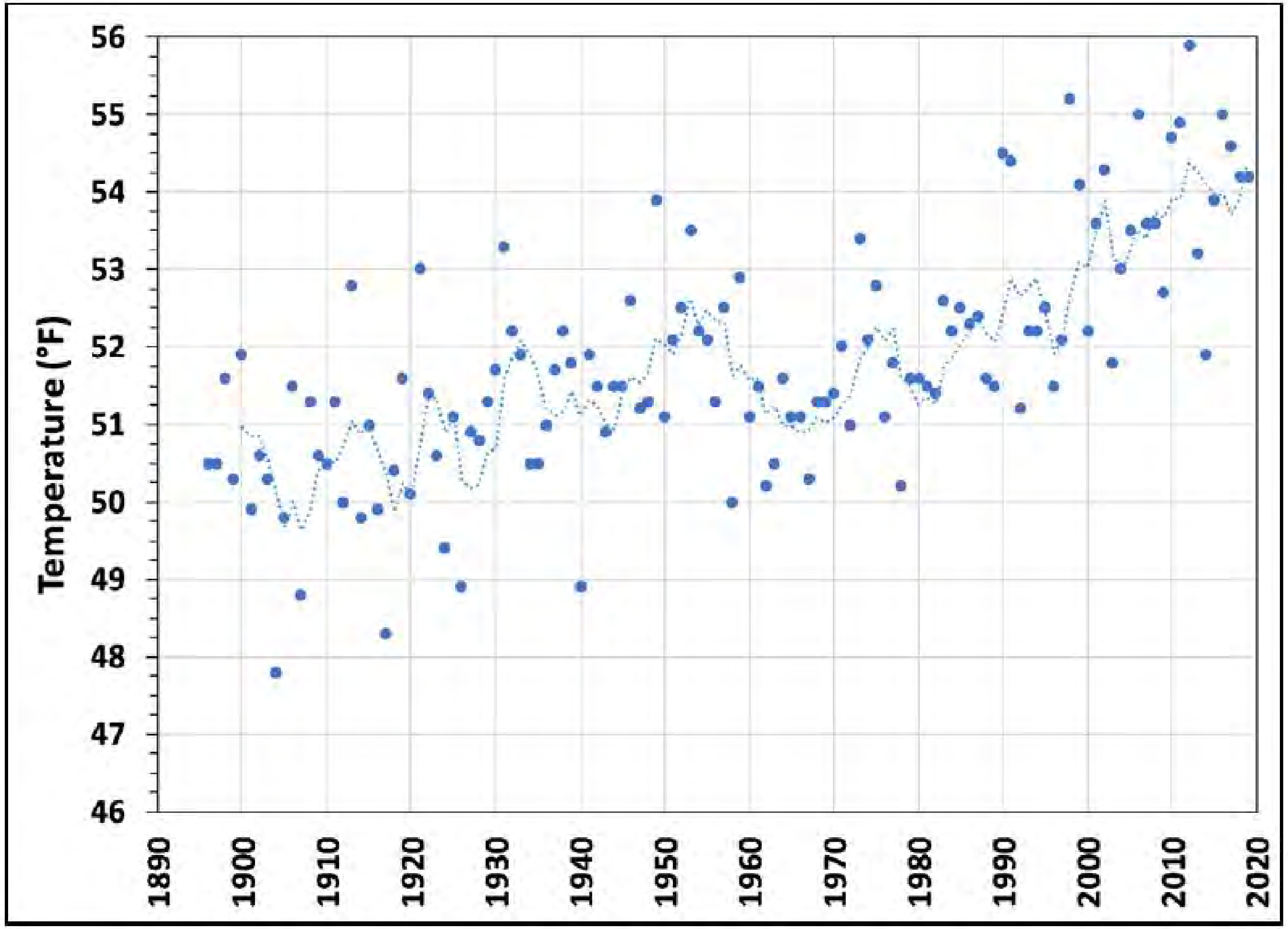


- Middlesex County is considered to have a medium-low community resilience score based on the Baseline Resilience Indicators for Communities (BRIC) scoring system

Source: American Community Survey 5-Year Estimates (2019)

EXTREME HEAT

Since 1895, annual average temperatures in New Jersey have increased by 3.5 degrees F



Source: Office of the New Jersey State Climatologist (2020)

- The graph on the left 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

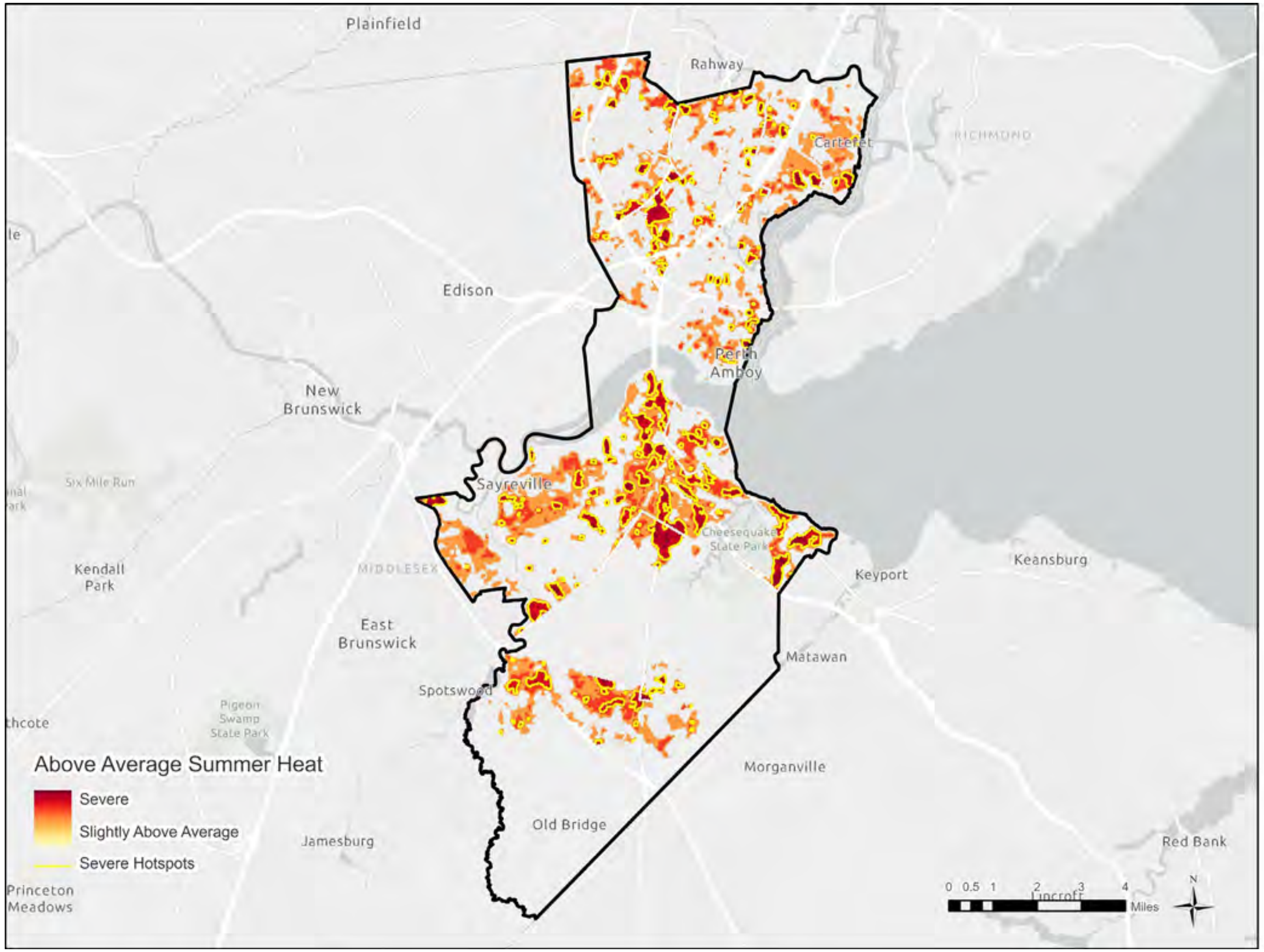
Extreme Heat Hazard

- By the mid-21st century, approximately **70% of summers** in the Northeast are expected to be hotter than the warmest summers to date
- **New Jersey is warming at a faster rate** than the rest of the Northeast region
- Since 1895, annual average temperatures in the state have increased by 3.5 deg F
- In a “business-as-usual” greenhouse gas emissions scenario average summer temperatures in the RRBC region are projected to increase—as high as 9.5 deg F in some areas—by the end of the century
- Parts of the region will see between as many as **69 more days per year** with temperatures rising above 90 deg F, resulting in **more frequent (and intense) heatwaves**, or prolonged periods of extreme heat
    - These heatwaves are increasingly affecting larger areas
- Average **winter temperatures will also increase** in the region—as much as 8.9 deg F in some areas—by the end of the century, resulting in less intense cold waves and reduced snow accumulation
- These hazards are exacerbated by increased urbanization, as large expanses of asphalt and concrete and loss of forests and open spaces can trap heat and pollution due to the **“urban heat island”** effect
    - Parts of the RRBC 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

Future Extreme Heat Impacts

- Increased frequency and intensity of heatwaves will impact the region in multiple ways:
  - Increased incidence of heat stress could result in a **55% increase in heat-related mortalities** 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**, leading to cascading economic impacts
  - 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 a separate section
- Increased annual average temperatures are likely to exacerbate **wildfire risk**, as detailed in a separate section. 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 a separate section
- **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
- Extreme heat can also result in disruption of **critical services** such as power and transportation
  - Prolonged periods of extreme heat can cause **damages to transportation infrastructure** by causing roadway surfaces and rail tracks to soften and expand
  - It can also make waiting for **public transportation potentially dangerous**, if cooling stations and adequate shading is not available
  - Heat waves are also known to cause **blackouts**, as they coincide with peak electricity demand and power plant inefficiencies
  - 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

Above-Average Summer Heat Hotspots (Summer 2021)



Source: The Trust for Public Land (2021)

- Approximately 25% of the total RRBC study area currently experiences above-average summer heat temperatures. These areas are likely to expand and experience more severe and prolonged heat in the future
- Hotspots of especially severe summer heat are especially prevalent in more urbanized and highly developed areas across the study area, including much of Sayreville, Woodbridge proper, pockets of Perth Amboy, southern Carteret, Laurence Harbor, and central and western Old Bridge. Some of these areas, especially parts of Carteret, Perth Amboy, and Sayreville, overlap with areas of high social vulnerability.

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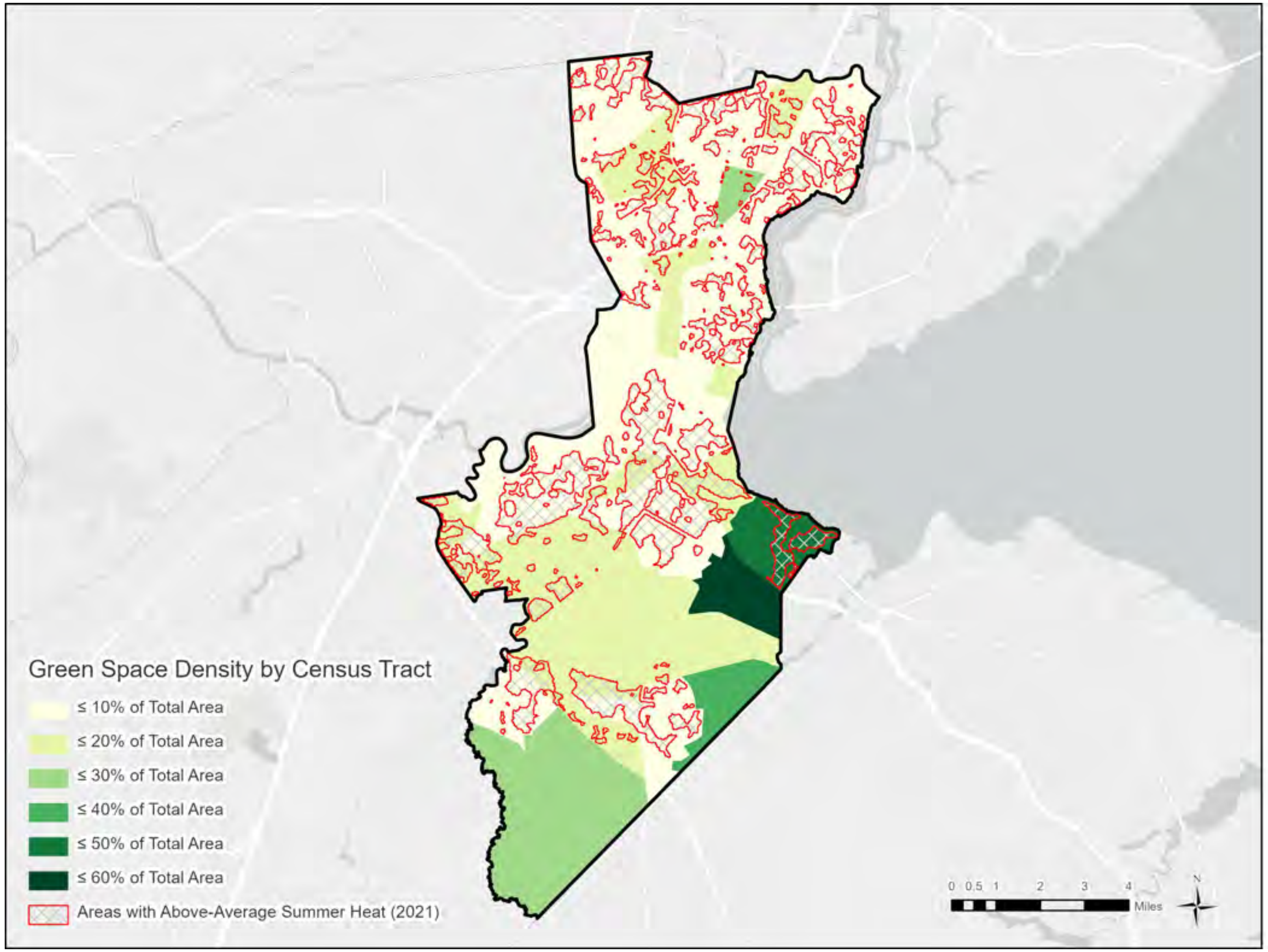
Green Space and High-Heat Areas



Sources: NJDEP Bureau of GIS: State, Local and Nonprofit Open Space of New Jersey (2021), The Trust for Public Land (2021)

- Access to 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
- However, most of the areas currently experiencing above-average summer heat are within census tracts that have a relatively low density of green space, especially in the more urbanized central and northern reaches of the RRBC region

Future Annual Days w/ Heat Index ≥ 90°F

“Business-as-Usual” Scenario (RCP 8.5)

	Historical Simulation (1971-2000 mean)	2010-2039		2040-2069		2070-2099	
Community	**Annual Days**	**Annual Days**	**% Increase**	**Annual Days**	**% Increase**	**Annual Days**	**% Increase**
Carteret	22.8 days	41.5 days	+82.0%	65.8 days	+188.6%	90.9 days	+298.7%
Old Bridge	26.4 days	45.5 days	+72.3%	69.7 days	+164.0%	94.3 days	+257.2%
Perth Amboy	25.5 days	43.2 days	+69.4%	67.2 days	+163.5%	92 days	+260.8%
Sayreville	26.6 days	45.9 days	+72.6%	70.2 days	+163.9%	94.6 days	+255.6%
South Amboy	25.1 days	44.1 days	+99.5%	68.2 days	+171.7%	92.9 days	+270.1%
South River	27.7 days	46.5 days	+67.9%	70.5 days	+154.5%	94.9 days	+242.6%

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

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Future Average Seasonal Temperatures

"Business-as-Usual" Scenario (RCP 8.5)

	Historical Simulation (1971-2000 mean)		2010-2039		2040-2069		2070-2099	
Community	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
Carteret	35 deg F	74.8 deg F	37.9 deg F	77.5 deg F	40.7 deg F	80.7 deg F	43.9 deg F	84.2 deg F
Old Bridge	34 deg F	73.8 deg F	36.8 deg F	76.5 deg F	39.6 deg F	79.8 deg F	42.8 deg F	83.2 deg F
Perth Amboy	34.7 deg F	74.6 deg F	37.6 deg F	77.2 deg F	40.4 deg F	80.5 deg F	43.6 deg F	84 deg F
Sayreville	33.7 deg F	73.8 deg F	36.6 deg F	76.4 deg F	39.4 deg F	79.7 deg F	42.6 deg F	83.2 deg F
South Amboy	34.4 deg F	74.3 deg F	37.2 deg F	77 deg F	40 deg F	80.2 deg F	43.3 deg F	83.7 deg F
South River	33.2 deg F	73.3 deg F	36.1 deg F	75.9 deg F	38.9 deg F	79.2 deg F	42.1 deg F	82.8 deg F

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

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AIR QUALITY

Air Quality

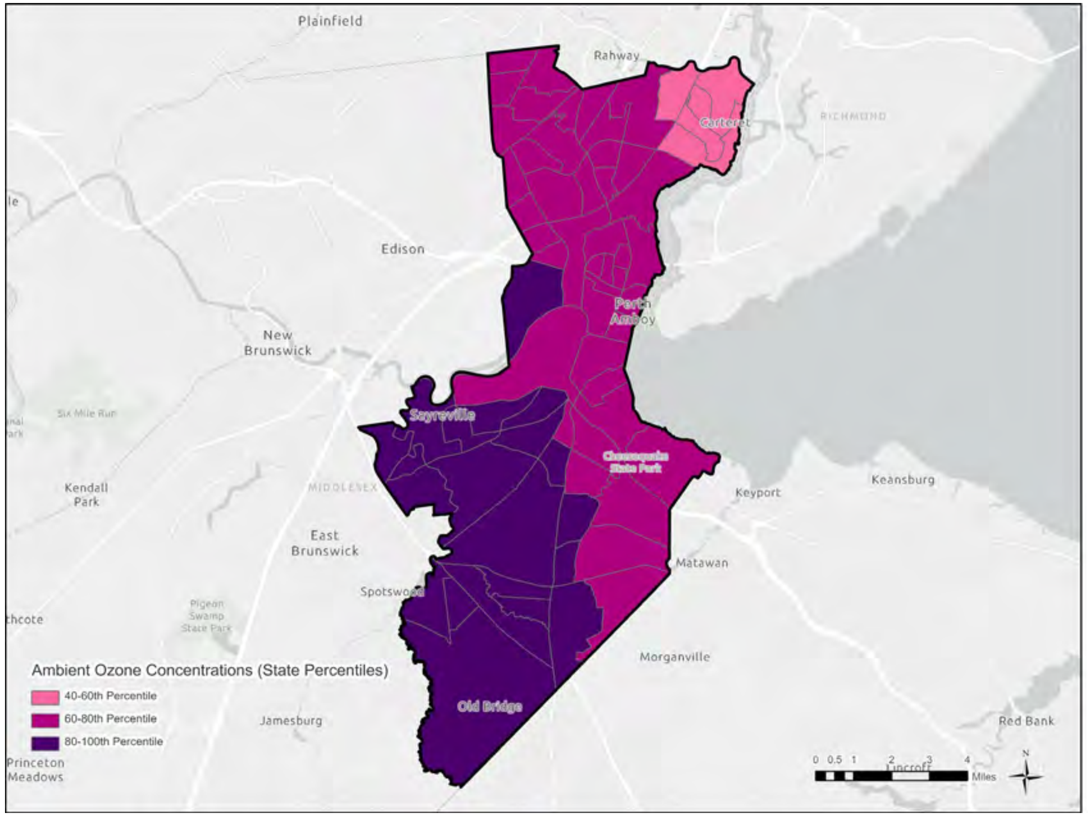
- There are impacts from climate change on ground-level ozone (haze/smog) and PM2.5 (particulate matter, or aerosol) pollution
    - Human-related activities are a major source of both of these types of pollutants
    - High levels of ground-level ozone are caused by a combination of higher temperatures (especially heat waves and urban heat island) and direct human-generated 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 things like sea salt, ash, and organic materials
    - Efforts in reducing air pollution through government regulation have helped
- In the case of temperature, correlations of sulfate, organic carbon (OC), and elemental carbon (EC) are predominantly positive, reflecting the joint association with stagnation and cold front ventilation, and with biogenic and fire emissions.
- Relative humidity (RH) is positively correlated with sulfate and nitrate, which may reflect in-cloud sulfate formation and the RH dependence of ammonium nitrate formation.
- 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 GHG emissions

Negative Air Quality Impacts

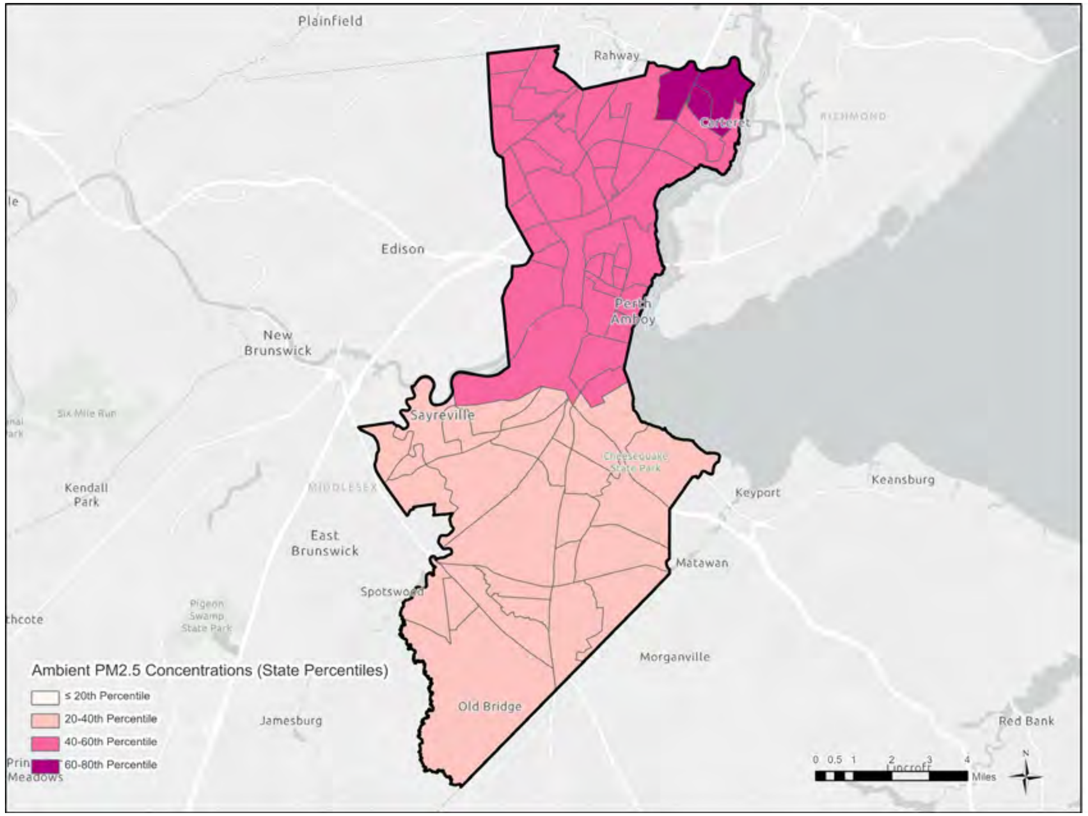
- To the extent that such impacts occur where large numbers of people are exposed, which is more likely to be the case for ozone and pollen than for smoke from wildfires, additional **adverse health effects** can be anticipated.
  - People with existing asthma, allergies, and other respiratory diseases 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 large metropolitan-fringe region of New Jersey that includes Middlesex County, **8.4% of the adult and child populations** 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
- 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

Compared to the rest of the state, RRBC has extremely high ambient ozone concentrations, especially further south

Ambient Ozone Concentrations (State Percentiles)



Ambient PM2.5 Concentrations (State Percentiles)



Source: EPA EJScreen

Note: PM2.5 concentrations are lower relative to the rest of the state but can still pose serious health issues. 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').

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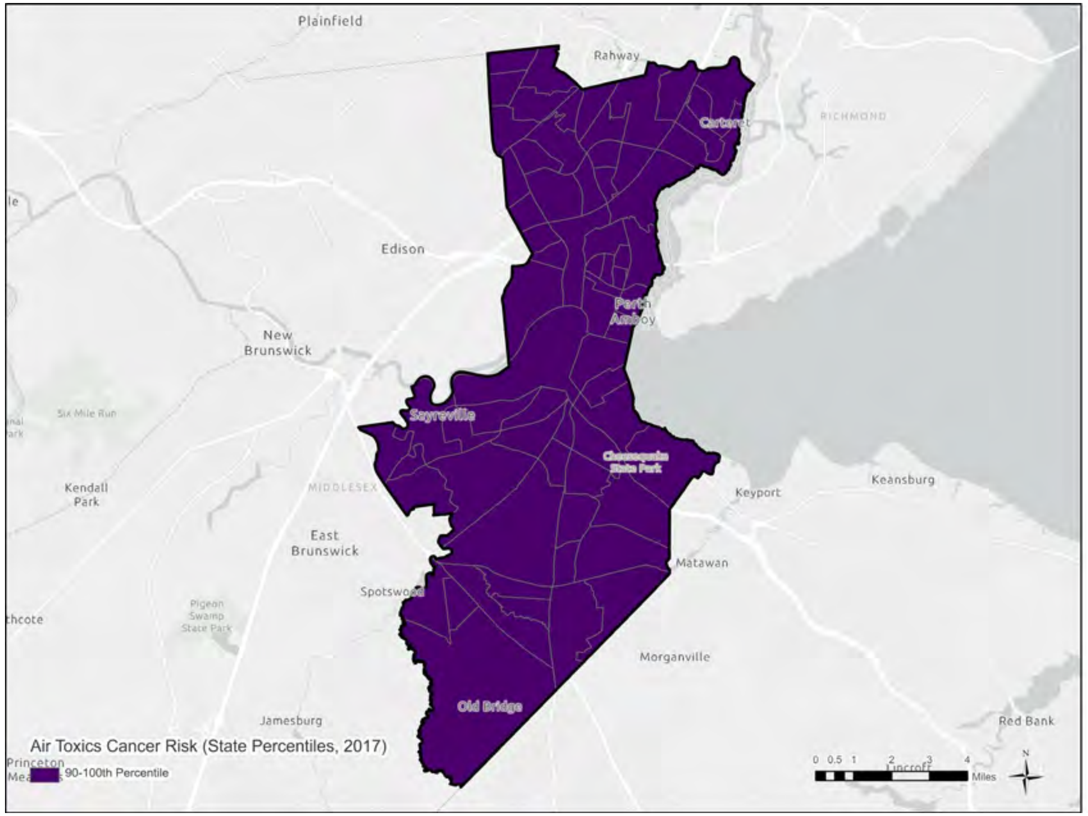
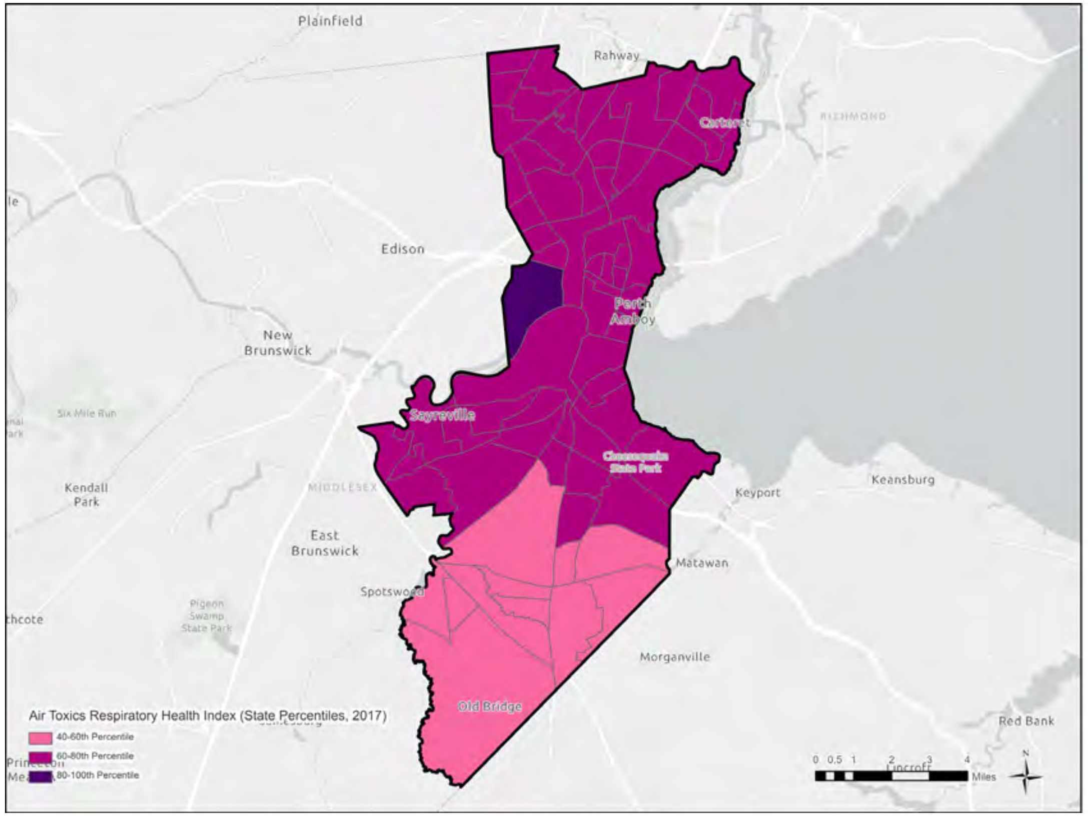
Compared to the rest of the state, the entire RRBC region is at the highest level of risk for cancer due to air toxics. Much of the study area is also at relatively high risk of respiratory health impacts

Air Toxics Cancer Risk (State Percentiles)



Air Toxics Respiratory Health Index (State Percentiles)



Source: EPA EJScreen

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By the 2030s, premature deaths in the Northeast due to ozone-related effects will see a notable increase

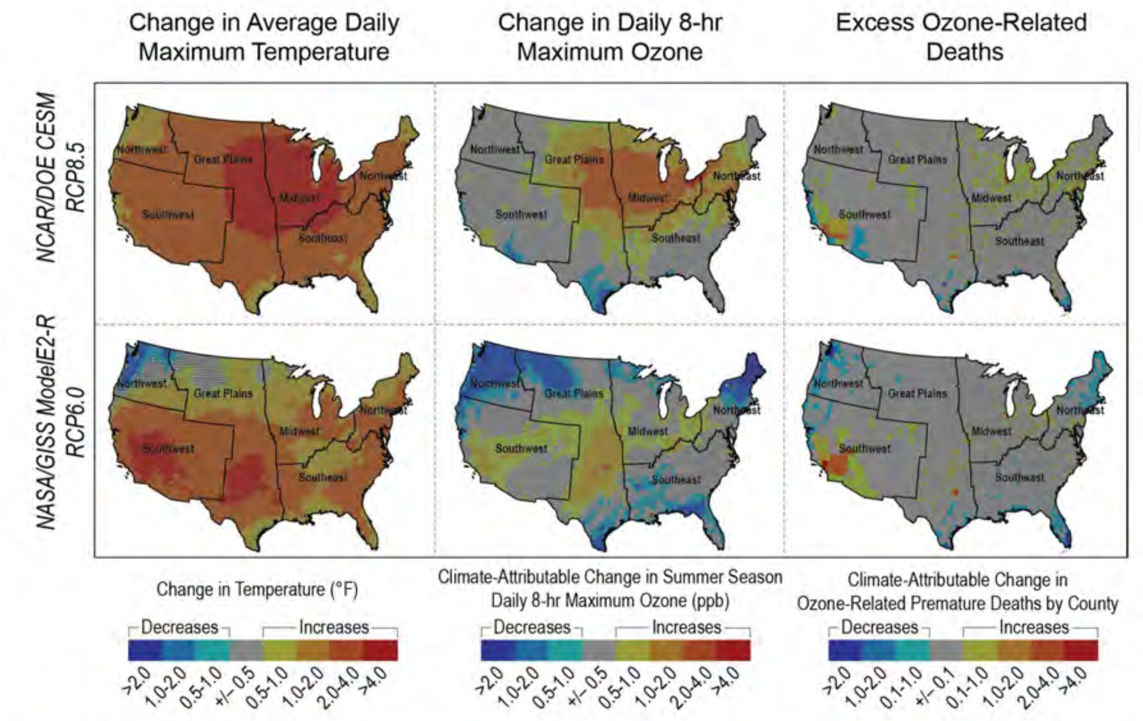
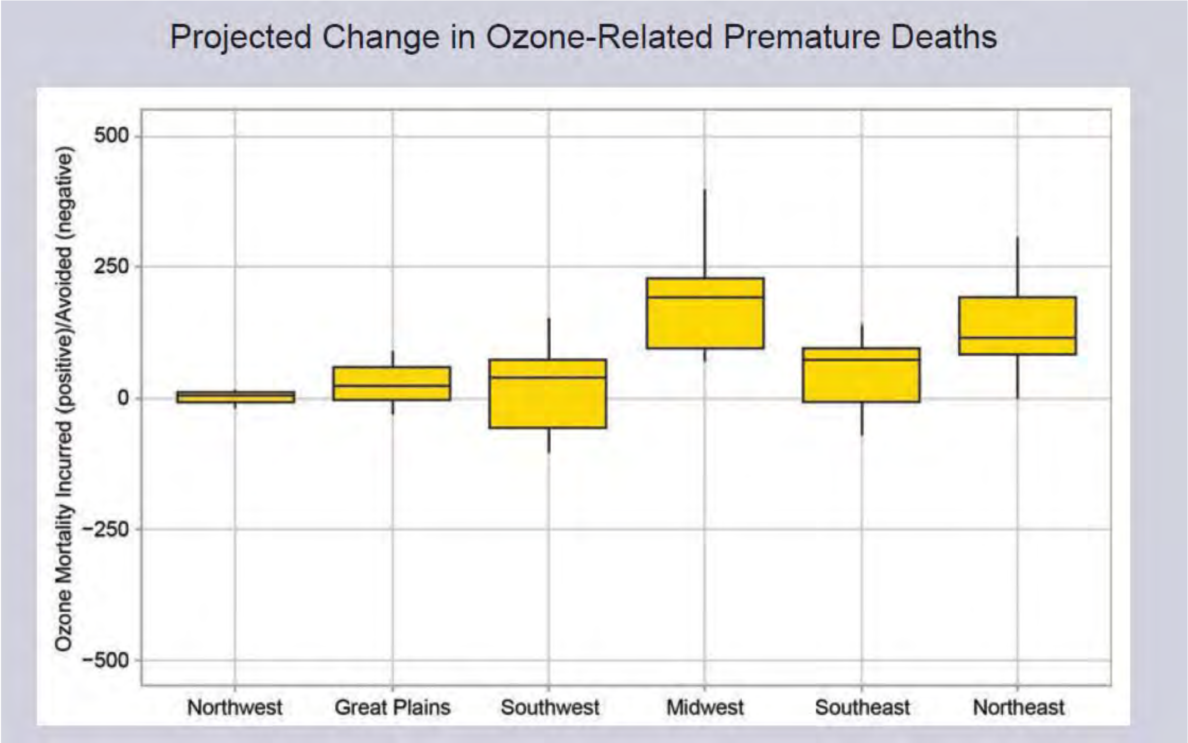


Figure 5.3. Projected Change in Temperature, Ozone, and Ozone-Related Premature Deaths in 2030. Projected changes



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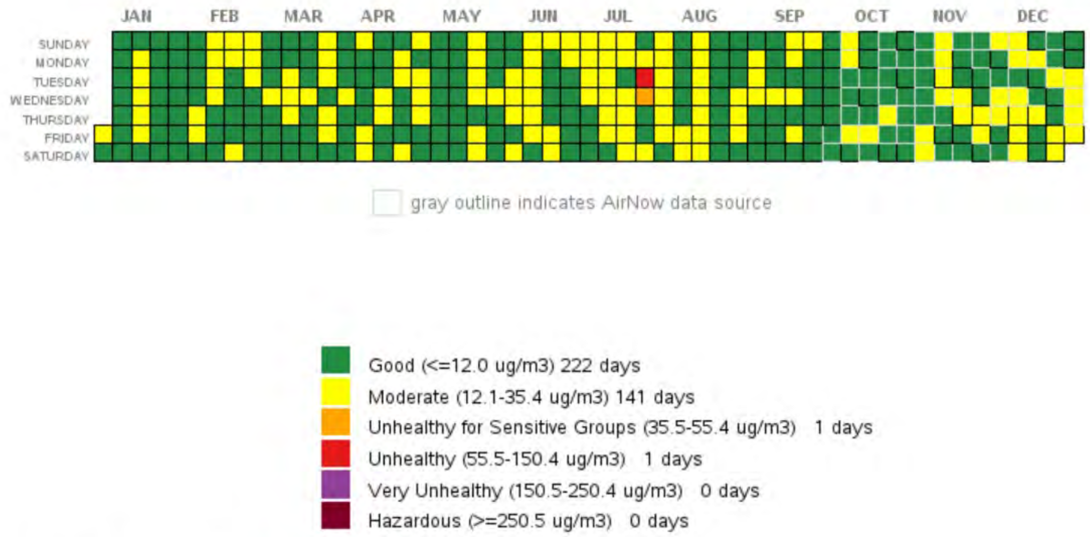
PM2.5

Wildfire Smoke

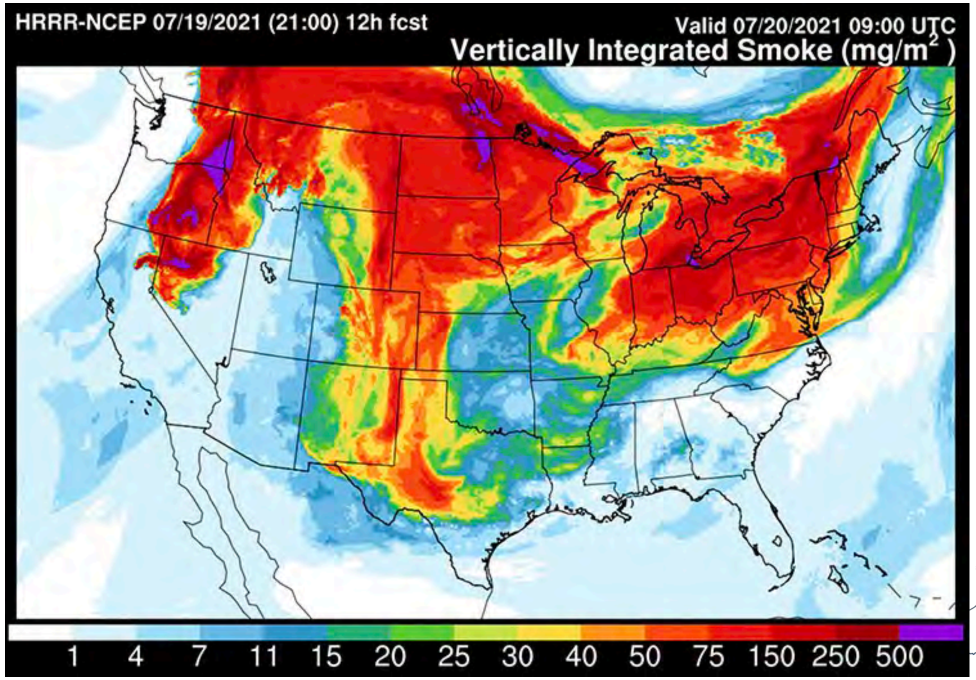
Western wildfires can cause indirect PM2.5 impacts in New Jersey. 2021 is an example of the poor air quality that resulted from a record-breaking fire season. Smoke is caught up in the Jetstream and is transported downstream. Subsidence from high pressure can cause the smoke to settle at the surface

Left: shows number days with Moderate air quality, which may cause issues for people with sensitivities

Right: high resolution forecast of vertically integrated smoke



Source: U.S. EPA AirData <https://www.epa.gov/air-data>
Generated: March 17, 2022



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PM2.5

Impacts of atmospheric variables

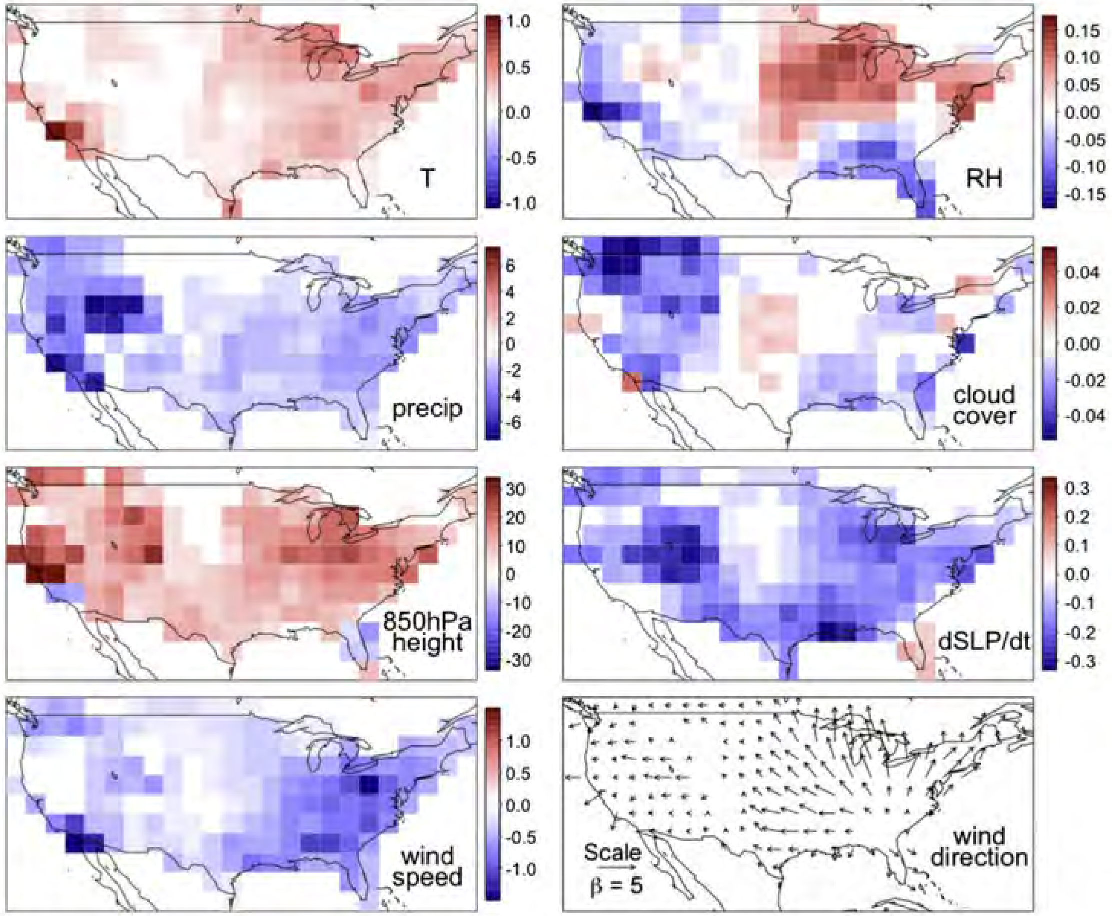


Fig. 4. Correlations of total $PM_{2.5}$ with meteorological variables. Figure shows multiple linear regression coefficients, β_k, in units of μg m^{-3} D^{-1}, where D is dimension of each meteorological variable listed in Table 1. Wind direction panel shows vector sums of regression coefficients β_8 and β_9. Values are for deseasonalized and detrended variables and are only shown when significant with 95% confidence (p-value < 0.05).

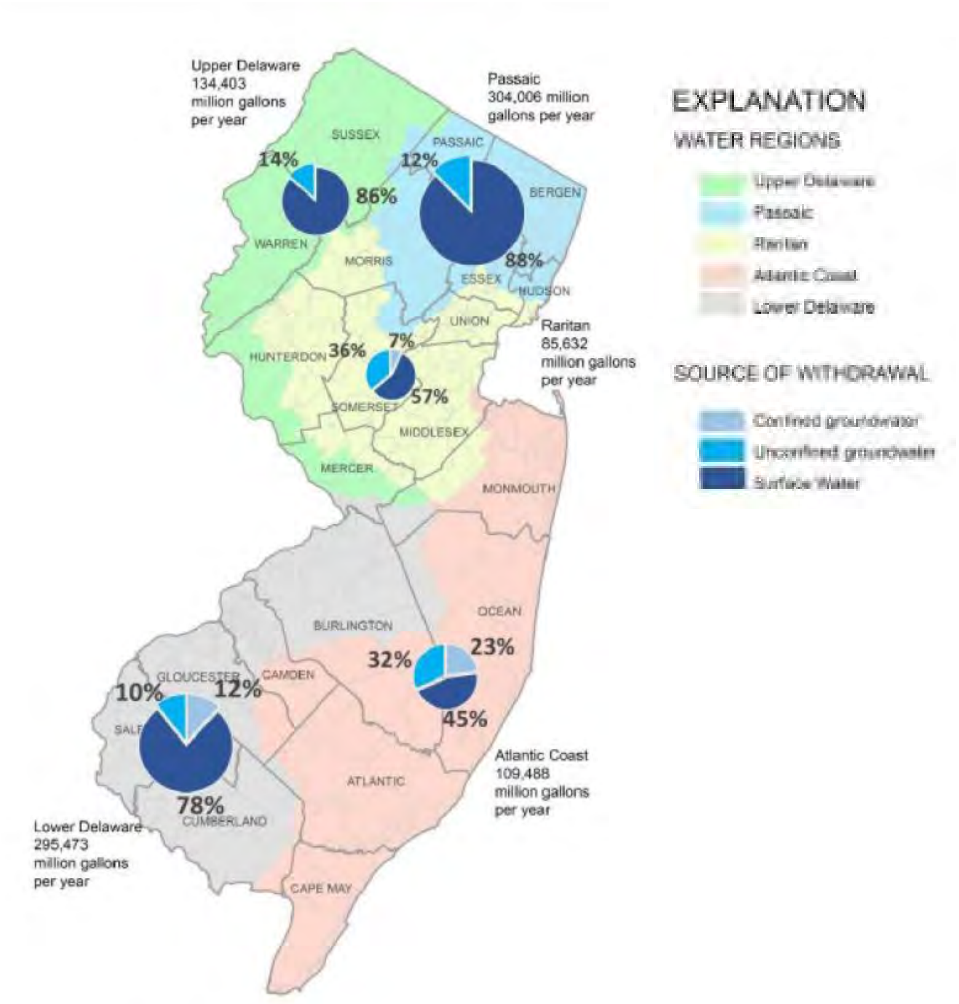
RARITAN RIVER AND BAY COMMUNITIES

DROUGHT & WATER SUPPLY

Drought Hazard & Stressed Water Supply

- Throughout the Northeast, it is anticipated that **droughts lasting 3-6 months or longer** will significantly increase in frequency under a “business-as-usual” emissions scenario, and increase slightly in a low emissions scenario
- 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 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 Post-Tropical Cyclone Ida
    - However, **dry periods** between these more intense rainfall events—especially in the hotter summer months—**are likely to increase**, leading to **increased 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 has experienced notable reductions in snow pack since 1970, causing peak streamflow to being 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
- 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
- RRBC, being primary within the Raritan water region, draws its water supply from a mix of **surface and unconfined groundwater sources**. Municipalities relying more on surface water will feel the impacts of drought more immediately
- 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
- In the future, the region may turn **increasingly toward groundwater** for its water supply as surface water sources struggle to maintain necessary capacity. This could lead to higher rates of groundwater pumping with implications for **water quality**

Drought & Stressed Water Supply Impacts



Source: NJDEP 2017

- As temperatures become warmer, **demand for water** will increase. Combined with drought-generated changes in streamflow and discharge, this could lead to **water supply shortages**, especially during times of drought
- **Surface water reservoirs**—which account for approximately 57% of water supply in the region—will dry out more quickly than groundwater. However, as increased incidence of drought threatens surface water supply, RRBC may come to increasingly rely on **groundwater**
- A shortage of potable water could generate serious **public health impacts**, including higher incidence of heat-related illness, waterborne diseases, recreational risks, limited food availability, and reduced living conditions—all exacerbated by indicators of social vulnerability such as age or limited ability to seek essential resources
- Water supply shortages could also impact critical utilities such as **power generation and availability**
- 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 pose a significant risk to water quality
  - **Saltwater intrusion** into aquifers, associated with sea level rise, will further limit the capacity of groundwater to serve as an adequate alternative to surface reservoirs—especially in areas where wells are over-pumped

Future Drought Indicators

“Business-as-Usual” Scenario (RCP 8.5)

Higher incidence of drought is likely to be correlated with drier soil conditions. While projections on this are scarce, lower future summer humidity and higher rates of evapotranspiration can be considered proxies.

	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)**
Carteret	-0.4%	+1.3 inches	-1.4%	+2.6 inches	-2.3%	+3.9 inches
Old Bridge	-0.5%	+1.2 inches	-1.4%	+2.5 inches	-2.3%	+3.7 inches
Perth Amboy	-0.4%	+1.2 inches	-1.4%	+2.5 inches	-2.3%	+3.8 inches
Sayreville	-0.5%	+1.2 inches	-1.4%	+2.5 inches	-2.4%	+3.7 inches
South Amboy	-0.4%	+1.2 inches	-1.4%	+2.5 inches	-2.4%	+3.8 inches
South River	-0.5%	+1.2 inches	-1.4%	+2.5 inches	-2.3%	+3.7 inches

Site-specific annual multi-model mean derived from 20 downscaled CMIP5 (Climate Model Intercomparison Project) models.
Source: https://climate.northwestknowledge.net/MACA/tool_summarymaps2.php
“High” fire danger days are defined as days with 100-hour fuel moisture below 20 percentile, and “extreme” the same below 3 percentile

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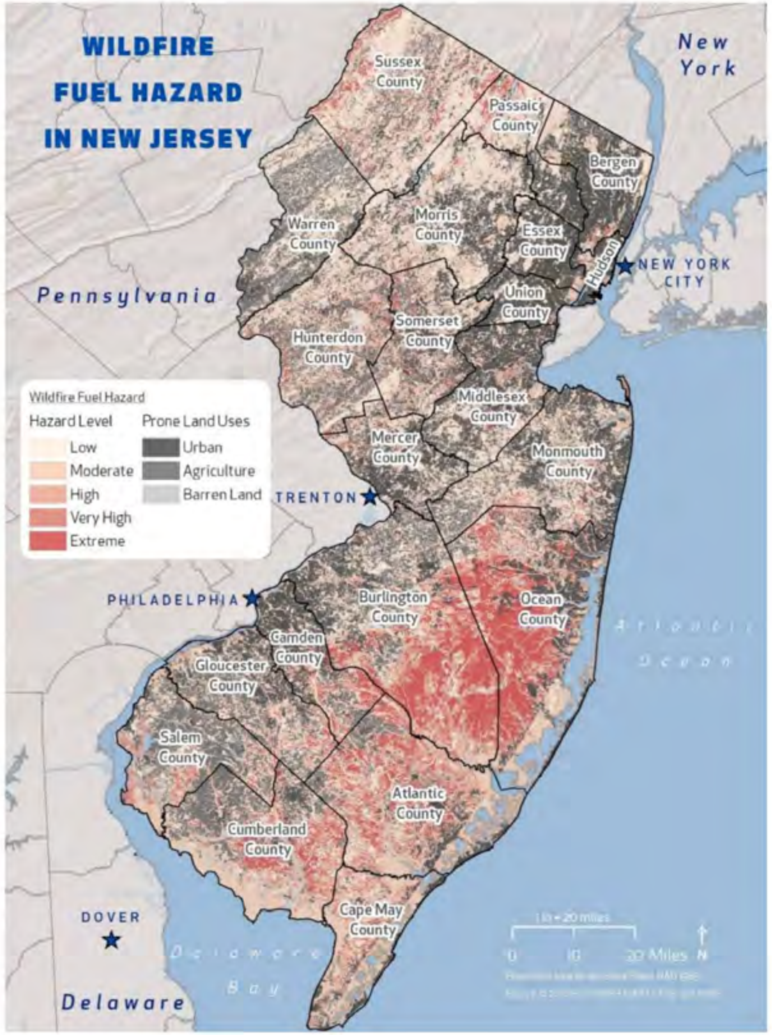
WILDFIRE RISK

Wildfire Hazard



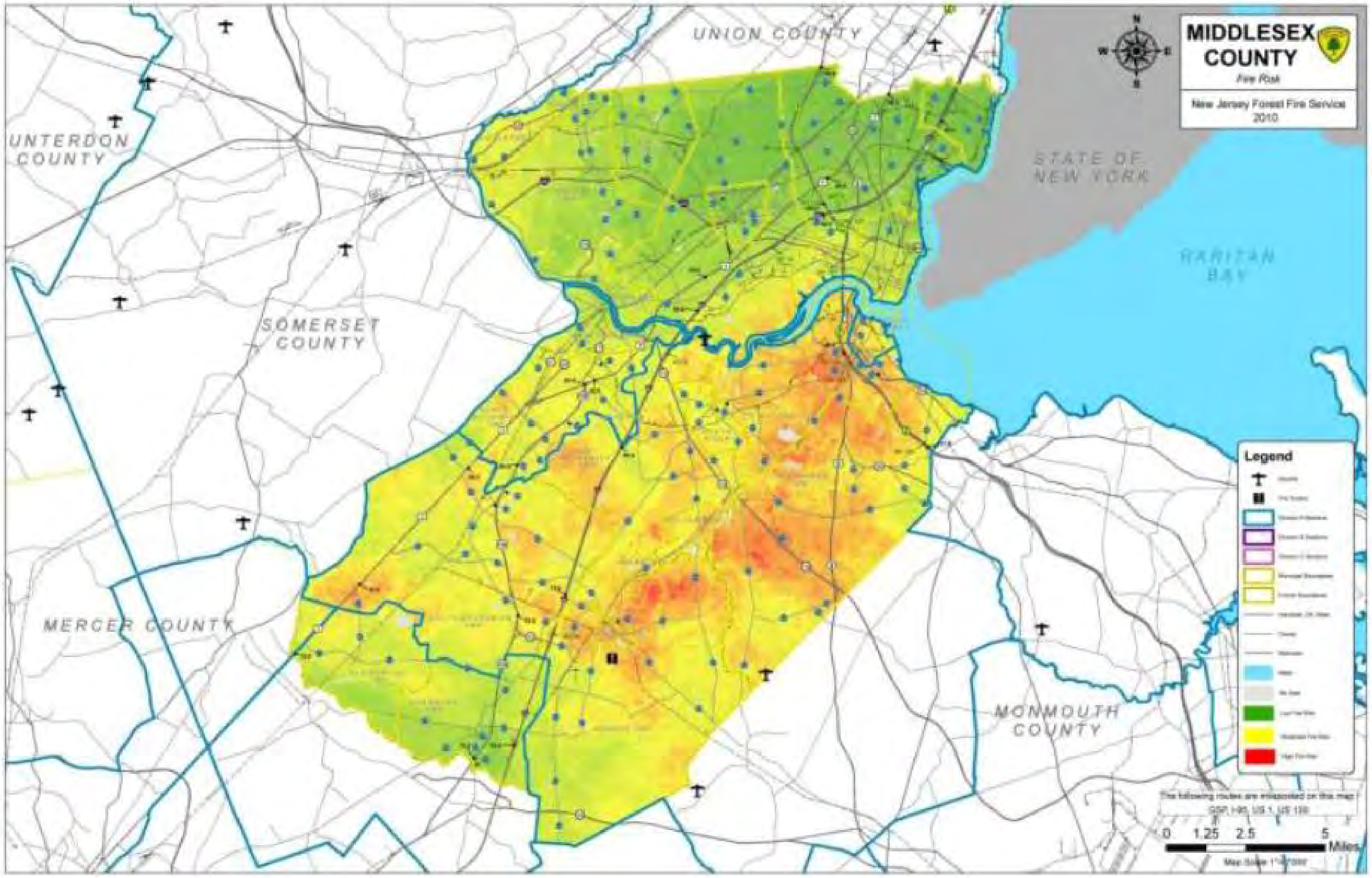
Source: State of New Jersey All Hazard Mitigation Plan (2019)

- 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
  - As more of New Jersey's population expands into rural areas, wildfires are more likely to be triggered and will expose a greater number of people
- Projected higher temperatures and increased frequency of drought are likely to **increase the length of the wildfire season** in New Jersey in the future
  - Increased frequency and severity of extreme weather events will increasingly **disrupt tree growth and regeneration**, which can alter the wildfire landscape
  - 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
- Although wildfires are more common in more heavily forested parts of the state, **urban areas** provide a significant amount of **wildfire fuel** with high concentrations of buildings. Therefore, some pockets of urban areas—especially those at the interface of wildlands—can face surprisingly high levels of wildfire risk

Wildfire Impacts

- Wildfires can lead to **loss of life** as well as the **destruction of forests, brush, grasslands, field crops, and public and private property**
  - Wildfires can also threaten **critical facilities** with potentially major impacts to transportation and/or utility services
- Large-scale fires can 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
  - Wildfires can also increase the incidence of damage from **debris** from flash floods and mudflows that may follow
- Wildfire **smoke** also has serious implications for **air quality**
  - Even higher levels of wildfire risk as close as southern New Jersey (the Pine Barrens region) or **as far away as western US and Canada** can negatively impact northern New Jersey’s air quality as smoke is carried upwind across vast distances

In the RRBC study area, the area around Cheesequake State Park in Old Bridge is at especially high levels of wildfire risk



Carteret
- 3.8% of total land in low hazard area, 8.2% in moderate, 6% in high, 1.6% in very high, 0% in extreme

Old Bridge:
- 38% of total land in low hazard area, 10.1% in moderate, 5.4% in high, 1% in very high, 5.9% in extreme

Perth Amboy
- 4.9% of total land in low hazard area, 3.2% in moderate, 5.1% in high, 0% in very high, 0% in extreme

Sayreville:
- 13.68% of total land in low hazard area, 11% in moderate, 8.9% in high, 4.8% in very high, 0.7% in extreme

South Amboy
- 4.3% of total land in low hazard area, 4.4% in moderate, 7.6% in high, 0% in very high, 0% in extreme

South River:
- 11.7% of total land in low hazard area, 3.6% in moderate, 5.3% in high, 4% in very high, 0% in extreme

Source: New Jersey Forest Fire Service (2010), Middlesex County HMP (2016)

Future Summer Fire Danger Days

“Business-as-Usual” Scenario (RCP 8.5)

	Historical Simulation (1971-2000 mean)		2010-2039		2040-2069	
Community	**“High” Danger**	**“Extreme” Danger**	**“High” Danger**	**“Extreme” Danger**	**“High” Danger**	**“Extreme” Danger**
Carteret	18.4 days	1.7 days	21.1 days	2.7 days	25.1 days	4.1 days
Old Bridge	16.6 days	1.2 days	19.2 days	2 days	23.4 days	3.1 days
Perth Amboy	18 days	1.6 days	20.6 days	2.5 days	24.6 days	3.9 days
Sayreville	17.1 days	1.2 days	19.8 days	2.1 days	24 days	3.2 days
South Amboy	18 days	1.5 days	20.7 days	2.4 days	24.8 days	3.7 days
South River	16.5 days	1.1 days	19.3 days	1.9 days	23.5 days	2.9 days

Site-specific annual multi-model mean derived from 18 downscaled CMIP5 (Climate Model Intercomparison Project) models.
Source: https://climate.northwestknowledge.net/MACA/tool_summarymaps2.php
“High” fire danger days are defined as days with 100-hour fuel moisture below 20 percentile, and “extreme” the same below 3 percentile

RARITAN RIVER AND BAY COMMUNITIES

GROUNDWATER

Groundwater Rise

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

Residents:

- Increased basement flooding
- Septic systems fill up

Municipalities:

- Higher corrosion rates of buried infrastructure
- Reduced storm water and wastewater system capacity
- Soil instability
- Soil contaminant mobilization
- Groundwater emergence and flooding
- Remobilization of contaminants into wastewater treatment facilities

Groundwater Rise

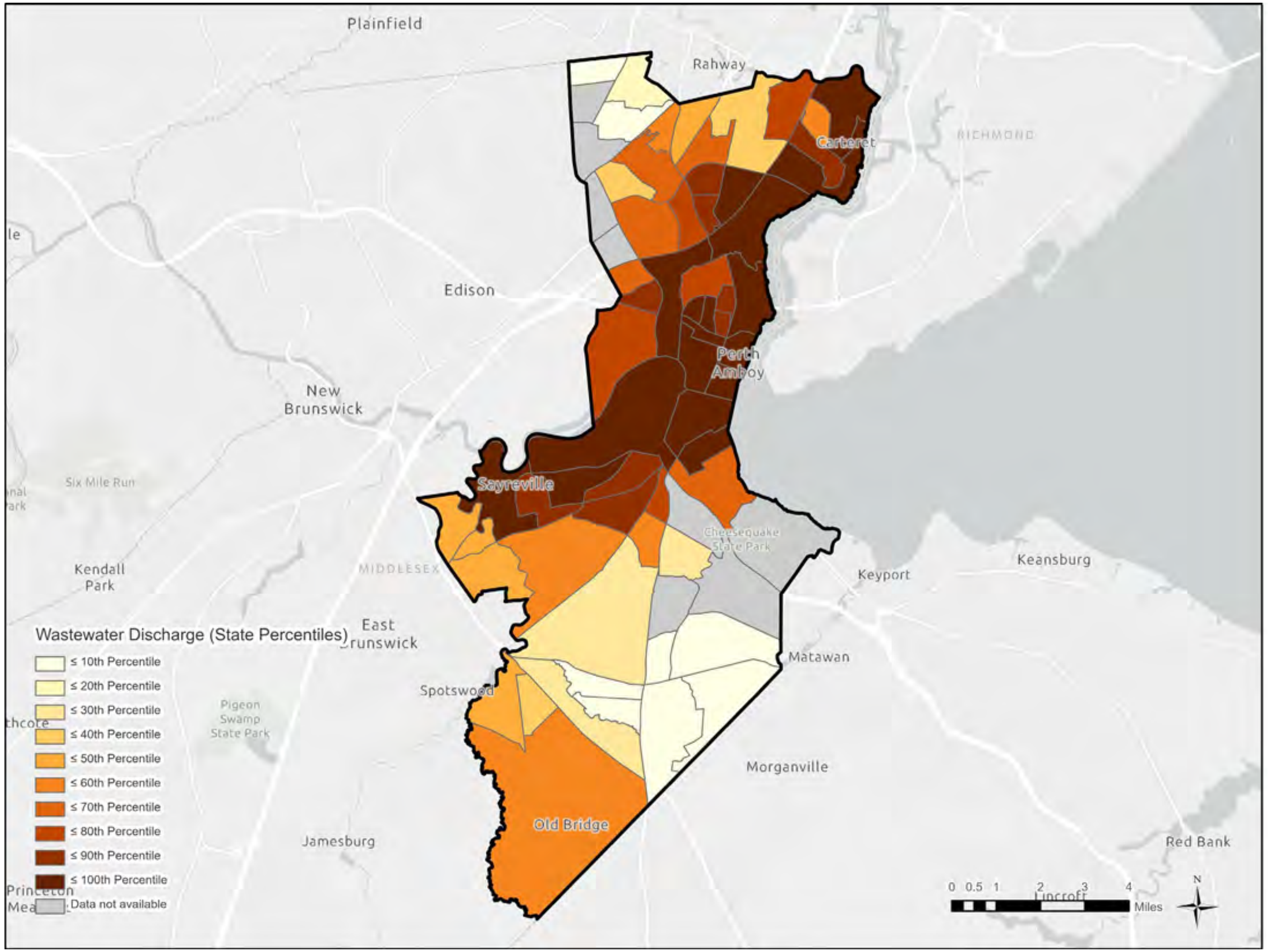
- The leading edge of the groundwater rise will be just ahead of that shown on coastal inundation maps
- Accounting for future sea level rise further extends the area of concern. There are very few data points for fluctuating groundwater—it's a costly process
- Rising groundwater levels will exacerbate the effects of several other climate change-generated processes, including:

Drought

Extreme Precipitation

Strained Water Supply

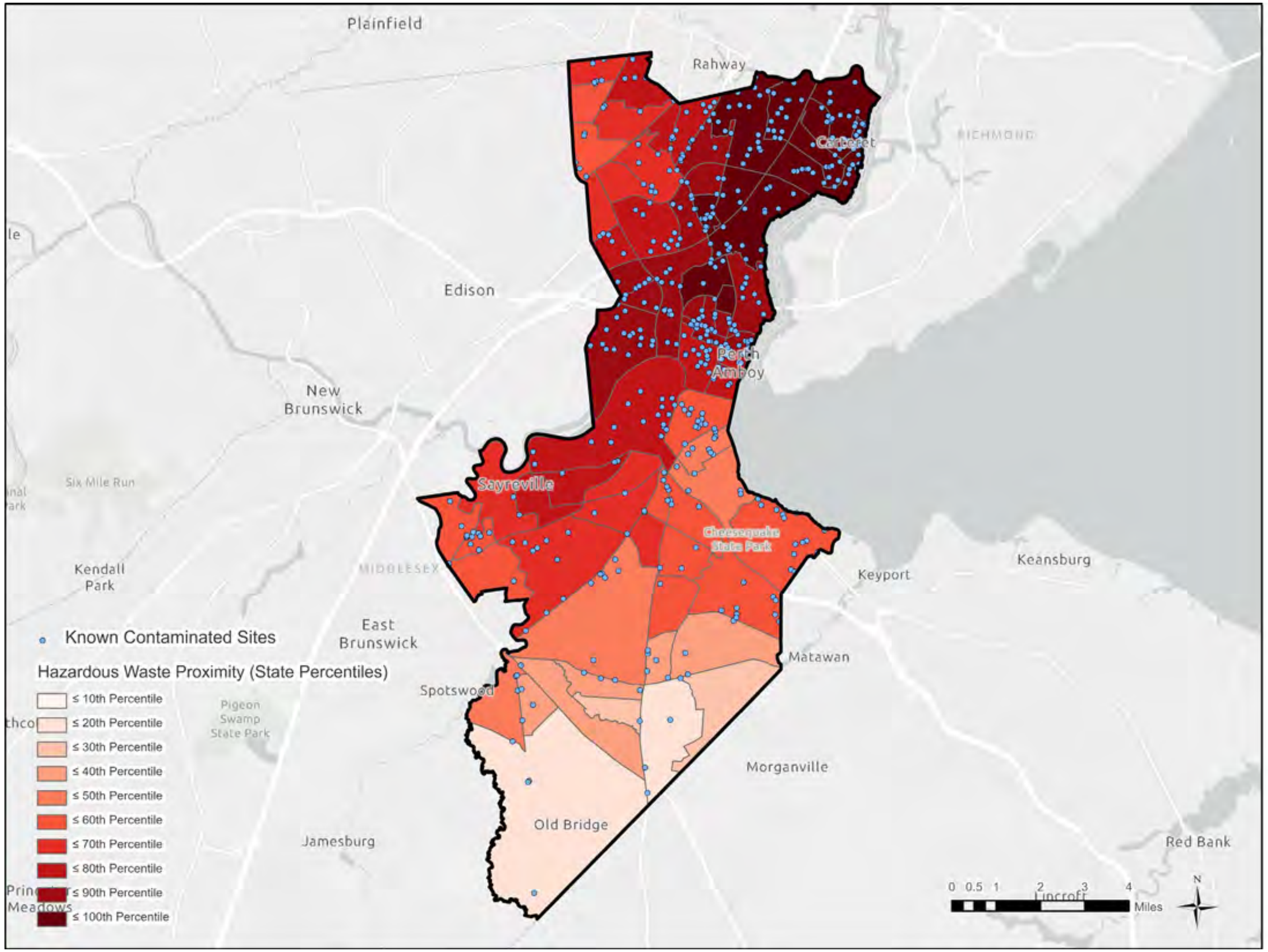
Areas of high wastewater discharge and shallow groundwater will increasingly be at risk of groundwater contamination



Source: EPA EJScreen

- Studies show that surface water carrying effluent can transport wastewater contaminants into shallow groundwater systems, even a great distance from wastewater treatment outfalls. This risk is likely to increase in areas where to depth-to-groundwater is decreasing due to sea level rise
- This could pose a risk of mobilization of contaminants into soils and water supply, especially as the region comes to increasingly rely on groundwater for drinking water with increased incidence of drought
- RRBC has some of the highest concentrations of wastewater discharge in the state, especially in Perth Amboy, Carteret, and Sayreville. Many of these areas are also highly socially vulnerable

Communities in northern RRBC—especially Carteret—have very high proximity to hazardous waste compared to the rest of the state



Sources: EPA EJScreen, NJDEP

- According to the EPA these sources include industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids gases, and sludges
- Rising sea and groundwater levels can disrupt these sources of pollution and spread the hazard away from the site

Saltwater Intrusion

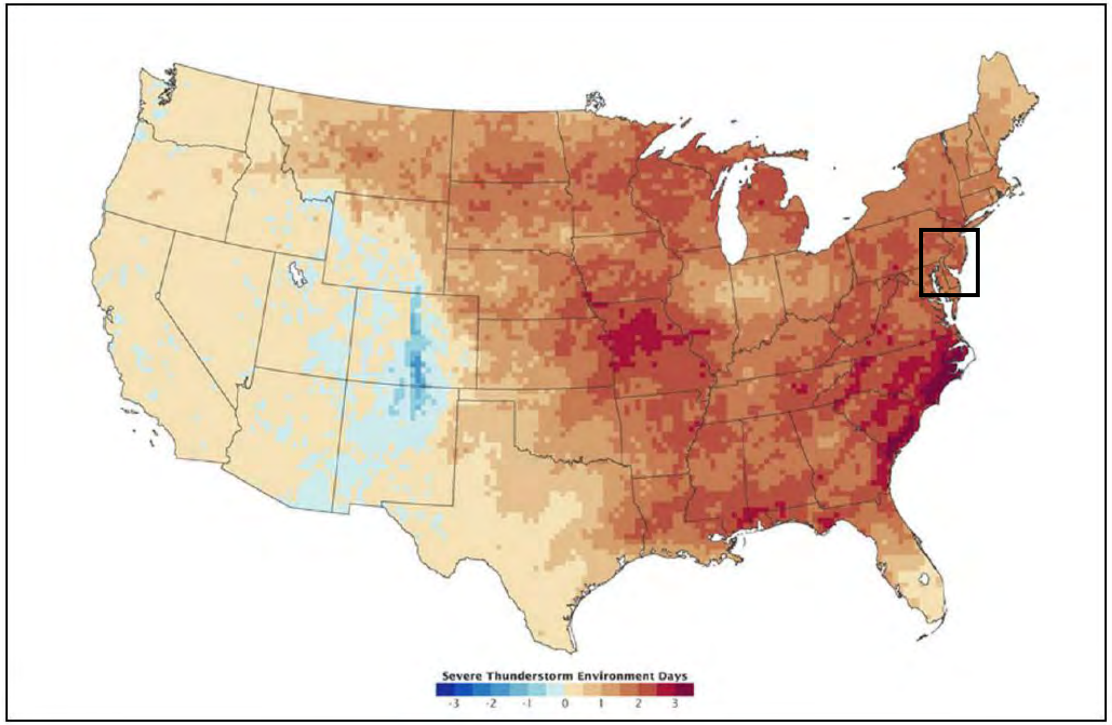
- Additionally, as groundwater levels rise, saltwater from the ocean can seep into aquifers near the coast—a process known as saltwater intrusion
- Saltwater intrusion poses multiple risks, including:
  - Speeding up the **corrosion of infrastructure**
  - Increasing **chloride levels** in drinking water. The World Health Organization suggests a safe level of chloride of 250 mg/L, but this is largely non-enforceable.
  - **Damaging ecosystems** in low-lying areas as soils become too salty to support crops and trees
- Potential **health-related impacts** of saltwater intrusion include:
  - Health impacts to pregnant women
  - Infant mortality
  - Hypertension
  - Triggering heavy metals in pipes to enter solution

Note: Fortunately, most drinking water sources in region don't come from groundwater. However, as increased incidence of drought threatens surface water supply, RRBC may come to increasingly rely on groundwater

SEVERE WEATHER

Severe Weather – Hazard

Figure 4.3.8-6. Predicted Change in Severe Thunderstorm Environment Days from the 1962-1989 Period to the 2072-2099 Period



Source: *Trapp et. al. 2007*

- There is **considerable uncertainty** around the future of severe weather events—such as tropical storms and hurricanes, tornadoes, severe lightning storms, hailstorms, and blizzards
- 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 in 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**. However, 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 and tornadoes**
    - As shown on the left, a 2007 study predicts an **annual increase of 1-2 severe thunderstorm environment days** in the region by the end of the century

Severe Weather – Impacts

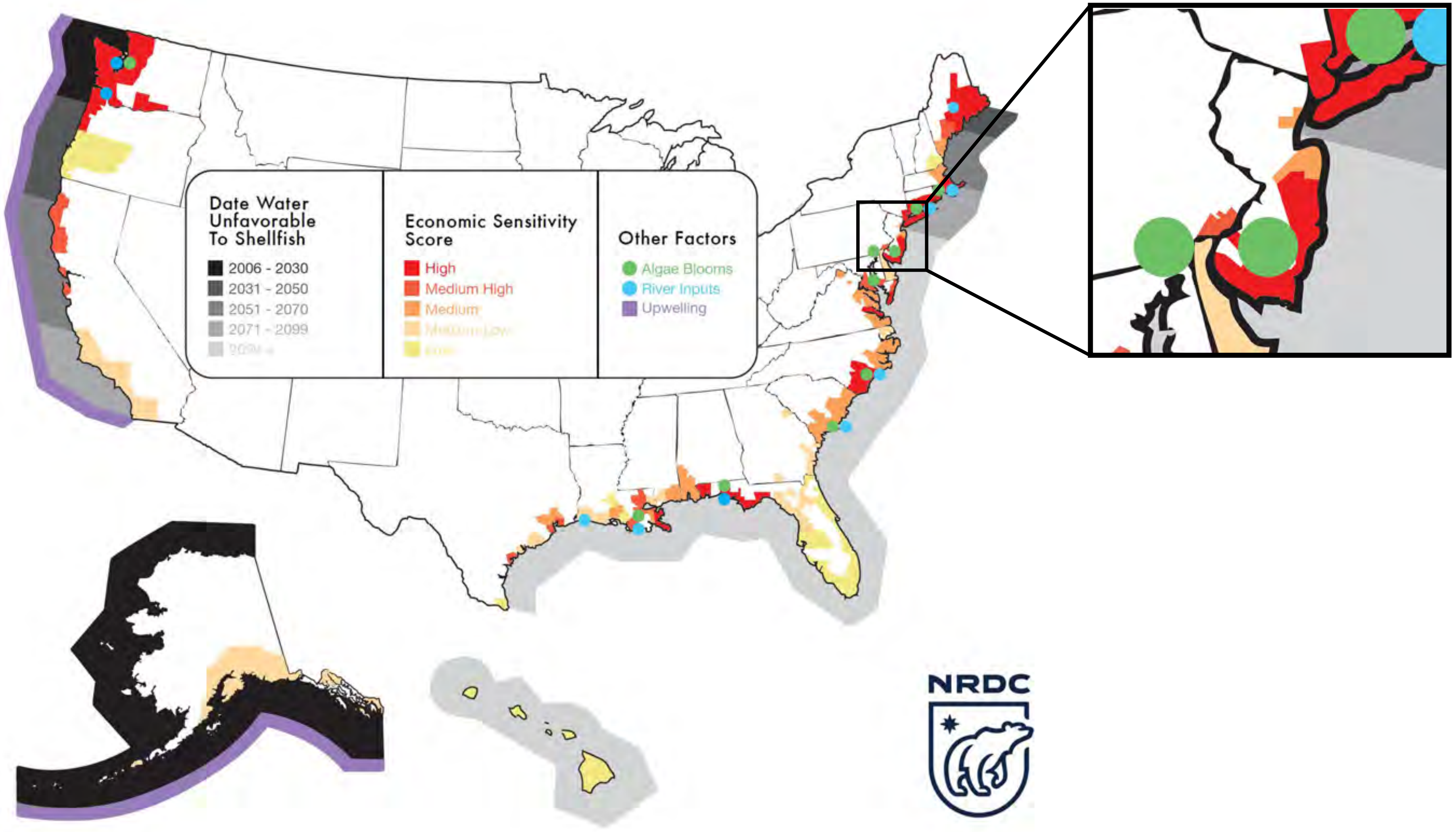
- **Residential buildings** are especially vulnerable to extreme wind events, due to greater use of wood and masonry in construction
  - **Mobile homes**—common across various parts of Middlesex County—are amongst the most vulnerable structures
  - Middlesex County is at a **moderate to high risk of high wind** effects from hurricanes and tropical storms
- Critical facilities may also sustain damage as a result of high wind events
  - 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 events or tornadoes pose an additional 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** due to salt application, and health risks—especially to **homeless and poor populations** lacking access to housing, proper insulation, or adequate heating

OCEAN ACIDIFICATION

Ocean Acidification

- 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 GHG emissions, pH levels are projected to drop another 0.3-0.4 pH to a level of 7.7-7.8 by the end of the century—**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 2/3rds 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
- Negative impacts to these ecosystems is also likely to **reduce natural protection from coastal storm surge and erosion**

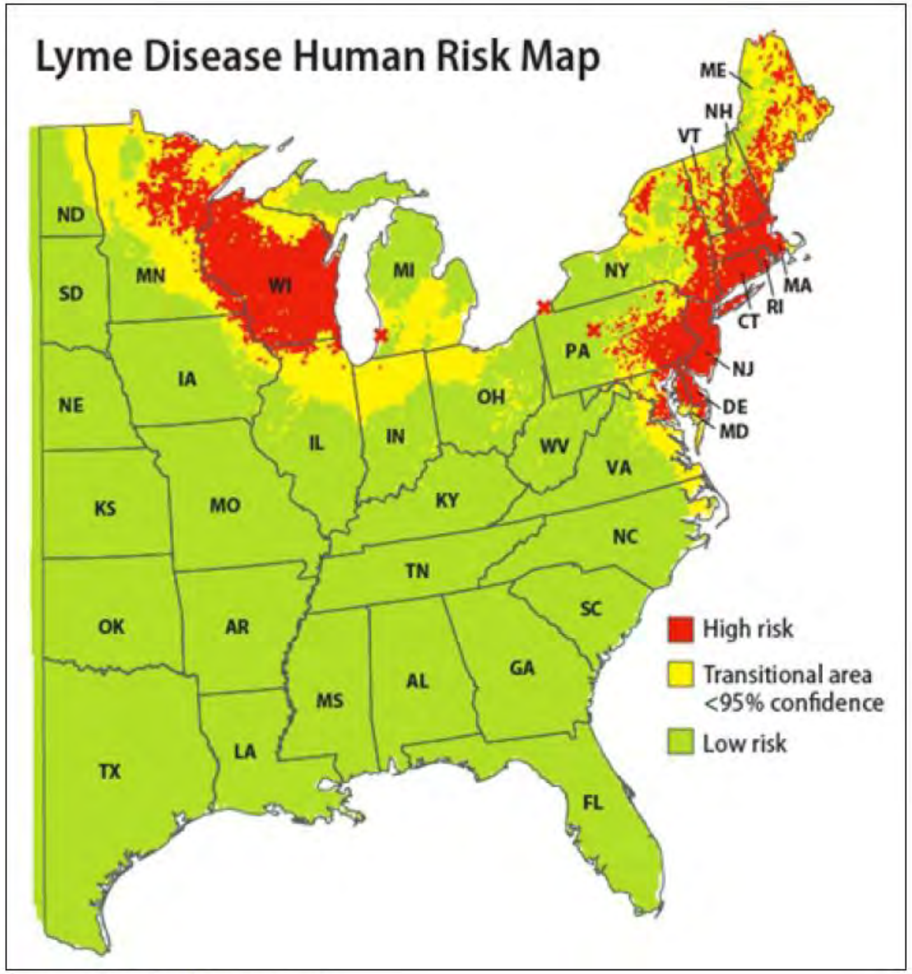
Ocean Acidification Economic Risks



- Although the majority of economic impacts affecting commercial fishing-dependent communities will be concentrated in southern New Jersey, much of coastal Middlesex County is still likely experience impacts of medium economic severity
- Coastal waters in the RRBC region could start becoming unfavorable to shellfish by the end of the century

INVASIVE SPECIES & VECTOR-BORNE ILLNESS

Invasive Species & Vector-Borne Illness



Source: *Yale School of Public Health, 2013*

- Warmer average future winter temperatures are likely to **elongate tick season** in the region, as ticks carrying **Lyme disease** emerge at temperatures above 45 deg 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. This risk will only increase
    - Already, incidence of reported Lyme disease in New Jersey increased by 8.8% between 2007 and 2019
    - While posing a lower risk to urban populations, studies indicate that Lyme disease is a growing threat to urban areas as well
- Additionally, warming temperatures combined with higher frequency of heavy rainfall-generated ponding could facilitate a growth in the **Asian Tiger mosquito** population in the region, 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. On rare occasions, this has resulted in human fatalities
- Warmer temperatures will also cause **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 NJ's forests. This has implications for northern NJ 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