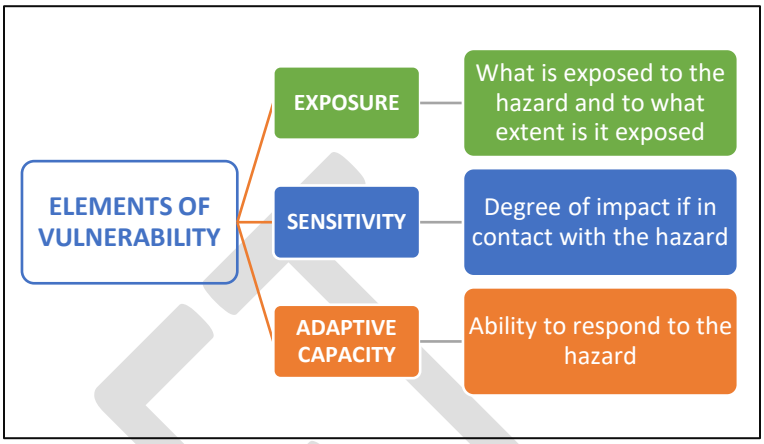
Climate Change Vulnerability Assessment Summary

SACO

Contents

Introduction

One of the first steps to understanding how communities can plan for and address climate change impacts is to assess climate hazards that are projected to impact an area as well as the things, people, and places that are vulnerable to those hazards. **Climate vulnerability is commonly defined** as the product of **exposure** to climate hazards, **sensitivity** of the built, social, and natural systems to those hazards, and the **adaptive capacity** of those systems for responding to change and stressors. The more sensitive something or someone is to a hazard and the lower their adaptive capacity to respond to the hazard, the greater their vulnerability. Vulnerability also increases as exposure to the hazard does. Evaluating vulnerabilities, including what will be impacted by climate hazards, and to what extent those impacts will occur, provides a baseline for developing targeted strategies, measures, and solutions for reducing vulnerabilities.



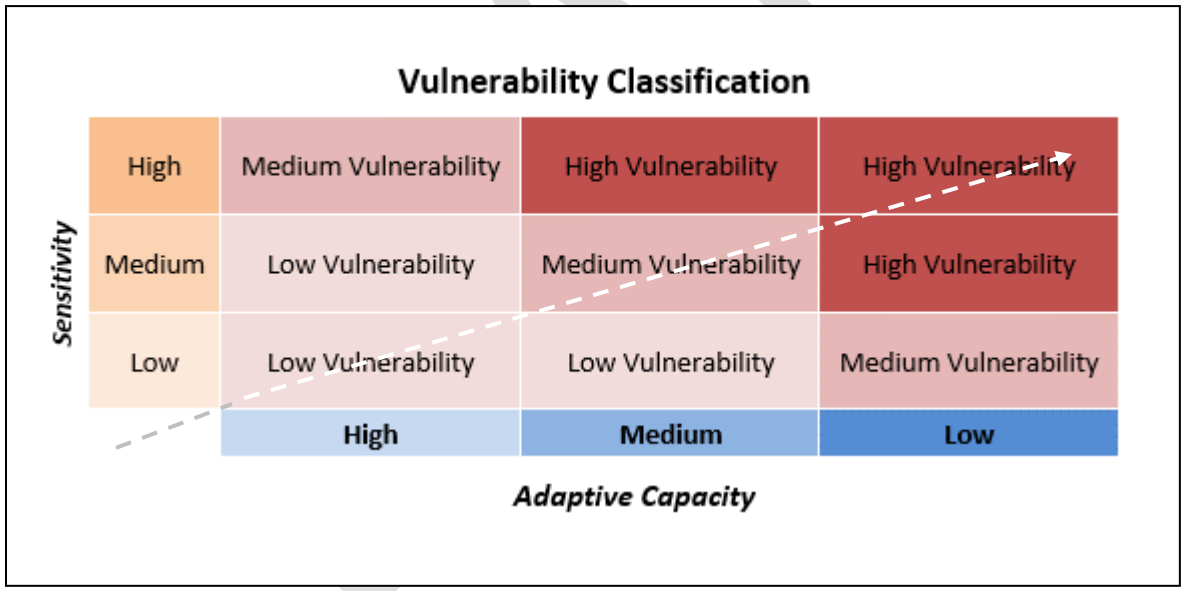


Figure 1 adapted from NOAA. 2022. Implementing the Steps to Resilience: a Practitioner's Guide.

This draft vulnerability assessment summary presents an overview of climate hazards and associated impacts and vulnerabilities for the City of Saco. The assessment uses local, regional, state, and national data pertaining to climate hazards, historical conditions, trends, and future projections to assess impacts of and local vulnerabilities associated with the following:

- Flooding from sea level rise and storm surge
- Precipitation and extreme storms
- Extreme temperatures

- Drought
- Changing marine conditions

The assessment evaluates impacts of those hazards to the built, social, and natural environment; public health; and the economy. The 'desktop' vulnerability assessment generated quantitative-based information about Saco's climate hazard exposure. Information about adaptive capacity and sensitivity, which is usually more qualitative in nature and not readily captured by state or national datasets or numeric data, as well as information about what/where/who is of greatest concern to the community, will be added to this document based on input from City staff and the Energy and Sustainability Committee. **This assessment will be updated and refined by the project team throughout the CAAP process.**

Key Takeaways

- Saco's downtown area has the highest social vulnerability compared with all other areas of the community. This vulnerability is driven by the prevalence of people/households with low annual incomes, without a vehicle, no internet access, living alone, are disabled, renters, age 65+ and living alone, and have limited English abilities.
- Extreme heat and temperatures are increasing in Saco and areas of the community with existing social vulnerabilities, such as the downtown, are already urban heat islands. Increasing air temperatures will exacerbate existing vulnerabilities, especially for the elderly, young, people with existing health conditions, and those with limited access to air conditioning, and will pose a risk to people and the natural environment.
- Coastal areas of Saco, especially neighborhoods, roads, and infrastructure in Camp Ellis, Ferry Beach, and Kinney Shores, as well as low-lying areas along the Saco River, including the Water Resource Recovery Facility, are extremely vulnerable to the increasing impacts of flooding, storm surge, and sea level rise. Some of the areas most exposed to flooding also have a relatively high percentage of structures built before modern building codes, making them more sensitive to flood hazards.
- Roughly $158.5 million in assessed property value is located in areas expected to be impacted by flooding from 1% annual chance storm surge plus 1.6 feet of sea level rise level, representing 3.7% of the city-wide assessed property value.
- More than 3 miles of roadway is vulnerable to flooding from 1% annual chance storm surge combined with 1.6 feet of sea level rise, impacting access to and travel within coastal areas of Saco. Portions of designated evacuation routes out of the Camp Ellis area are vulnerable to flooding.
- Several pockets along tidal portions of the Saco River, especially near Camp Ellis, have been identified as being able to support future marsh migration. Most of those areas are not adjacent to conserved lands and some are identified as having development potential based on current zoning requirements (minimum lot size).
- Drought is becoming a hazard of increasing concern, particularly in the more rural regions where there could be negative impacts to private wells and agriculture, and could lead to increased wildfire risk.
- Compounding climate change vulnerabilities will impact all areas of life, including public health, natural areas, the local economy, municipal fiscal health, and community well-being.

Social Vulnerability

The impact of climate change will not be felt evenly across the community and will not be uniformly distributed among population groups. Individuals who already have increased social vulnerability will be disproportionately affected by climate hazards, as they generally have lower capacity to prepare for, respond to, and recover from hazard events and disruptions. Demographic information can help determine local populations' adaptive capacity, or the ability to adapt and respond to a disaster.

The following demographic information summarizes indicators of social vulnerability and adaptive capacity at the community level and US Census-designated block group level, which is the smallest geographic unit at which this demographic data is available. Information about the community's social vulnerability will be supplemented and contextualized with information gathered from the Task Force and community members through engagement approaches.

Demographic Profile

Table 1 outlines 17 demographic indicators of social vulnerability at the community-wide and block group levels, which align closely with those used in the Maine Social Vulnerability Index.[1] These data are from the 2021 American Community Survey (ACS), which is conducted by the U.S. Census Bureau. The 2021 ACS is the most current demographic data available because the results of the 2020 Decennial Census have not been released yet. Block groups are the smallest geographic unit for which the U.S. Census provides demographic data. Block groups are delineated based on population and contain between 600 to 3,000 people. There are a total of 13 block groups in Saco (Map 1).

The ACS is conducted annually on an ongoing basis throughout the year to collect information about the changing socioeconomic characteristics of communities. Unlike the Decennial Census which surveys every household, the ACS only surveys a portion of households in the community and uses the results to estimate demographic characteristics across the community. In small communities, like many of those along the coast of Maine, that accuracy of ACS estimates may be imperfect due to the small sample size. In larger communities the estimates tend to be more accurate because the sample size is more statistically robust. The ACS also surveys seasonal residents which can make it difficult to understand the characteristics of the year-round population in seasonal communities. The Task Force can use the 17 demographic indicators to begin thinking about which parts of the community may be more socially vulnerable to the impacts of climate change. However, qualitative anecdotal information from the Task Force and City staff can improve the accuracy of this information.[2]

Demographic data are presented at the population and household level. The U.S. Census Bureau defines a household as a group of people who live within the same housing unit regardless of whether or not they are related. A housing unit is a room or group of rooms that is designed to be separate living quarters such as a house, apartment, or condo.[3]

[1] Johnson et al., 2018, A lifeline and social vulnerability analysis of sea level rise impacts on rural coastal communities

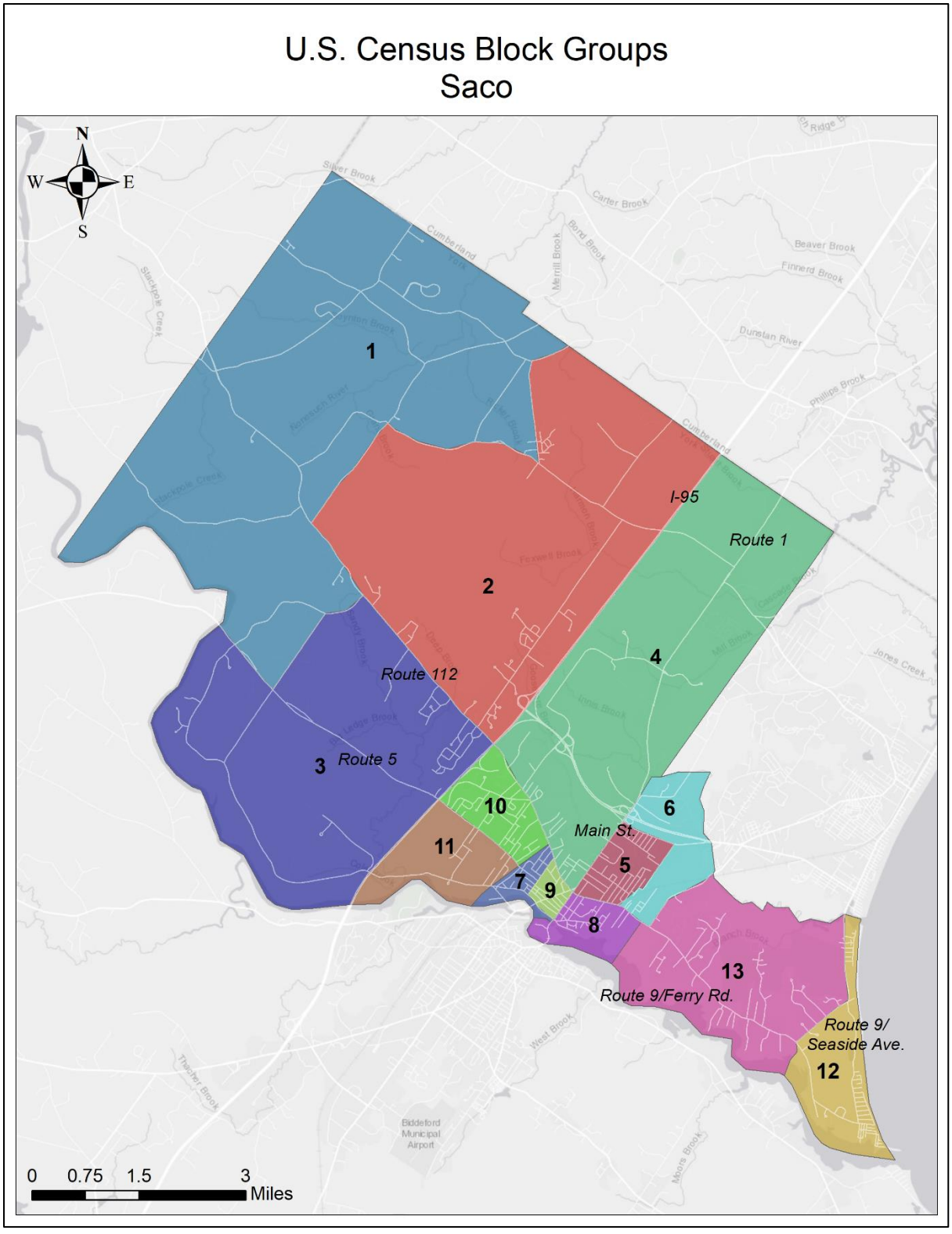
[2] Johnson et al., 2018, A lifeline and social vulnerability analysis of sea level rise impacts on rural coastal communities

[3] U.S. Census Bureau, Subject Definitions: https://www.census.gov/programs-surveys/cps/technical-documentation/subject-definitions.html#household

There are three income thresholds referenced in Table 1. These thresholds were selected because they approximate the US EPA climate change and social vulnerability income threshold ($51,500), the State median income ($64,767), and the York County median income ($73,856).

Key Takeaways

- Downtown Saco (block groups 8 and 9) is the most socially vulnerable area based on the 17 demographic indicators.
- The neighborhoods on Factory Island and around Pepperell Park (block group 8) have the highest percentage of the population and households within the block group that are 17 years old or younger, unemployed, are below the EPA climate change and social vulnerability income threshold, are below the County and State median incomes, have no internet, are living alone, and are 65 plus and living alone. An elevated percentage of the population and households within these neighborhoods have no high school diploma, have one or more persons with a disability, are below the national poverty level, and have no vehicle compared to the rest of the community.
- The neighborhood around Saco City Hall (block group 9) has the highest percentage of the population and households within the block group that speak English less than well, have one or more persons with a disability, are below the national poverty level, and have no vehicle. An elevated percentage of the population and households within this neighborhood are a minority, are below the EPA climate change and social vulnerability income threshold, are below the County and State median incomes, and are living alone compared to the rest of the community.
- The northeastern portion of the City, bounded by I-95 and Route 112 (block group 4), has the highest percentage of the population and households within the block group that are a minority, and have no high school diploma. An elevated percentage of the population and households within this neighborhood speak English less than well.
- Across the community 22% of the population is 17 years old or younger, 23% of households have at least one person with a disability, and 33% of households are below the EPA climate change and social vulnerability income threshold.



Map 1 Census block groups in Saco. Data source: U.S. Census Bureau 2021 American Community Survey

Table 1 Demographic Profile Summary Table. Data source: U.S. Census Bureau 2021 American Community Survey

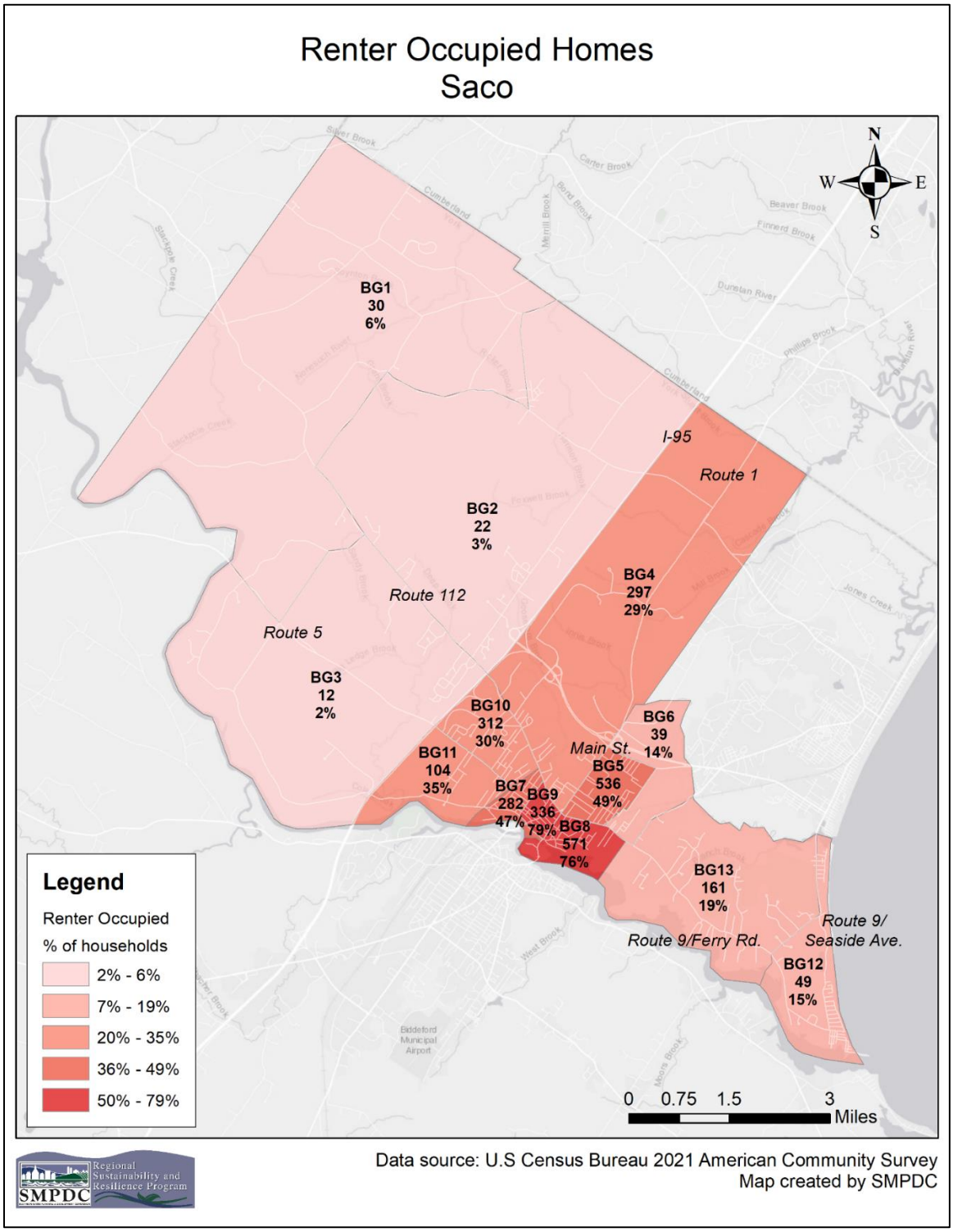
	Community wide	Block Groups												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Total Population	13,416	1,402	1,999	1,927	2,292	2,321	797	1,171	1,507	874	2,382	687	826	2,018
Total Households	5,701	514	777	649	1,030	1,100	282	602	747	425	1,046	298	335	826
Age <18	2,917	318	504	457	459	496	219	56	408	146	363	114	208	310
% total population	22%	23%	25%	24%	20%	21%	27%	5%	27%	17%	15%	17%	25%	15%
Age 65+	1,967	202	260	257	466	305	70	113	294	96	354	95	116	686
% total population	15%	14%	13%	13%	20%	13%	9%	10%	20%	11%	15%	14%	14%	34%
Minority	1,574	137	80	9	627	391	103	152	75	145	186	47	6	58
% total population	12%	10%	4%	0%	27%	17%	13%	13%	5%	17%	8%	7%	1%	3%
Speaks English "Less than well"	119	1	0	12	95	11	0	0	0	49	0	0	0	22
% population age 5+	1%	0%	0%	1%	4.3%	0%	0%	0%	0.0%	6%	0%	0%	0.0%	1%
No HS Diploma	680	29	24	43	322	51	18	60	133	32	56	13	0	33
% population age 25+	7%	3%	2%	3%	18%	3%	3%	6%	12%	5%	3%	2%	0%	2%
1+ Persons with a Disability	1,313	107	182	127	315	191	32	87	272	175	273	63	116	236
% households	23%	21%	23%	20%	31%	17%	11%	14%	36%	41%	26%	21%	35%	29%
Below Poverty Level	645	17	85	0	108	230	16	39	150	144	72	0	11	69
% households	11%	3%	11%	0%	10%	21%	6%	6%	20%	34%	7%	0%	3%	8%
Unemployment	224	60	0	10	14	62	0	0	78	20	12	13	0	17
% population age 16+	2%	5%	0%	1%	1%	3%	0%	0%	7%	3%	1%	2%	0%	1%
Income <$50k	1,868	117	301	92	298	427	42	230	361	201	270	89	85	178
% households	33%	23%	39%	14%	29%	39%	15%	38%	48%	47%	26%	30%	25%	22%
Income <$60k	2,331	152	335	116	391	476	79	297	485	286	428	102	100	213
% households	41%	30%	43%	18%	38%	43%	28%	49%	65%	67%	41%	34%	30%	26%
Income <$75k	3,045	185	406	195	540	628	79	335	677	317	565	152	100	257
% households	53%	36%	52%	30%	52%	57%	28%	56%	91%	75%	54%	51%	30%	31%
No Internet	413	0	36	16	96	80	0	33	152	19	0	0	8	61
% households	7%	0%	5%	2%	9%	7%	0%	5%	20%	4%	0%	0%	2%	7%
No Vehicle	191	0	7	0	66	15	0	0	103	76	0	0	8	112
% households	3%	0%	1%	0%	6%	1%	0%	0%	14%	18%	0%	0%	2%	14%
Single Parent	675	53	63	27	57	312	33	51	79	52	91	15	0	19
% households	12%	10%	8%	4%	6%	28%	12%	8%	11%	12%	9%	5%	0%	2%
Living Alone	1,394	81	195	69	279	277	17	131	345	190	436	84	76	254
% total population	10%	16%	25%	11%	27%	25%	6%	22%	46%	45%	42%	28%	23%	31%
65+ Living Alone	600	13	61	26	129	170	17	0	184	36	28	24	39	205
% total population	4%	1%	3%	1%	6%	7%	2%	0%	12%	4%	1%	3%	5%	10%

Housing Characteristics

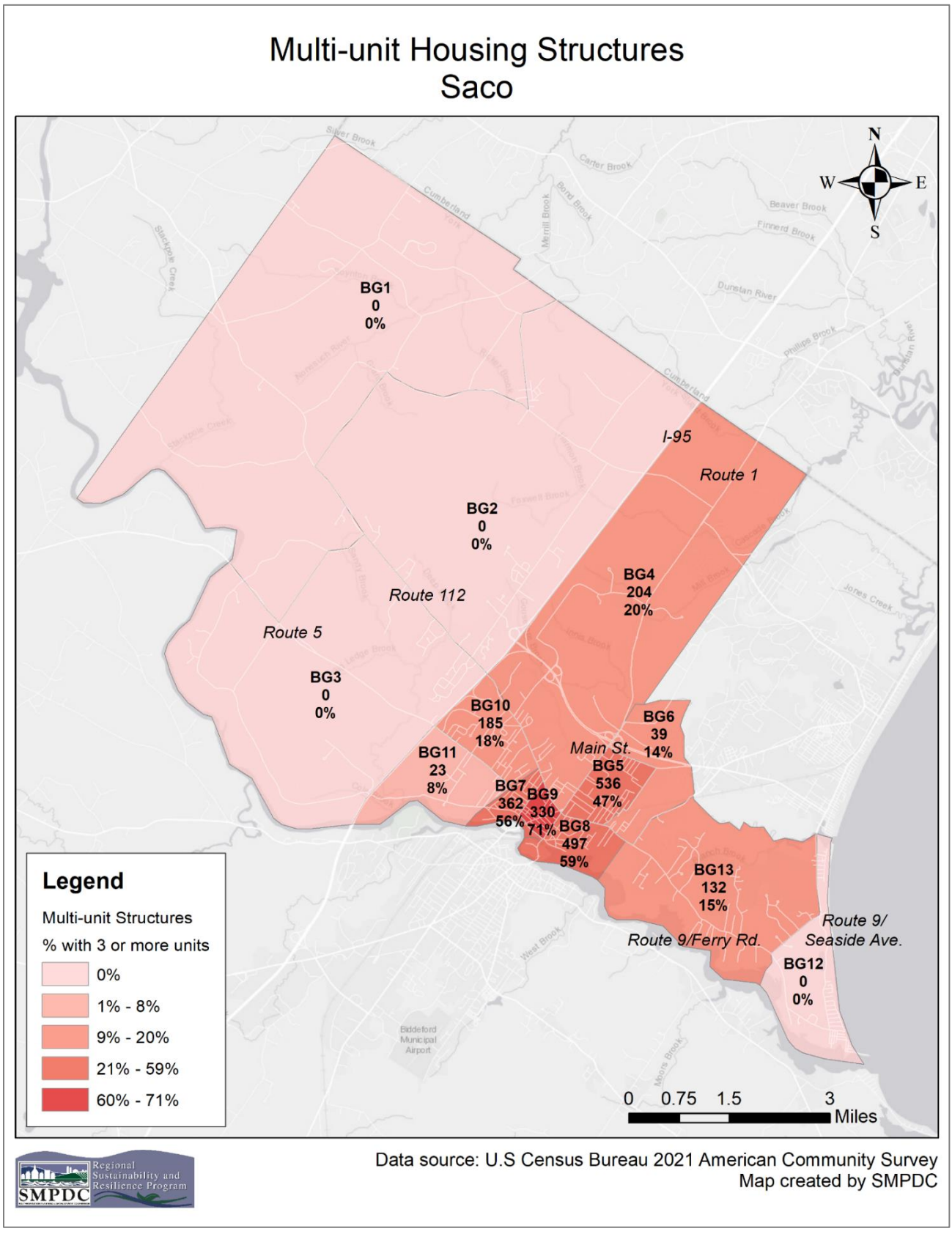
Renter occupied households, multi-unit homes, and mobile homes (Map 2, Map 3, and Table 2) are associated with elevated social vulnerability and/or reduced adaptive capacity. For example, renters and multi-unit households generally have less adaptive capacity than single family homeowners because they tend to have lower incomes/financial resources and have less ability to make property improvements. Additionally, landlords have little incentive to improve energy efficiency because energy costs are borne by tenants. Mobile homes have a higher energy cost per square foot than site-built homes and are generally more vulnerable to the impacts of climate hazards. Rented, multi-unit, and mobiles homes also tend to be associated with socially vulnerable populations. Data are from the 2021 American Community Survey (see Demographic Profile for a description of ACS data).

Key Takeaways

- Community-wide, 12% of households are renter occupied.
  - The neighborhood around Saco City Hall (block group 9) has the highest percentage of households within the block group that are renter occupied at 79%, followed by the neighborhoods around Pepperell Park and Factory Island (block group 8) at 76%. These areas also have elevated social vulnerability.
  - The neighborhoods west of I-95 (block groups 1-3) have the lowest percentage of households within the block group that are renter occupied ranging from 2% to 6%.
- Community-wide, 7% of Saco's housing stock is multi-unit (3 or more units).
  - The neighborhood around Saco City Hall (block group 9) has the highest percentage of housing structures within the block group that are multi-unit at 71%, followed by the surrounding downtown neighborhoods around Pepperell Park and Factory Island (block group 8) at 59%, and the Saco Valley Shopping Center (block group 7) at 56%. These areas also have elevated social vulnerability.
  - There are zero multi-unit housing structures west of I-95 (block groups 1-3)
- Community-wide, mobile homes account for 11% of Saco's housing stock.
  - The northeastern portion of the City, bounded by I-95 and Route 112 (block group 4), has the highest percentage of mobile homes within the block group. There are 277 mobile homes in this area representing 27% of the block group's housing stock, and 87% of all mobile homes in Saco.



Map 2 Breakdown of renter occupied households in Saco by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Saco. The block group is labeled (BG#) as well as the total number of renter-occupied households in the block group and the percent of renter-occupied households within the block group. Data source: U.S. Census Bureau 2021 American Community Survey



Map 3 Breakdown of multi-unit (3 or more units) housing stock in Saco by block group. Housing units include occupied households as well as vacant units and represent the total housing stock in Saco. The block group is labeled (BG#) as well as the total number of multi-unit housing structures in

the block group and the percent of total housing units within the block group that are multi-unit. Data source: U.S. Census Bureau 2021 American Community Survey

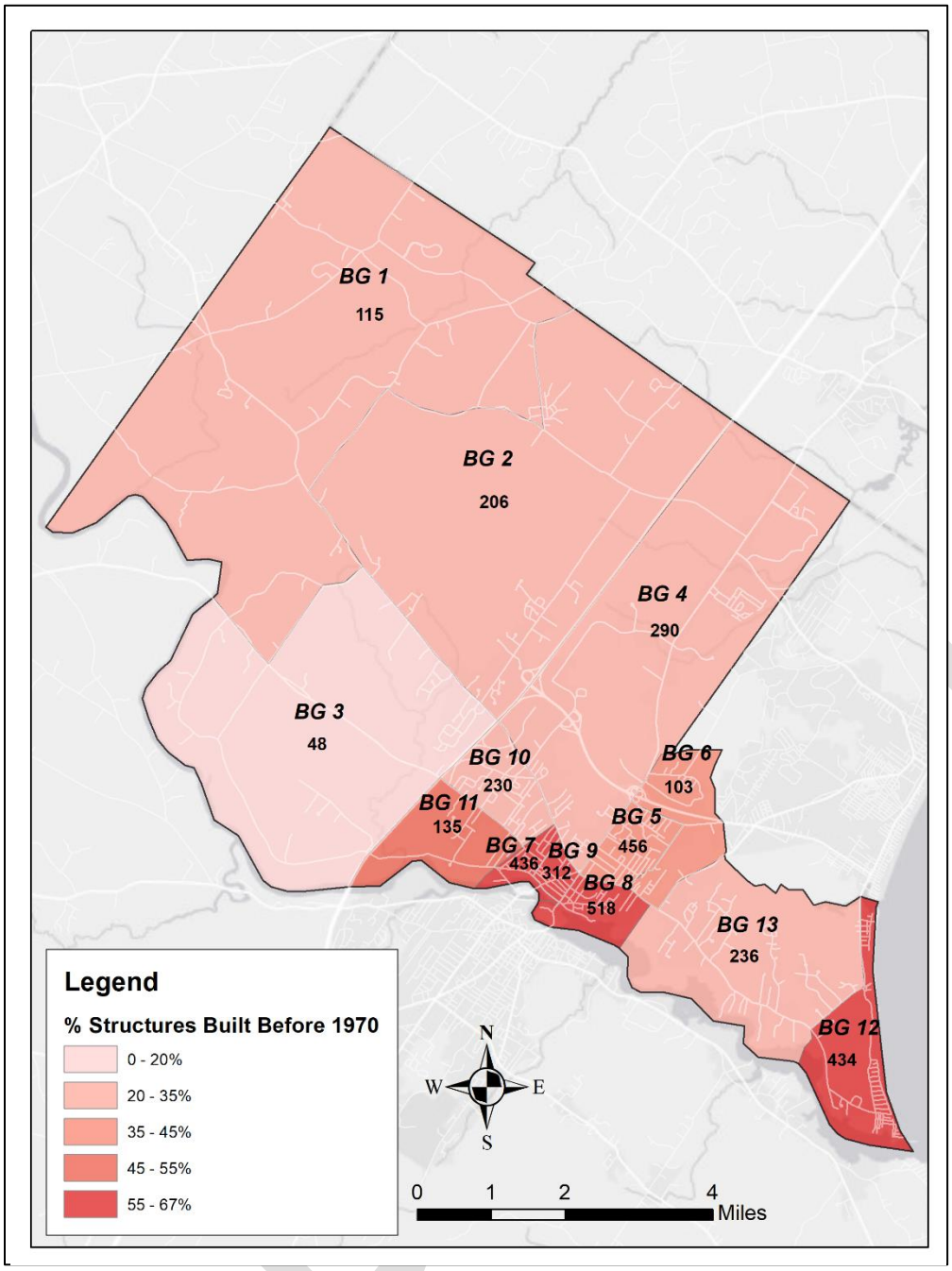
Table 2 Community-wide and block group level housing characteristics in Saco. Housing units include occupied households as well as vacant units and represent the total housing stock in Saco. Data source: U.S. Census Bureau 2021 American Community Survey

	Community wide	Block Groups												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Total Housing Units	3,075	514	882	649	1,030	1,149	282	651	843	467	1,046	298	741	858
Total Households	2,970	514	777	649	1,030	1,100	282	602	747	425	1,046	298	335	826
Renter Occupied	361	30	22	12	297	536	39	282	571	336	312	104	49	161
% households	12%	6%	3%	2%	29%	49%	14%	47%	76%	79%	30%	35%	15%	19%
Multi-unit	204	0	0	0	204	536	39	362	497	330	185	23	0	132
% total with 3+ units	7%	0%	0%	0%	20%	47%	14%	56%	59%	71%	18%	8%	0%	15%
Mobile Homes	317	34	6	0	277	51	0	0	0	0	12	0	0	0
% total units	11%	7%	1%	0%	27%	4%	0%	0%	0%	0%	1%	0%	0%	0%

Age of Buildings

Maine has one of the oldest housing stocks in the country. Older buildings tend to be less energy efficient, which is especially problematic during the winter and summer months when outdoor temperatures are at their extremes. Further, houses constructed before 1970 were built prior to the adoption of modern building codes and significant federal and state/local risk-reduction policies (National Flood Insurance Program (1968), Maine Shoreland Zoning (1971)). Older buildings are ideal targets for weatherization, energy efficiency upgrades, and resilience retrofits.

Map 4 shows the percentage of structures, at the block group level, built before 1970. In Saco, areas with the highest concentration of buildings constructed before 1970 are in the downtown area and along the coastline. These areas also have elevated social vulnerability based on demographic characteristics and are vulnerable to hazards, including coastal and riverine flooding, sea level rise, and urban heat islands. The concentration of older buildings in flood prone areas means that it is likely those structures are not built to modern codes and are not elevated above projected future flood levels, or even current flood levels.



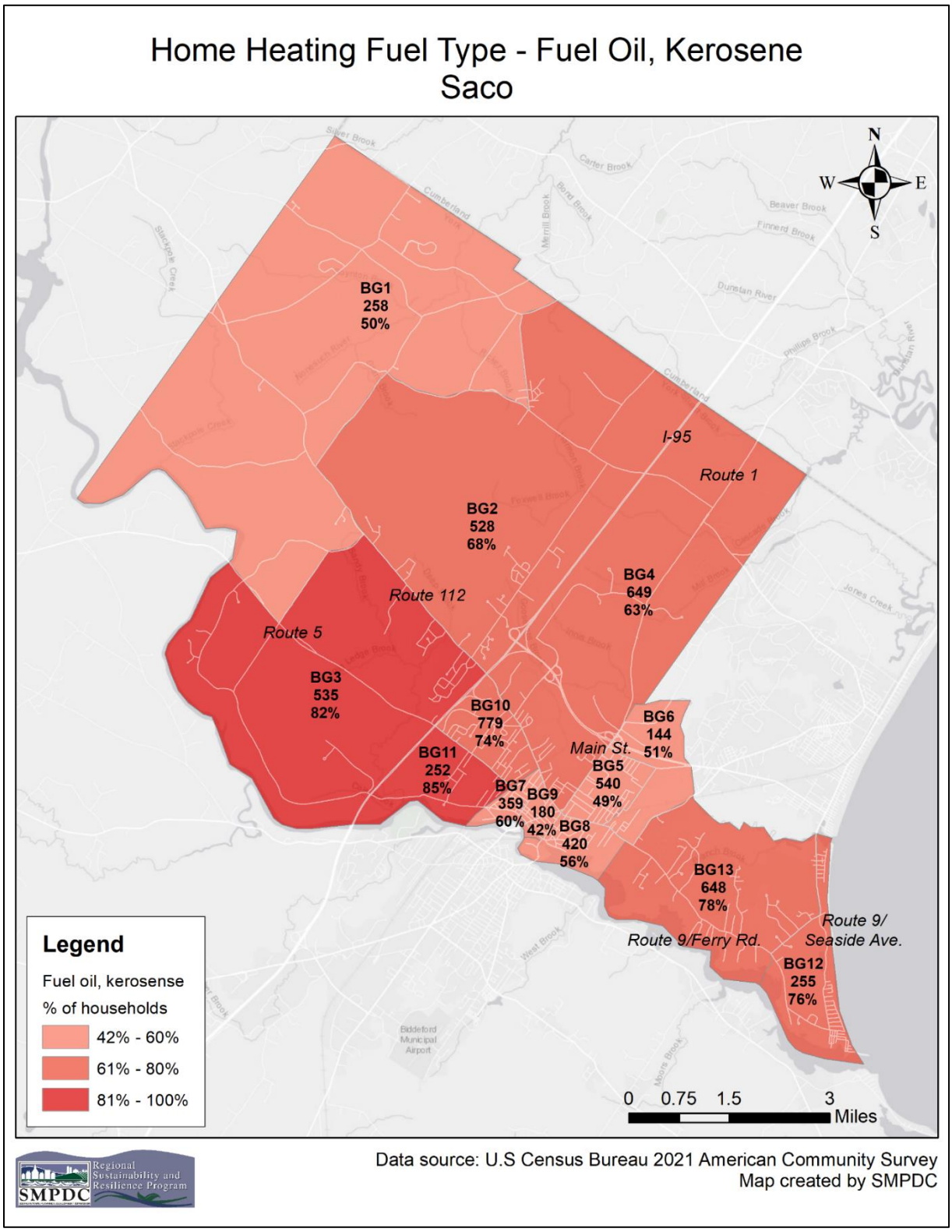
Map 4 Percent and actual number of structures built before 1970 presented at the block group level. The block groups are color-coded by the percentage of structures built before 1970 and are labelled with the block group and corresponding number of structures built before 1970. (Data source: year structures built: US Census American Community Survey; building footprints: Microsoft)

Household Heating Fuel Types

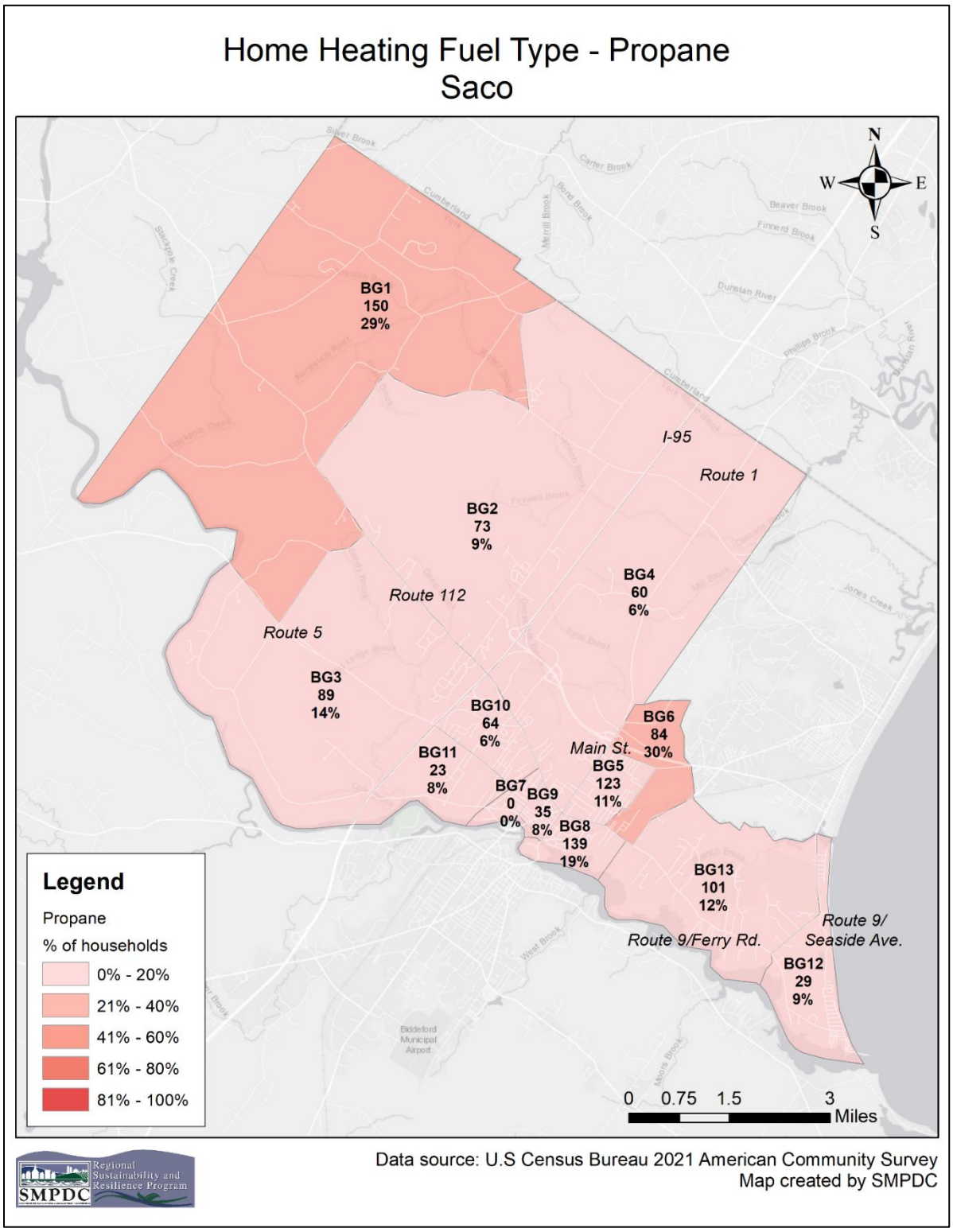
Map 5, Map 6, Map 7, Map 8, and Table 3 show data about primary household heating fuel types, which provides context about where fossil fuels are used most heavily and where electrified heating is more common. Data are from the 2021 American Community Survey (see Demographic Profile for a description of ACS data).

Key Takeaways

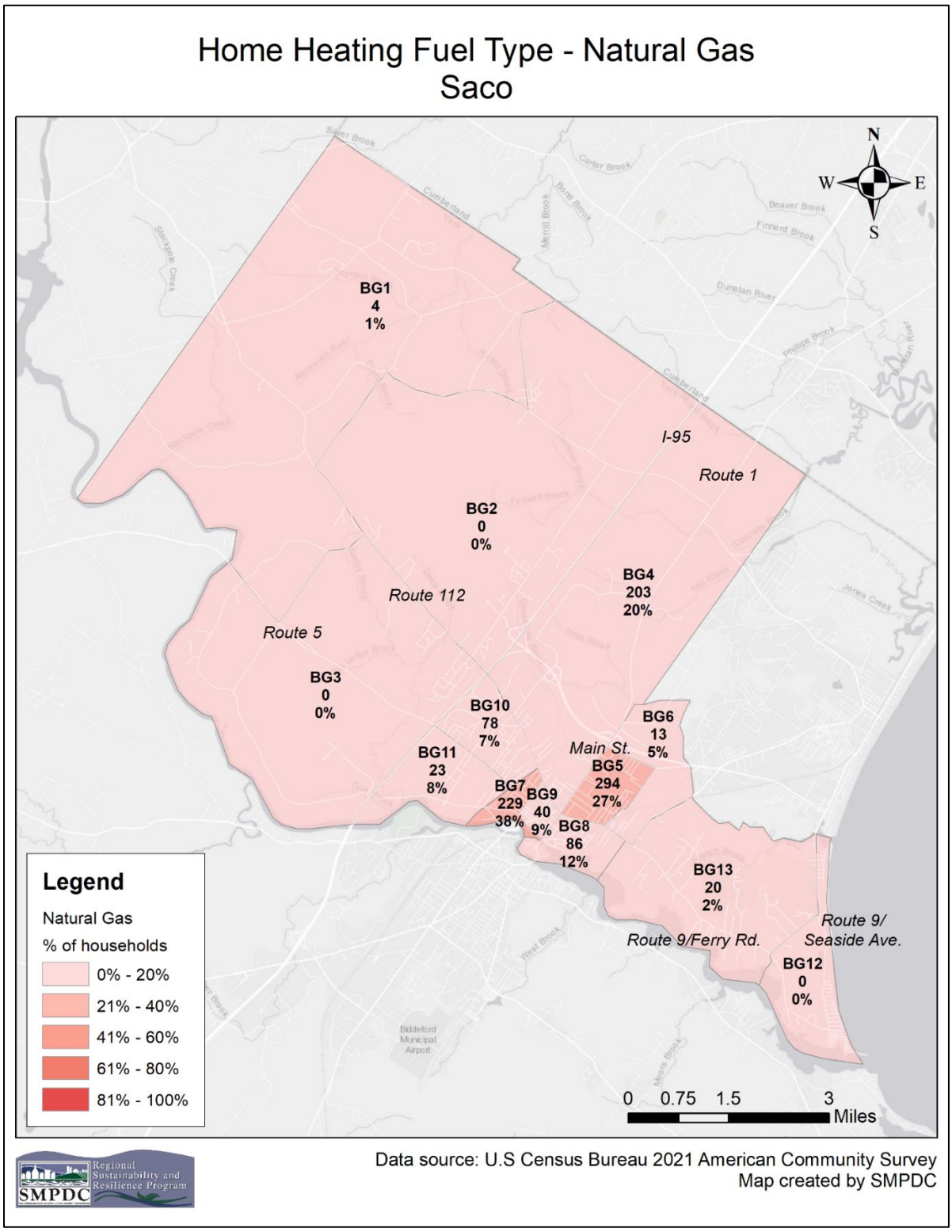
- Community-wide, the majority (66%) of households in Saco use fuel oil or kerosene to heat their homes.
    - The neighborhoods in the southwestern portion of Saco along the Saco River and surrounding the Deep Brook Golf Course and Saco Transfer Station (block groups 3 and 11) have the highest percentage of households within the block group that heat with fuel oil or kerosene, ranging from 82% to 85% of households.
    - The neighborhoods along Route 9 and the shore (block groups 12 and 13) have an elevated percentage of households within the block group that heat with fuel oil or kerosene compared to the rest of the community, ranging from 76% to 78% of households.
    - The neighborhood around Saco City Hall (block group 9) has the lowest percentage (42%) of households within the block group that heat with fuel oil or kerosene. This is also an area of elevated social vulnerability and has the highest percentage of multi-unit and renter occupied homes within the block group.
- Community-wide, 13% of households in Saco use propane to heat their homes.
    - The northwestern portion of Saco bordering Buxton (block group 1) and the neighborhood along Goosefare Brook boarding Old Orchard Beach (block group 6) have the highest percentage of households within the block group that heat with propane.
    - The neighborhood around the Saco Valley Shopping Center (block group 7) is the only area where there is no propane usage. This area also has an elevated percentage of multi-unit housing structures within the block group.
- Community-wide, 7% of households in Saco use natural gas to heat their homes.
    - The neighborhood around the Saco Valley Shopping Center (block group 7) has the highest percentage (38%) of households within the block group that heat with natural gas. This area also has an elevated percentage of multi-unit housing structures within the block group.
    - The northeastern portion of the City, bounded by I-95 and Route 112 (block group 4) and the neighborhood east of Main Street (block group 5) have an elevated percentage of households within the block group that heat with natural gas compared to the rest of the community, ranging from 20% to 27%.
- Community-wide, 7% of households in Saco use electricity to heat their homes.
    - The neighborhood around Saco City Hall (block group 9) has the highest percentage (38%) of households within the block group that heat with electricity. This is also an area of elevated social vulnerability and has the highest percentage of multi-unit and renter occupied homes within the block group. The neighborhood along the Saco River east of I-95 (block group 11) is the only area where no households heat with electricity. This is also the area with the highest percentage of households within the block group that heat with fuel oil or kerosene.



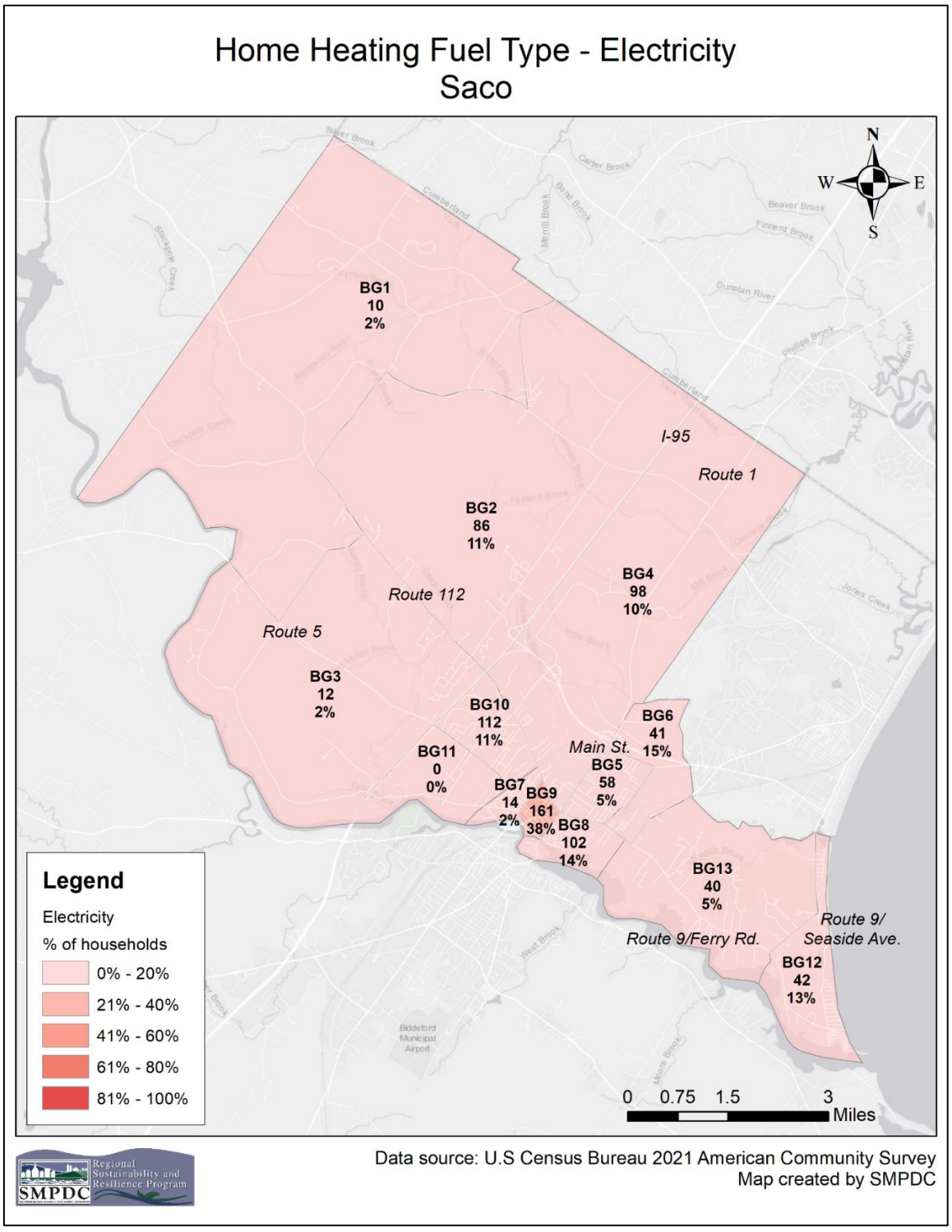
Map 5 Breakdown of households in Saco that use fuel oil or kerosene for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Saco. The block group is labeled (BG#) as well as the total number of households and the percent of households within the block group that heat with fuel oil or kerosene. Data source: U.S. Census Bureau 2021 American Community Survey



Map 6 Breakdown of households in Saco that use propane for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Saco. The block group is labeled (BG#) as well as the total number of households and the percent of households within the block group that heat with propane. Data source: U.S. Census Bureau 2021 American Community Survey



Map 7 Breakdown of households in Saco that use natural gas for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Saco. The block group is labeled (BG#) as well as the total number of households and the percent of households within the block group that heat with natural gas. Data source: U.S. Census Bureau 2021 American Community Survey



Map 8 Breakdown of households in Saco that use electricity for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Saco. The block group is labeled (BG#) as well as the total number of households and the percent of households within the block group that use electricity for heating. Data source: U.S. Census Bureau 2021 American Community Survey

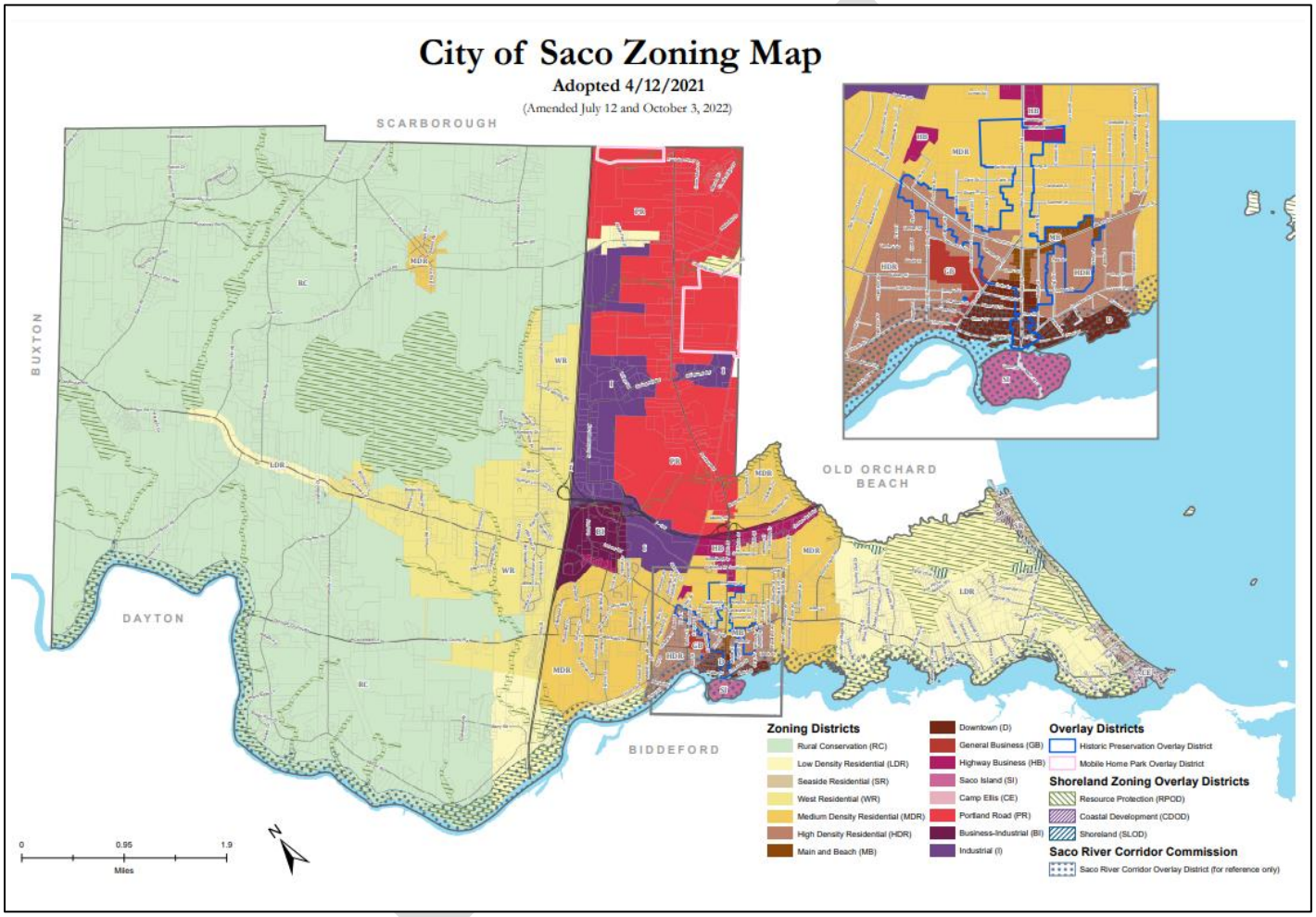
Table 3 Community wide and block group level household heating fuel types in Saco. Households do not include vacant housing units, so this data is representative of occupied housing units in Saco. Data source: U.S. Census Bureau 2021 American Community Survey

	Community wide	Block Groups												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Total Households	2,970	514	777	649	1,030	1,100	282	602	747	425	1,046	298	335	826
Fuel oil, kerosene	1,970	258	528	535	649	540	144	359	420	180	779	252	255	648
% households	66%	50%	68%	82%	63%	49%	51%	60%	56%	42%	74%	85%	76%	78%
Propane	372	150	73	89	60	123	84	0	139	35	64	23	29	101
% households	13%	29%	9%	14%	6%	11%	30%	0%	19%	8%	6%	8%	9%	12%
Natural gas	207	4	0	0	203	294	13	229	86	40	78	23	0	20
% households	7%	1%	0%	0%	20%	27%	5%	38%	12%	9%	7%	8%	0%	2%
Electricity	206	10	86	12	98	58	41	14	102	161	112	0	42	40
% households	7%	2%	11%	2%	10%	5%	15%	2%	14%	38%	11%	0%	13%	5%

Supplemental Community Information

Zoning

Local zoning will impact where in the community (*i.e.* particular geographic areas) certain types of development-related climate mitigation and adaptation strategies would likely have more impact due to where different types of development are allowed and what the standards are for those types of development. The zoning map below is provided for reference to show where areas zoned for commercial, industrial, and residential uses are located.

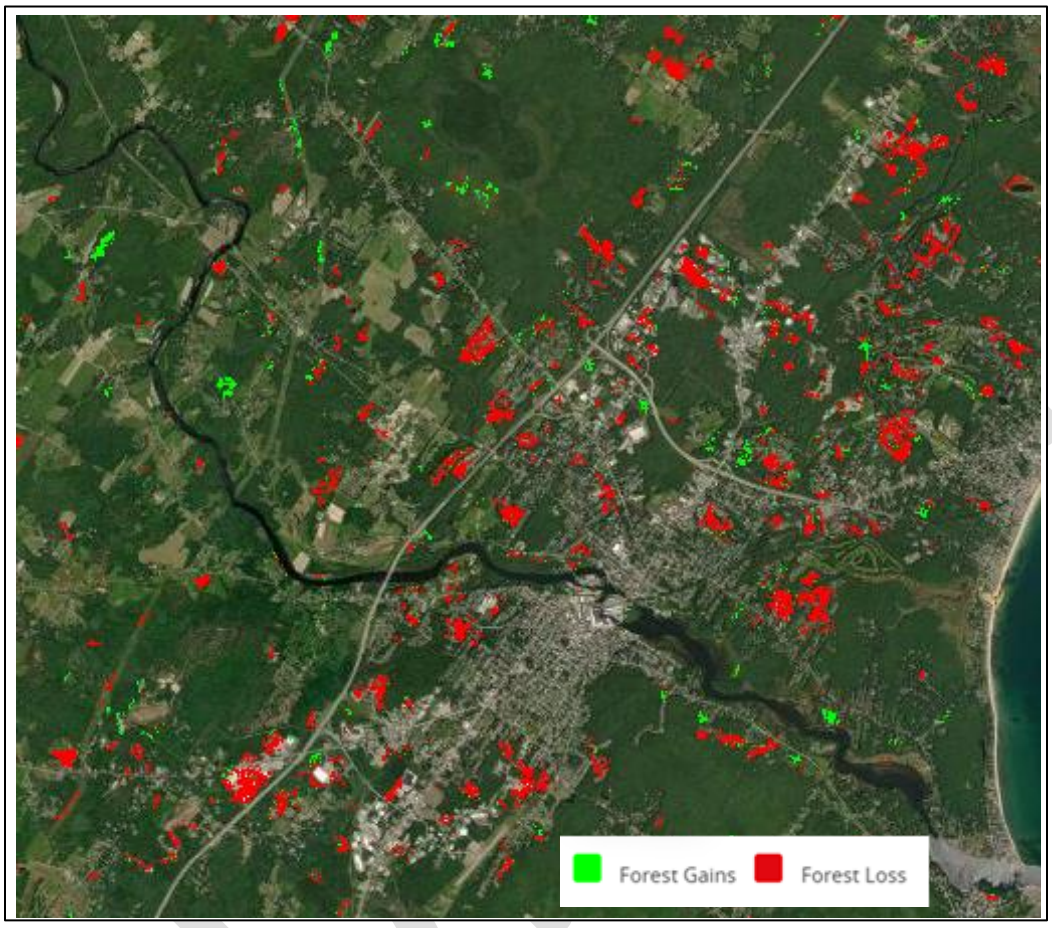


Land Cover and Carbon Sequestration

Forests, wetlands, and grasslands store high amounts of organic carbon. Coastal wetlands are among the largest natural carbon sinks of all terrestrial ecosystems, particularly on a per unit area basis. Undisturbed forest soils also store substantial amounts of carbon. Certain land use activities can enhance carbon storage, such as soil health and conservation practices, whereas others can be a source of carbon release [4]. In built environments, carbon is stored in trees, grassy areas, gardens, and in

[4] State of Maine. 2022. Maine Soil Carbon Incentives Study Policy Recommendations.

wooden structures and are increasingly important for reducing carbon in the atmosphere. Changes in land cover, such as conversion of forest to developed land, impacts not only the health of the natural environment, but the carbon sequestration potential of land. Map 9 shows the change in forested land coverage in Saco from 1996 to 2016. Overall, Saco has experienced more forest loss than gain, spread across various parts of the city.



Map 9 Changes in forested land cover from 1996 to 2016. Green areas indicate a transition of non-forested land to forested, while red areas indicate a transition from forested land to a different type of land cover (e.g., impervious, grassland, wetland, shrub-scrub habitat, etc.). Source: NOAA Coastal Change Analysis Program (C-CAP) Land Cover Atlas.

Extreme Storms & Precipitation

Key Takeaways

- Since 1895 annual precipitation in York County has increased 6.9 inches, and extreme precipitation events (greater than 2 inches in a day) have become more frequent. Future projections indicate that annual precipitation will likely continue to increase, and extreme precipitation events will become even more frequent.

- Flooding events are the most common type of disaster in York County and the most destructive. In the last quarter century, flooding events have caused nearly $45 million in property damage across coastal York County, and coastal floods alone have caused about $22 million in property damage.
- Downtown Saco and the corridors along I-95 and Route 1 are particularly vulnerable to flooding and stormwater overflow during extreme precipitation events because of a high degree of impervious surfaces. Downtown Saco is also an area of high social vulnerability in the community.
- The shorefront from Kinney Shores to Camp Ellis also has a high degree of impervious surfaces and is more vulnerable to the combined flooding impacts of extreme precipitation and coastal flooding during severe storms.
- Increases in extreme storms are likely to cause more frequent and longer duration power outages in Saco.

Background Info, Trends, & Projections

Storms and heavy rainfall are becoming more frequent and intense with climate change. From 1895 to 2022 total annual precipitation in York County has increased 6.9 inches (Figure 2), which is slightly higher than the statewide trend of about 6 inches. Shifting weather patterns are causing more precipitation to fall as rain rather than snow,[5] and extreme precipitation events (greater than 2 inches in a day) are becoming even more frequent. Coastal communities like Saco are experiencing even more frequent extreme storms and precipitation events because of the influence of Atlantic storm tracks.[6] Hurricanes and tropical storms are tracking further northward and there is a high increase in the probability of lower category storms impacting the East Coast. A recent national study found that the Northeast is expected to see the largest increases in the annual probability of at least tropical storm wind conditions or higher, as hurricanes are expected to move further up the Atlantic coast in the future. This may have a significant impact on buildings not built to a code considering the wind speeds they will likely face over the next 30 years.[7]

[5] ME Climate Council, Scientific Assessment of Climate Change and Its Effects in Maine, 2020: http://climatecouncil.maine.gov/reports

[6] University of Maine, Maine's Climate Future, 2020: https://climatechange.umaine.edu/climate-matters/maines-climate-future/

[7] First Street Foundation. 2023. Embargoed: The 7th National Risk Assessment: Worsening Winds

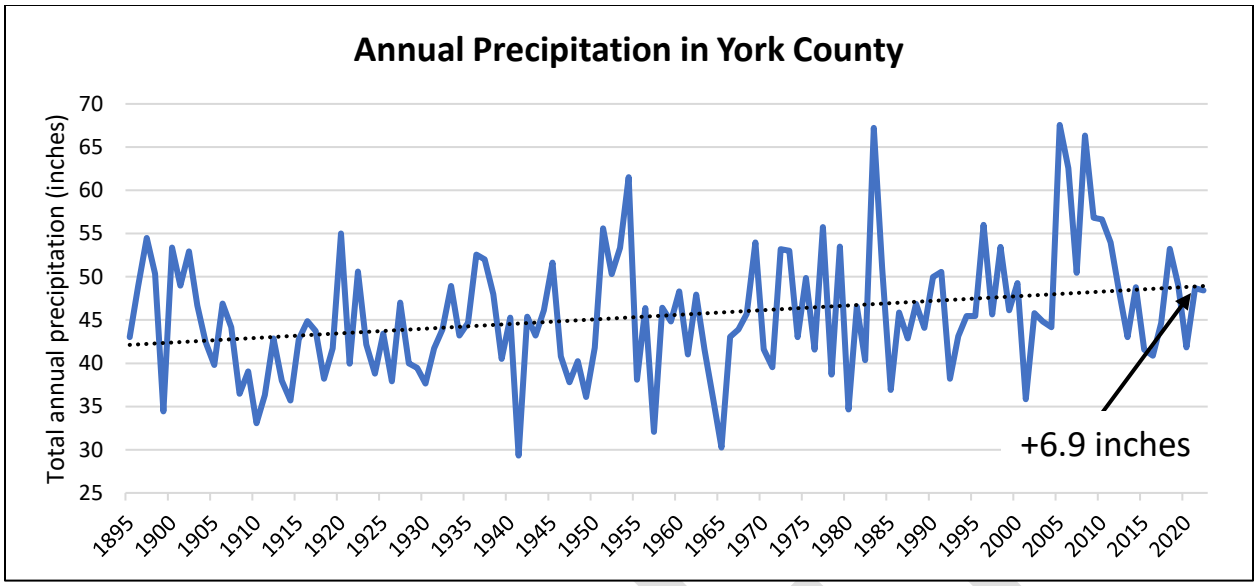


Figure 2 Total annual precipitation in York County from 1895 to 2022 based on monthly data from the NOAA National Centers for Environmental Information. Over this time period total annual precipitation has increased by 6.9 inches.

Since 1970 there have been 34 federally declared disasters in York County related to storm events. Severe storms with heavy rains, strong winds, and coastal flooding have been the most common type of event and have occurred most frequently during the months of February and March followed by October.[8] NOAA maintains a database of all reported storm events, including storms that did not qualify for a disaster declaration. Since 1996, there have been a total of 361 storm events in coastal York County, and 122 events that caused significant property damage totaling about $54 million (Table 4). Flooding events alone, including coastal flooding, have caused nearly $45 million in damage across the region.[9]

Table 4 Cumulative storm events and property damage in coastal York County from 1996 to 2022 based on data from the NOAA Storm Events Database.

Storm Events in Coastal York Co. from 1996-2022		
Event Type	**Number**	**Property Damage**
Coastal Flood	58	$21,659,000
Flash Flood	8	$12,625,000
Flood	10	$10,653,500
Ice Storm	2	$7,930,000
High/Strong Wind	28	$537,500
High Surf	8	$229,000
Lightning	8	$145,000
TOTAL	**122**	**$53,779,000**

[8] FEMA Disaster Declarations Summary, as of 2022: https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v1

[9] NOAA Storm Events Database, as of 2022: https://www.ncdc.noaa.gov/stormevents/

Recent notable storms include:

- December 23rd Storm 2022 – The highest water level recorded at the Portland tide gauge was 13.72 ft MLLW, the third highest ever recorded. Heavy rainfall, high winds, and storm surge caused extensive power outages, coastal flooding, and property damage along the coast of Maine. Governor Mills requested a disaster declaration in February 2023, but FEMA has not made a determination yet.
- Flash flood, October 2021 – (Federally declared disaster) Biddeford reported 6.7 inches of rain in a 6-hour period. A stone embankment supporting the RiverWalk near the Pepperell Mill on the Biddeford side of the Saco River was washed away during the storm causing millions of dollars in damage. It also caused widespread power outages and flooded roads. [10]
- Nor'easters, March 2018 – (Federally declared disaster) Two nor'easters, only days apart, brought heavy rainfall, high storm surge, and high winds which caused severe coastal flooding and damage.[11]
- Patriot's Day Storm, April 2007 – (Federally declared disaster) High wind, waves, and coastal flooding caused severe damage to roads, bridges, and wastewater treatment plants as well as private homes and businesses. Extensive power outages left residents without electricity for days. The most extensive damage occurred along coastline caused by flooding and storm surge.[12]
- Mother's Day Storm, May 2006 – Southern Maine received up to 16 inches of rain, exceeding precipitation amounts associated with the 100-year storm event and resulting in extensive flooding and damage.[13]

In the future, as sea level rises and storms become more frequent and intense, Saco can expect to see more damage from coastal flooding, high winds, and heavy rainfall. With 1.6 feet of sea level rise by 2050, it's estimated that cumulative damage costs caused by coastal flooding could be $16.9-$18.2 billion statewide.[14]

Historically, flooding has been the most common type of disaster in York County, particularly coastal flooding caused by nor'easters.[15] Storm tides cause extensive coastal flooding and occur when a storm surge coincides with an astronomical high tide. The highest water level recorded at the Portland tide gauge (the closest gauge to Saco) occurred during the Blizzard of 1978 and exceeded 14 feet MLLW (Figure 3). The 2018 nor'easter and 2007 Patriot's Day Storm also caused storm tides within the top 20 water levels recorded at the Portland tide gauge. During the recent December 23rd storm (which is not

[10] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management
[11] SMPDC, Economic Resilience Planning for Coastal York County, 2022: https://smpdc.org/coastal
[12] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management
[13] SMPDC, Tides, Taxes, and New Tactics, 2021: https://smpdc.org/coastal
[14] ME Climate Council, Assessing the Impacts Climate Change May Have on the State's Economy, Revenues, and Investment Decisions, Summary Report, 2020: http://climatecouncil.maine.gov/reports
[15] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management

displayed on the graph) a water level of 13.72 feet MLLW was recorded in Portland, about an inch lower than the 2018 nor'easter storm tide.[16]

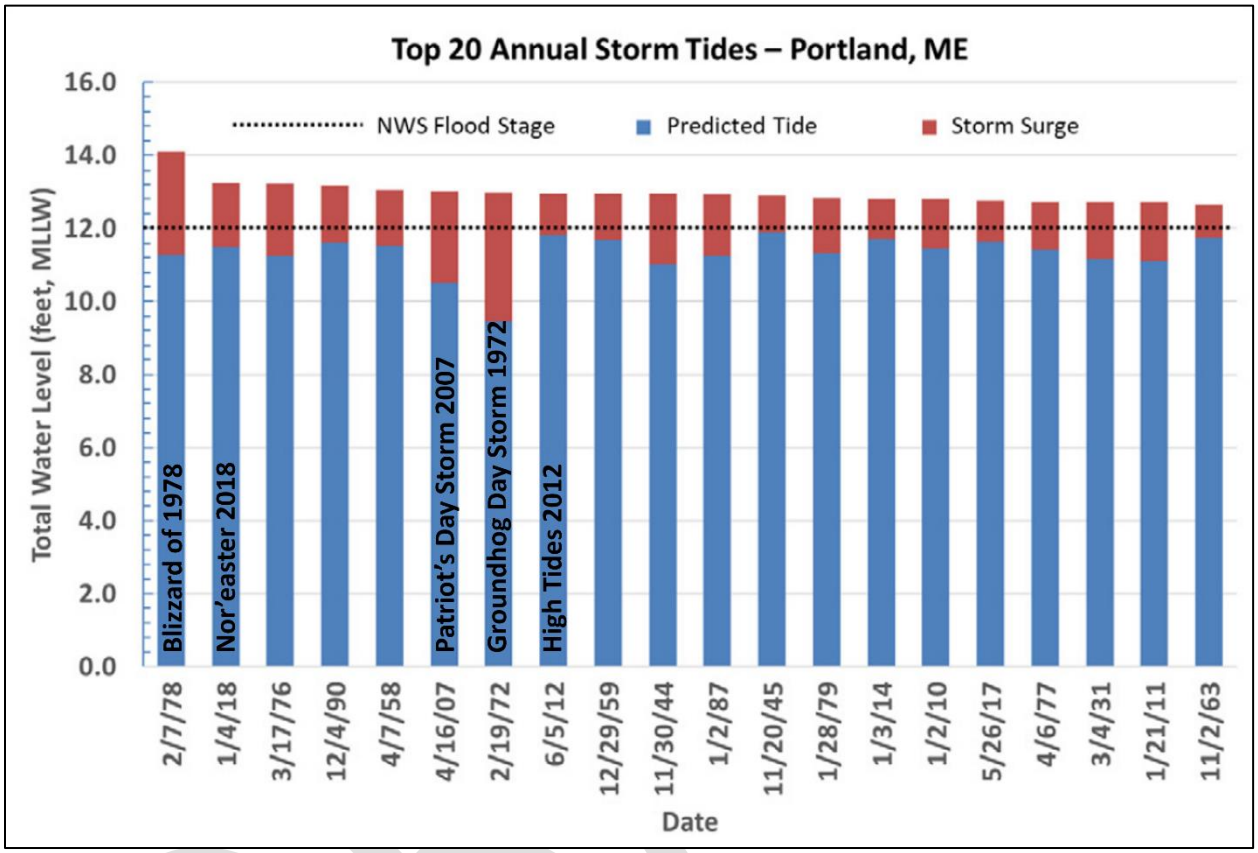


Figure 3 Major storm events and the top 20 storm tides recorded at the Portland tide gauge from 1912-2019. The National Weather Service Flood Stage of 12 feet MLLW is shown as a dashed line. This threshold indicates when elevated water levels begin to create a hazard to public safety, property, and infrastructure. Graph was created by Pete Slovinsky at the Maine Geological Survey for the ME Climate Council, Scientific Assessment of Climate Change and Its Effects in Maine, 2020.

Intense storms and heavy precipitation can cause inland flooding along rivers and streams and exacerbate coastal flooding. Developed areas with lots of impervious surfaces such as roads, parking lots, sidewalks, and buildings experience more flooding during heavy rainfall because the water has nowhere to go. Stormwater systems can overflow because of limited capacity to handle high water volumes, causing runoff into lakes and rivers. Inland and urban flooding poses a threat to public safety, infrastructure, and property. Runoff also increases the risk of contaminated drinking water supplies and degraded water quality in coastal areas, making it unsafe to swim.[17] (*Note: Local information about beach closures due to poor water quality is forthcoming and will be included in the final version of the assessment)*

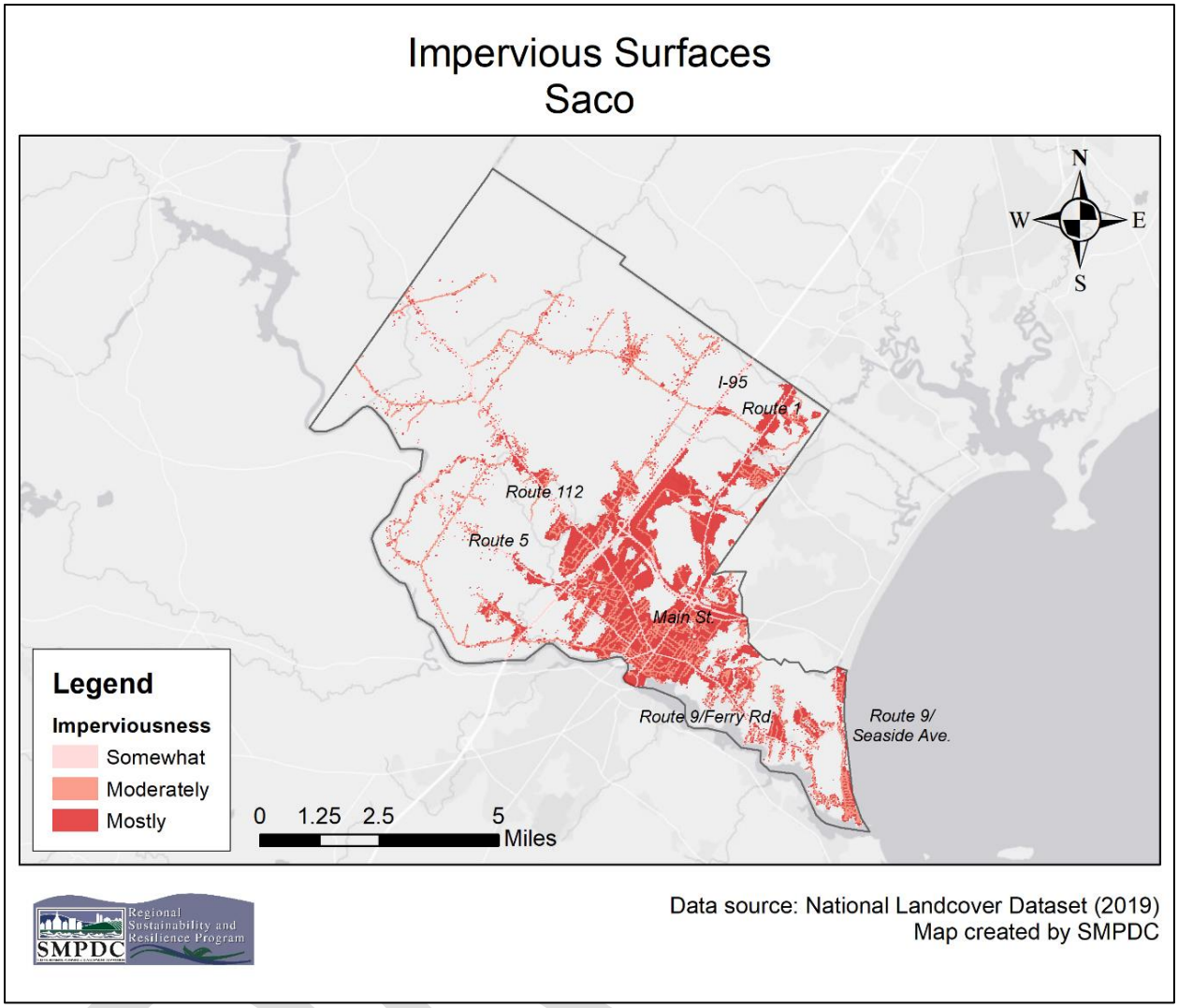
Like coastal flooding, inland and urban flooding may occur during winter nor'easters, but also occur during summer and fall tropical storms or intense thunderstorms. Flash floods are historically

[16] NOAA Tides and Currents https://tidesandcurrents.noaa.gov/waterlevels.html?id=8418150
[17] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management

uncommon in Maine, but in October 2021 a flash flood dropped 6.7 inches of rain on Biddeford in 6 hours. It caused extensive damage, especially along the developed areas of the Saco River. Inland flooding is difficult to predict but changing weather patterns and more frequent and intense hurricanes in the southern U.S. have the potential to cause more inland and urban flood events in coastal communities like Saco. [18]

Saco's proximity to the Saco River and its tributaries increases the community's risk of inland flooding. Furthermore, Saco's downtown is highly impervious as are the corridors along I-95 and Route 1 (Map 10). The shorefront from Kinney Shores to Camp Ellis also has a high degree of impervious surfaces. There is an elevated risk of flooding from extreme precipitation and stormwater overflow in Saco's downtown and developed areas. Along the shorefront, heavy rainfall coupled with a high degree of impervious surfaces can exacerbate the impacts of coastal flooding. In the future, with more intense storms and extreme precipitation events these areas will be at an even higher risk of flooding.

[18] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management



Map 10 Impervious surfaces in Saco based on their level of imperviousness (somewhat, moderately, or mostly impervious). Data is from the 2019 National Landcover Dataset.

Power Outages

Power outages due to extreme weather can have significant impacts and hazards for a community. Power outages can jeopardize essential public safety services. Downed wires during power outages can make roads impassable or dangerous. Lack of heating and electricity during power outages puts vulnerable community members at risk. Homes and businesses also face significant costs due to power outages.

Maine has some of the worst power outages in the country. From 2015-2019 Maine had the highest average annual frequency of power outages per customer of any state (3.9 outages per year). Maine also had the second longest average duration of power outages per customer annually (14.1 hours), only behind Florida (14.6 hours).

Major events and storms significantly impact the duration of power outages, greatly impacting the number of hours Mainers spend without power. In 2020, a greater number of severe weather events meant that CMP customers experienced an average of 29.5 hours without power. However, in 2021 CMP customers experienced only an average of 5.25 hours of power outages.[19]

In Saco, the leading cause of power outages is tree limbs falling on power lines due to high winds or heavy ice or snow loads on trees. Tree limbs can cause outages by leaning on conductor lines, pulling lines down completely, or by damaging utility poles. In Saco, tree impacts caused 72% of all customer hours without power in 2021.[20]

In addition to downing lines, extreme storms can put other power system infrastructure at substations at risk. Substations are a key part of electrical power generation, transmission, and distribution systems and often serve circuits that span multiple municipal jurisdictions. Flooding can damage substation components, leading to power outages and even fires. During extreme storms, damages to roads and other infrastructure can prevent utility services from reaching and repairing sub-stations, prolonging power outages. The City of Saco is served by several CMP substations. Several are located near the I-95 connector, one is off of New Country Road, and one is located on Saco Island. While located close to the Saco River, the substation on Saco Island is well elevated and therefore unlikely to be at high risk to flooding.

Flooding: Sea Level Rise & Storm surge

Key Takeaways

- Neighborhoods and infrastructure located in Camp Ellis, Ferry Beach, and Kinney Shores and along the Saco River are vulnerable to flood hazards associated with climate change. As sea levels rise, and storms become more frequent and intense, these neighborhoods can expect more frequent coastal flooding events and associated damage to property, infrastructure, and the coastline. These areas also have elevated vulnerability due to a high percentage of structures built before 1970, meaning that they are likely not constructed to modern building codes increasing sensitivity to flooding.
- Saco's coastal neighborhoods (block group 12) are the most vulnerable to flooding and have elevated social vulnerability based on several indicators; 35% of households have at least one person with a disability, 51% of households have annual incomes of less than $75k, and 23% of households are just one person living alone. These factors increase those individuals' sensitivity to storm and sea level rise impacts and also limit their adaptive capacity to respond to climate hazards.

[19] Annual Electric Power Industry Report, Form EIA-861 detailed data files, https://www.eia.gov/electricity/data/eia861/

[20] Data supplied by Central Maine Power

- Saco's wastewater recovery facility is critical to community function and health and is exposed to flooding from sea level rise and storms, making the facility and surrounding area extremely vulnerable. Significant efforts to assess site-specific vulnerabilities have been undertaken by the City and a major adaptation project to increase the facility's resilience to flooding and sea level rise is underway.
- Tourism activity driven by Saco's sandy beaches and a healthy coastline could decline as flooding becomes more frequent and the amount of dry beach decreases as sea level rises.
- As coastal properties become increasingly exposed to flooding, their market and assessed values could decline, reducing local tax revenues from affected parcels and potentially straining municipal fiscal health. $158.5 million in assessed property value is vulnerable to flooding from storm surge associated with the 1% annual chance event plus 1.6 feet of sea level rise, representing 3.7% of the city-wide assessed property value.
- Road access to 358 parcels will be cut off by flooding from storm surge plus 1.6 feet of sea level rise, putting the people who live there and emergency access to them at risk.
- Road access to the Camp Ellis, Ferry Beach, and Kinney Shores coastal neighborhoods is at-risk of flooding, placing residents and visitors in those areas particularly vulnerable.
- A section of Route 9 / Ferry Road, a designated evacuation route, is vulnerable to sea level rise.
- Future sea level rise will cause regular inundation of low-lying coastal areas during high tide, likely leading to increased erosion of sandy beaches, dunes, and salt marshes.
- The majority of engineered coastal structures (e.g., seawalls, riprap, etc.) in Saco along tidal portions of the Saco River and Atlantic coastline are vulnerable to overtopping by water from the 1% annual chance event.
- Several pockets along tidal portions of the Saco River, especially near Camp Ellis, have been identified as being able to support future marsh migration. Most of those areas are not adjacent to conserved lands and some are identified as having development potential based on current zoning requirements (minimum lot size).

Background Info, Trends, & Projections

Sea level in Maine has been rising in the long-term, but over the past few decades the rate of rise has accelerated. That rise is increasing the frequency of nuisance or high tide flooding, with southern Maine seeing 4 times as many nuisance flooding events over the last decade compared with the average of the past 100-years. According to a recent State assessment, there is a 67% probability that sea level will rise between 1.1 and 1.8 feet by 2050, and between 3.0 and 4.6 feet by the year 2100 under intermediate global greenhouse gas emissions scenarios, with higher sea level rise amounts possible. With that rate of sea level rise, not accounting for increased intensity and frequency of storms, Maine will see a 15-fold increase in coastal flooding by 2050. Those scenarios do not account for more intense rainfall that climate change is bringing to the region, which will exacerbate flood risk.

As sea level rises in the future, normal high tides will be higher and storms, and accompanying storm surge, will be more impactful, causing extensive coastal flooding to roads, homes, and businesses. Storm surge is the abnormal rise in ocean water level during a storm event, measured as the height of the water above the normal predicted astronomical tide. It is caused primarily by storm winds pushing ocean water onshore. This rise in water level can cause extreme flooding in coastal areas, especially

when storm surge coincides with normal high tide. While future sea level rise will occur gradually over time, extreme storm events can cause damaging flooding episodically in the short-term.

In addition to rising seas, storm surge, and more nuisance flooding events, southern Maine's coastal areas are seeing more frequent and intense precipitation events. Further, the intensity and frequency of precipitation is expected to increase in the future with climate change. Stormwater runoff from rainfall events combined with surge and future sea level rise will lead to more extensive flooding in coastal areas.

Coastal flooding threatens public health and safety by putting transportation corridors, evacuation routes and provision of emergency services at risk; disrupts economic activity through lost business and reductions in tourism; reduces property values; and imperils municipal revenue and budgets. Additionally, individuals who already have increased social vulnerability will be disproportionately affected by sea level rise and climate change as they have less capacity to prepare for, respond to, and recover from coastal hazard events.

Sea level rise threatens not only the landscape above ground, but also the below-grade environment. Along the coast, groundwater and saltwater are naturally separated by the seaward movement of groundwater. As seas rise, landward intrusion of seawater pushes groundwater levels up and shifts the interface of fresh groundwater and saltwater inland. Low-lying coastal communities and critical infrastructure are at risk of impacts including intrusion of saltwater into groundwater and drinking water resources, increased flooding from higher coastal water tables, and water damage to pavement from below. Potential impacts of unmitigated groundwater rise include:

- Water quality degradation
- Premature septic system failure
- Mobilization of hazardous waste
- Saltwater intrusion into drinking water supplies
- Wetland expansion, transition, or drowning
- Flooding due to higher coastal water tables
- Damage to pavement and other hardscape surfaces

To plan for sea level rise and associated impacts, the Maine Climate recommends an approach of committing to manage for a higher probability, lower risk scenario, but also preparing to manage for a lower probability, higher risk scenario. That concept involves building flexibility into designs and decisions so that adjustments can be made to address more extreme sea level rise. It accounts for some of the variability and uncertainty regarding global emissions reductions efforts and evolving science about potential future melting of land-based ice. The State recommends that Maine commit to manage for 1.5 feet of relative sea level rise by 2050, and 3.9 feet of sea level rise by the year 2100, but prepare to manage for 3.0 feet by 2050, and 8.8 feet by 2100, all in relation to 2000 local sea level. When planning for sea level rise, consideration should be given to the risk tolerance of different kinds of infrastructure. In other words, the intended lifespan, criticality, and exposure of infrastructure and assets to flood hazards should be considered when evaluating what sea level rise scenarios and planning horizons to account for in design and maintenance decisions.

In Biddeford, future sea level rise will cause regular inundation of low-lying coastal areas during high tide, leading to contamination of groundwater aquifers and wells from saltwater intrusion, and increased erosion of sandy beaches, dunes, and salt marshes.

This section presents assessment results of the impacts of modeled flooding from storm surge combined with sea level rise to represent what flooding from storm events could look like in the future. The two flooding scenarios, listed below, align with the Maine Climate Council's planning recommendation of committing to manage 1.5 feet of rise by 2050 and preparing to manage 3.0 feet by 2050.

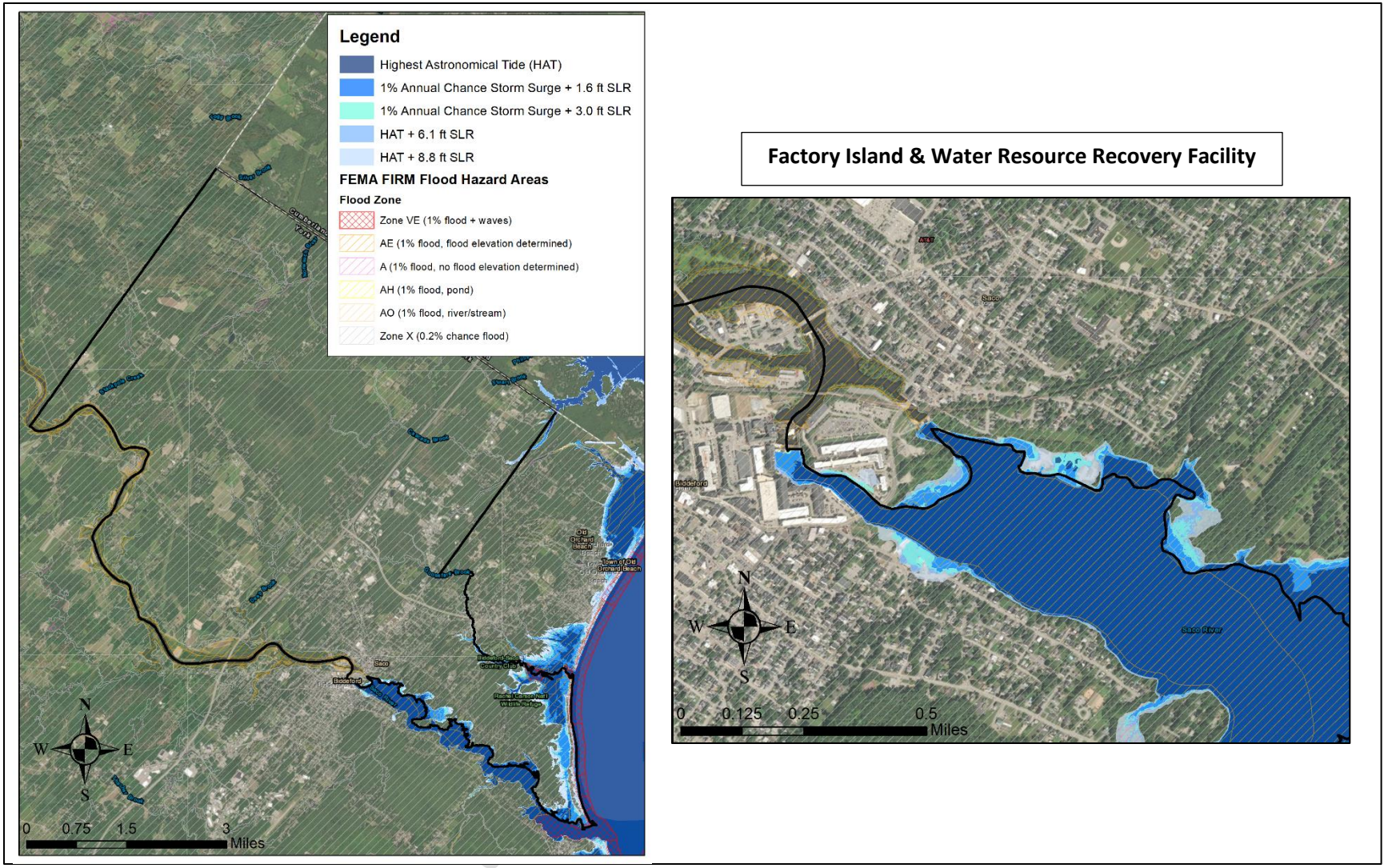
Flooding scenarios used for assessment[21]:

- **Storm surge from 1% annual chance storm event (*i.e.* 100-year storm) + 1.6 feet of sea level rise**
- **Storm surge from 1% annual chance storm event + 3.0 feet of sea level rise**

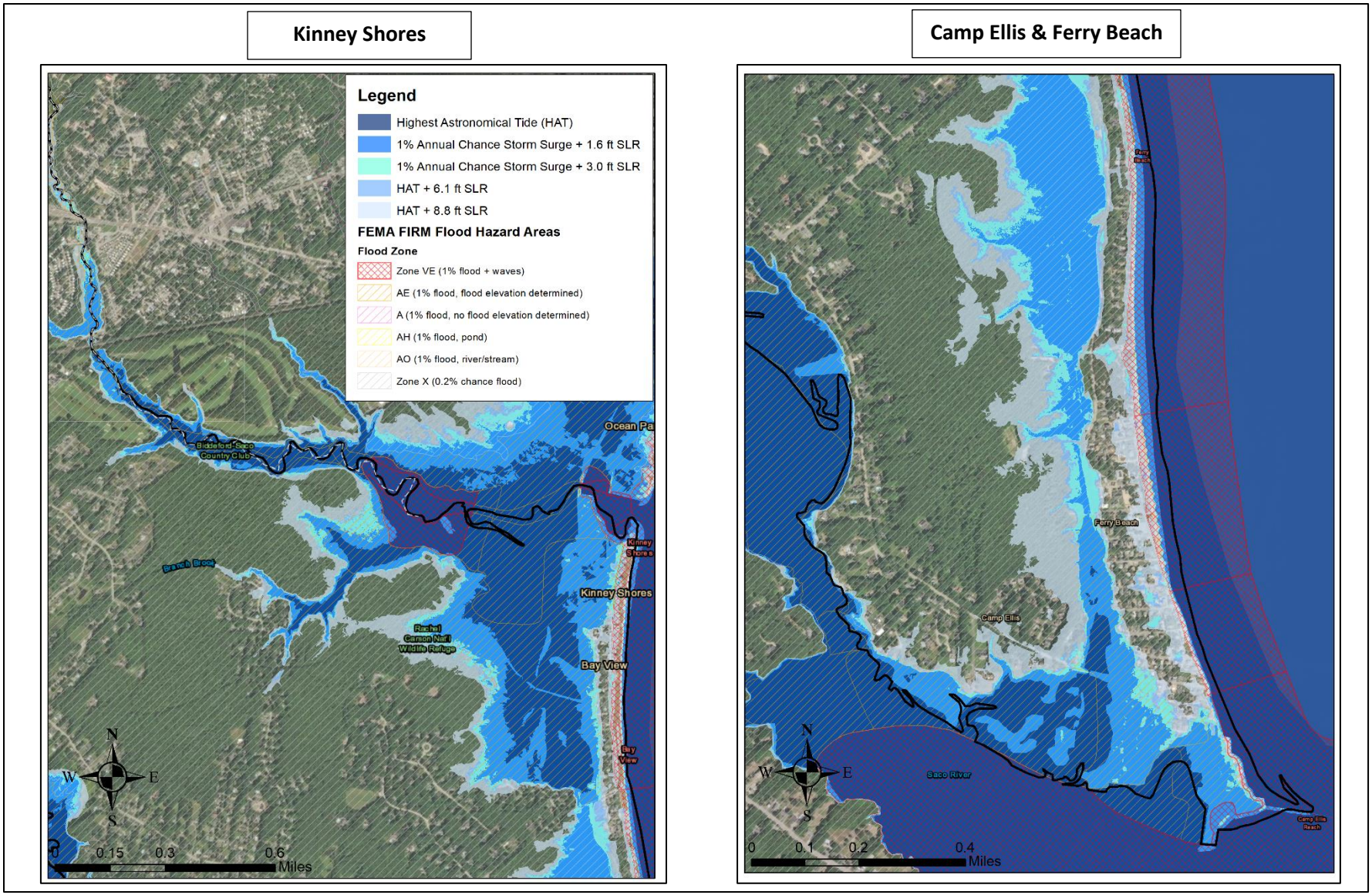
The assessment results presented below use the terms 'vulnerable', 'impacted', and 'at-risk' to describe impacts. All three terms mean that the parcel, asset, or area is touched by water under the given inundation scenario. It is important to note that the modeled flood scenarios show inundation at high tide, so not every area or thing that is directly impacted by the flood scenarios will be permanently inundated.

Map 11 and Map 12 show modeled inundation from the two flood scenarios noted above, as well as the regulatory flood zones (*i.e.*, Special Flood Hazard Areas) from Saco's preliminary Flood Insurance Rate Map (FIRM) published by FEMA.

[21] The sea level rise scenarios were developed by the Maine Geological Survey and do not account for wave action or precipitation. The storm surge values were provided by Ransom Consulting, LLC, and consist of storm surge and static wave set-up, without additional wave action due to crests or wave runup.



Map 11 Modeled inundation from sea level rise (SLR), storm surge, and the 1% annual chance storm event (Special Flood Hazard Area depicted on the FEMA-Issued Flood Insurance Rate Map



Map 12 Modeled inundation from sea level rise (SLR), storm surge, and the 1% annual chance storm event (Special Flood Hazard Area depicted on the FEMA-Issued Flood Insurance Rate Map).

Property Impacts

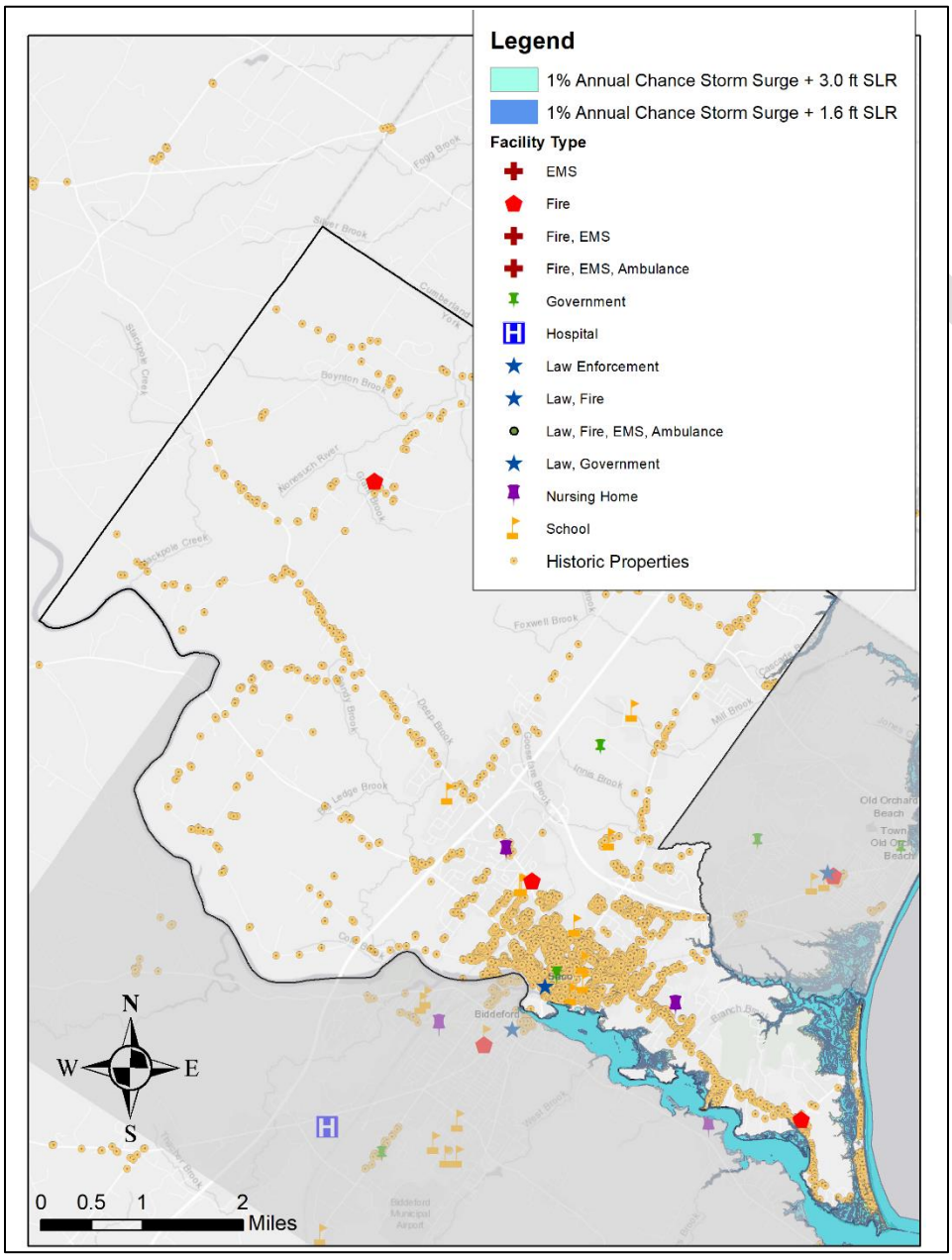
Where and how we choose to develop land profoundly impacts the resilience of our community. Buildings located in areas exposed to natural hazards like flooding are at greater risk of climate change impacts. Saco's municipal budget, like most southern Maine coastal communities, is highly dependent on revenue from local property taxes and coastal development provides a substantial portion of the municipal tax base, generating vital funds that sustain community operations, services, and programs. However, it is that same development that is most susceptible to coastal flooding, placing residents, visitors, and municipal fiscal health at risk. Studies have shown that coastal hazards and climate change diminish the value of impacted properties[22]. Municipal fiscal health could be negatively impacted if coastal properties, which generate a large portion of local tax revenue, are exposed to flooding and if development in vulnerable areas continues. In addition, the coastal areas and resources, especially sandy beaches, that serve as the economic engine for towns, the region, and state are particularly vulnerable to storms and rising seas as increasing water levels reduce the area of dry beach available.

- Parcels that are expected to be impacted by flooding from the 1.6 ft sea level rise scenario total almost **$158.5 million in assessed property value, representing 3.7% of the city-wide assessed property value** (Table 5).
- **Road access to 358 parcels is projected to be cutoff** by flooding from the 1.6 ft scenario and 222 will be cut off with the 3.0 ft scenario, putting the people who live there and emergency access to them at risk (the number decreases because with the higher sea level rise scenario, more of the parcels cutoff by the 1.6 ft scenario become directly impacted by flooding).
- Properties along **Camp Ellis**, **Ferry Beach**, **Kinney Shores** are vulnerable to flooding from both the 1.6 ft and 3.0 ft scenarios. These areas also have a high percentage of structures built before 1970, meaning that they are likely not constructed to modern building codes increasing sensitivity to flooding.
    - A recent study of Camp Ellis found that with 1.5 of sea level rise, the majority of buildings in the Camp Ellis neighborhood will experience 1 – 3 feet of inundation above grade during a more extreme 1% annual chance extreme water level[23].
    - Roughly 15% of households in the coastal areas at greatest risk of flooding and sea level rise are renter-occupied. Renters generally have lower adaptive capacity to adapt to flood hazards because they usually lack the ability to make substantive changes to the properties in which they are living.
- Areas of **Ferry Beach Sate Park** are exposed to flooding from the modeled scenarios, but road access to the park is not.
- There is a **high concentration of designated historic properties** along Saco's Atlantic Coastline and the Saco River that are **located in areas that are vulnerable to flood hazards**, including sea level rise, storm surge, and flooding from the 1% annual chance event.
- There are no emergency management buildings or schools in Saco that are located in areas vulnerable to the mapped scenarios of storm surge and sea level rise. However, as noted in the following section, the Water Resource Recovery Facility and other sewer and stormwater

[22] Shi, L., Varuzzo, A. M. (2020). *Surging seas, rising fiscal stress: Exploring municipal fiscal vulnerability to climate change*. Cities 100 (2020) 102658.
[23] Kleinfelder. 2022. Camp Ellis Architectural Survey and Climate Resiliency options.

infrastructure, which are critical to community health, function, and well-being, are vulnerable to flooding.

- Most coastal properties in areas vulnerable to flooding from sea level rise are on public water and sewer, reducing the risk of drinking water contamination from saltwater intrusion and water quality issues stemming from septic system failures associated with age, malfunctioning, and/or rising groundwater caused by sea level rise.



Map 13 Mapped locations of historic properties, emergency management and public health facilities, and schools.

	Parcel Value: Only Land Impacted	Parcel Value: Buildings & Land Impacted	Total Assessed Value Impacted	% of City-Wide Assessed Value (2022)
Storm surge + 1.6 ft SLR	$27,658,660	$130,754,600	$158,413,260	3.7%
Storm surge + 3.0 ft SLR	$33,833,135	$178,817,600	$212,650,735	5.0%

Table 5 Assessed value of parcels impacted by flooding from storm surge combined with sea level rise (Source: SMPDC. 2022 coastal economic resilience assessment, phase 2. Unpublished.)

Infrastructure Impacts

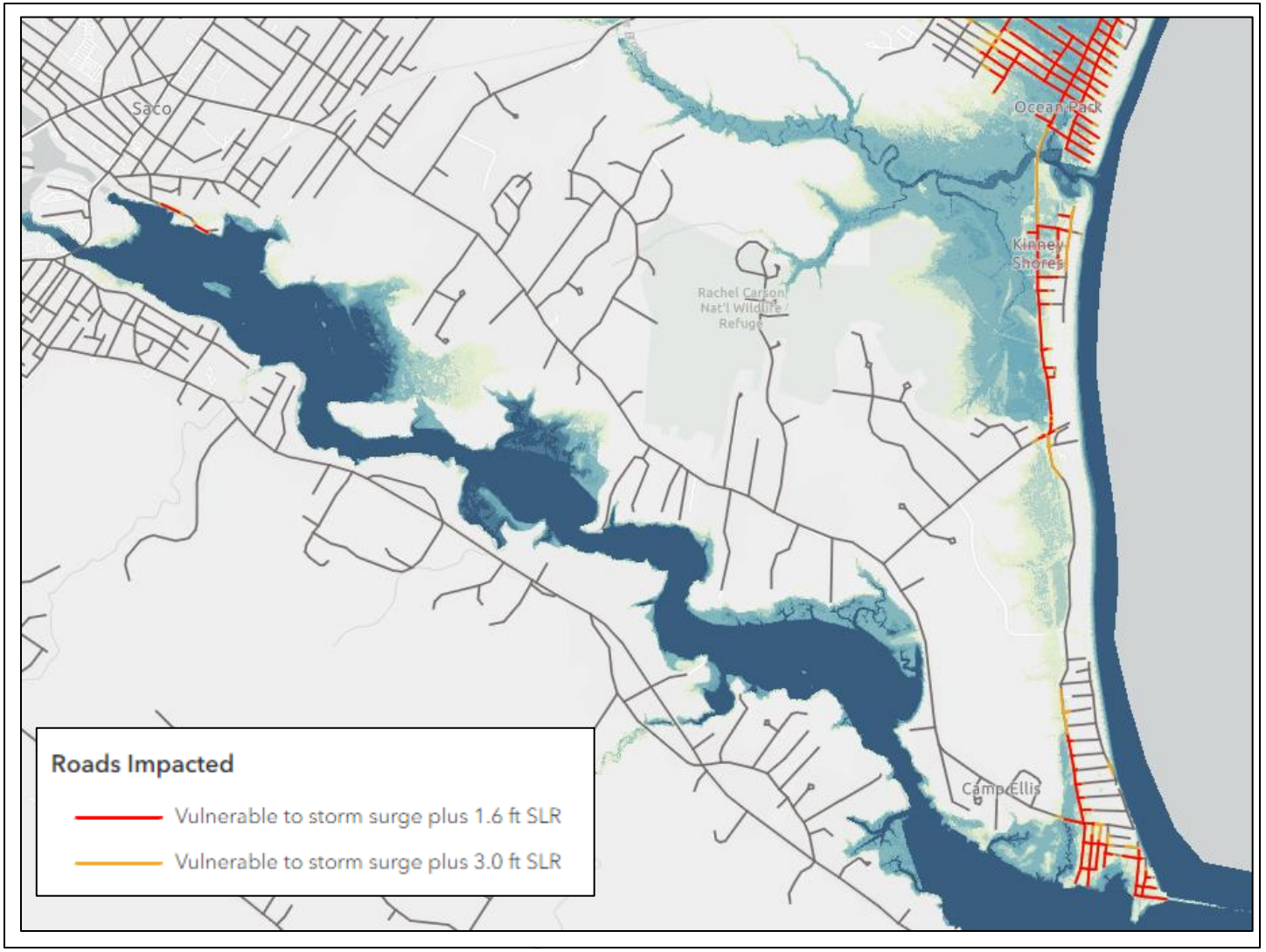
- **Stormwater and Sewer Infrastructure**: Storm and sewer infrastructure vulnerable to flooding are located along Camp Ellis, Ferry Beach, and Kinney Shores neighborhoods, and along Front Street where the Water Resource Recovery Facility is located (Map 15, Table 6).
    - The **Water Resource Recovery Facility** is extremely vulnerable to flooding and sea level rise. It is within two feet of the tidally influenced Saco River and already experiences the harmful effects of flooding during storm events and is located in an area that is exposed to flooding from 1.6 feet of sea level rise. The estimated replacement cost of the plant, in 2018 dollars, is between roughly $14.6 million and $43.8 million[24].
    - **3 sewer pump stations** (Bay View, Camp Ellis, and Fish Pier Pump Stations) **are located in areas at risk of flooding** from both modeled scenarios, increasing their vulnerability as flooding could impact their function and/or disrupt access to them.
- **Water Infrastructure**: Saco is served by Maine Water and public water infrastructure (mains, hydrants, etc.) around coastal neighborhoods and Front Street, are located in areas that are vulnerable to flooding from the 1.6 ft scenario.
- **Transportation Infrastructure**: More than 3 miles (16,211 feet) of roadway are vulnerable to flooding with the 1.6 ft scenario and roughly 4.5 miles are vulnerable to the 3.0 ft scenario. Vulnerable roads are concentrated along the beach areas (Map 14, Table 7).
    - Section of **Route 9 / Ferry Road** near the intersection with Seaside Avenue and Lower Beach Road is a **designated evacuation route and is vulnerable to both the 1.6 ft and 3.0 ft scenarios**.
    - Road access to and within the Camp Ellis, Ferry Beach, and Kinney Shores neighborhoods is vulnerable to both modeled flood scenarios.
    - **Route 9, a significant local and regional route, over Goosefare Brook** is vulnerable to flooding from the 3.0 ft scenario, which would significantly impact travel and emergency access to coastal areas
- Based on an assessment by the Maine Geological Survey, coastal engineered structures (e.g., seawalls, bulkheads, jetties, etc.) in the following areas are vulnerable to overtopping by flooding from the modeled current 1% annual chance storm event, not including sea level rise.
    - Most rip-rap and bulkhead areas along the mouth of the Saco River.
    - The majority, but not all, of structures along the beach between the jetty and Riverside Avenue.

[24] Eastern Research Group, Inc. State of Maine. 2020. Assessing the Impacts Climate Change May have on the State's Economy, Revenues, and Investment Decisions: Volume 2: Cost of Doing Nothing Analysis.

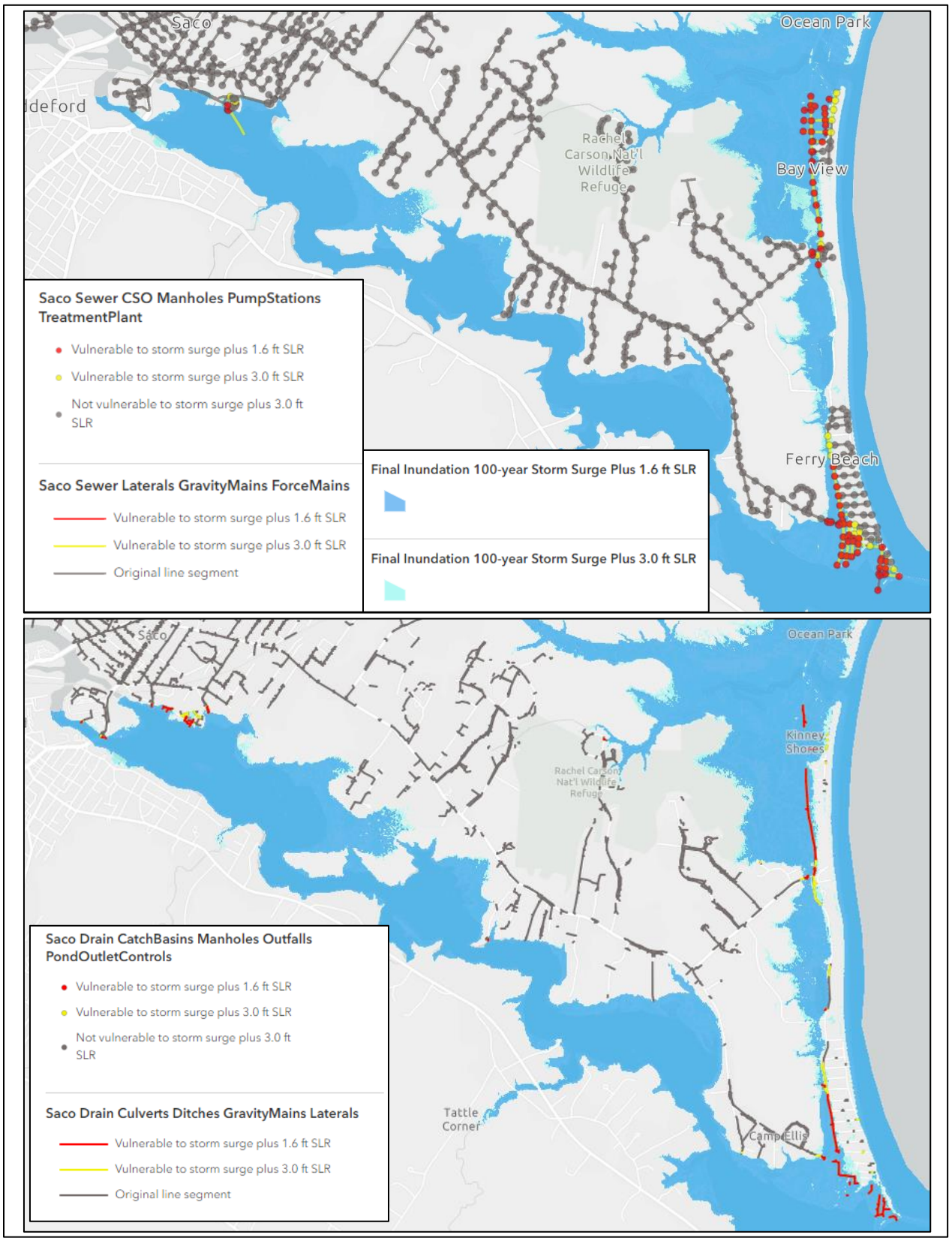
- Most of the beachfront rip-rap in the area from Lower Beach Road to Fairhaven Avenue.
- Most of the structures at the mouth of Goosefare Brook, however, nearly structures along the ocean-facing side of Kinney Shores are above the base flood (e.g., will not be overtopped).

Infrastructure Type		**Vulnerable to Surge + 1.6 ft SLR Scenario**	**Vulnerable to Surge + 3.0 ft SLR Scenario**	**Not vulnerable to 1.6 ft or 3.0 ft Scenarios**
Sewer	Wastewater Treatment Facility	Yes	Yes	-
	Pump stations	3 *Bay View, Camp Ellis, & Fish Pier Pump Stations*	3 *Bay View, Camp Ellis, & Fish Pier Pump Stations*	
	Manholes, CSO, other points	81	105	2,057
	Gravity & force mains, laterals	19,693 ft	26,239 ft	560,089 ft
Stormwater	Catch basins, manholes, outfalls, pond outlet controls	96	126	4,162
	Gravity mains, laterals, culverts, ditches	8,914 ft	12,402 ft	769,498 ft

Table 6 Sewer and stormwater infrastructure vulnerable to storm surge plus 1.6 feet and 3.0 feet of sea level rise. (SMPDC. 2022 coastal economic resilience assessment, phase 2. Unpublished)



Map 14 Roads vulnerable to flooding from 1% annual storm surge plus 1.6 ft and 3.0 ft of sea level rise. (Source: SMPDC. 2022 coastal economic resilience assessment, phase 2. Unpublished.)



Map 15 Sewer and storm infrastructure located in areas exposed to flooding from 1% annual storm surge plus 1.6 ft and 3.0 ft of sea level rise. (Source: SMPDC. 2022 coastal economic resilience assessment, phase 2. Unpublished.)

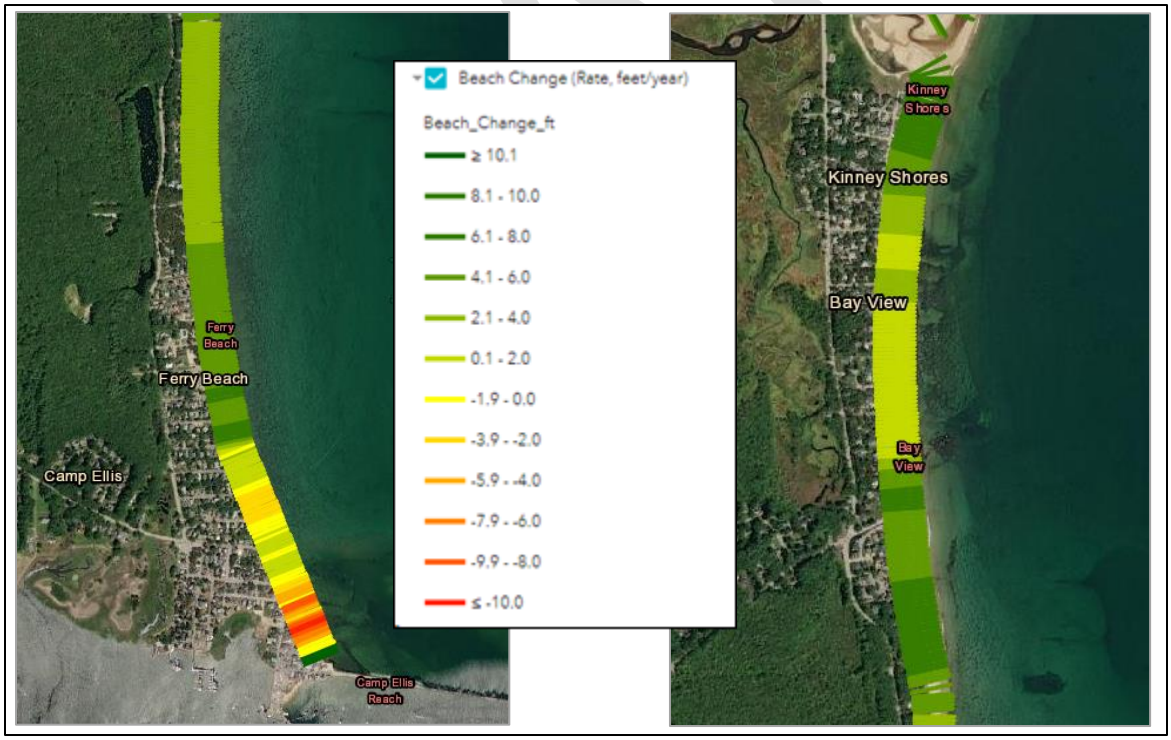
		Storm Surge + 1.6 ft SLR	Storm Surge + 3.0 ft SLR
Road Name	**Classification**	**Feet of Roadway Impacted**	**Feet of Roadway Impacted**
Anthony Est	Private	97.2	166.8
Bay Ave	Local	522.2	535.7
Bay View Rd	Local	173.1	430.5
Beach Ave	Local	303.8	347.5
Beacon Ave	Local	77.1	96.9
Boardwalk Dr	Local	-	98.2
Camp Ellis Ave	Private	1,041.1	1,041.1
Cottage Ave	Local	157.2	224.2
Cove Ave	Local	371.6	552.3
Curtis Ave	Local	144.4	190.3
Driftwood Ln	Local	-	75.9
Dune Ave	Local	331.5	357.7
Eagle Ave	Local	39.7	52.8
Eastern Ave	Local	420.5	479.6
Fairhaven Ave	Local	61.8	114.4
Ferry Park Ave	Local	-	24.1
Ferry Rd	Secondary	307.7	475.3
Fore St	Local	246.3	246.3
Front St	Local	556.7	771.4
Island View Ave	Local	65.5	81.9
Island View St	Local	-	52.5
Lower Beach Rd	Local	167.4	339.0
Main Ave	Local	380.5	703.9
Meadow Ave	Local	145.3	145.3
North Ave	Local	766.6	823.9
Oceanside Dr	Local	-	1,091.0
Outlook Ave	Local	174.0	206.8
Palmer Ave	Local	614.4	732.1
Pearl Ave	Local	77.6	113.8
Pine Tree Ave	Local	493.0	769.8
Piney Woods Rd	Local	614.5	680.4
Riverside Ave	Local	425.7	545.7
Saltaire Ave	Local / Private	677.7	677.7
Seagrass Ln	Private	253.5	378.0
Seaside Ave	Secondary	4,896.8	7,777.4
Shore Ave	Local	507.6	587.3
Sunrise Ave	Local	85.2	111.5
Sunset Ave	Local	170.4	203.2
Surf St	Local	-	245.1
West Ave	Local	843.6	1,035.0

Table 7 Roads vulnerable to flooding from 1% annual chance storm surge plus 1.6 ft and 3.0 ft of sea level rise. The table shows the length of each road vulnerable to flooding and is color-coded by relative length impacted. Brighter red cells indicate roads with the greatest amount of length vulnerable to flooding.

Impacts to the Natural Environment

Rising seas and coastal storms threaten local beaches and dune systems through erosion and flooding. Hardened coastal structures, like seawalls, roads, and homes, prevent beach systems from migrating inland as ocean levels increase. Additionally, how beaches will fare with increased sea level is related to sediment supply, both sources and volumes of the supply. Sand and gravel for beaches can come from rivers, eroding bluffs, the offshore seafloor, or marine shells. Shorelines that have been engineered to prevent erosion, protect property, and stabilize the shoreline offer reduced sediment supply to beaches.

- With 1.6 ft of sea level rise (no storm surge), Saco's dry beach width (distance from the mean high water to seawall or dune edge) is projected to decrease by 3.5 acres, or by 26.5% from existing conditions. With 3.9 feet of sea level rise, the dry beach width is projected to decrease by almost 60%[25].
- Sea level rise is expected to lead to loss of coastal habitat. Along Saco's coast, loss of dry beach will impact local species, including piping plovers and other shorebirds that use the beach for nesting.
- Monitoring data from the Maine Geological Survey show that most of Saco's sandy beaches have been relatively stable in terms of measured beach width over the past several years (2016 – 2020). Camp Ellis is the exception and has experienced significant erosion, a known and much-discussed issue related to impacts stemming from the jetty constructed by the U.S. Army Corps of Engineers. Sea level rise will likely exacerbate erosion in areas already experiencing it and lead to additional erosion along all beach areas.



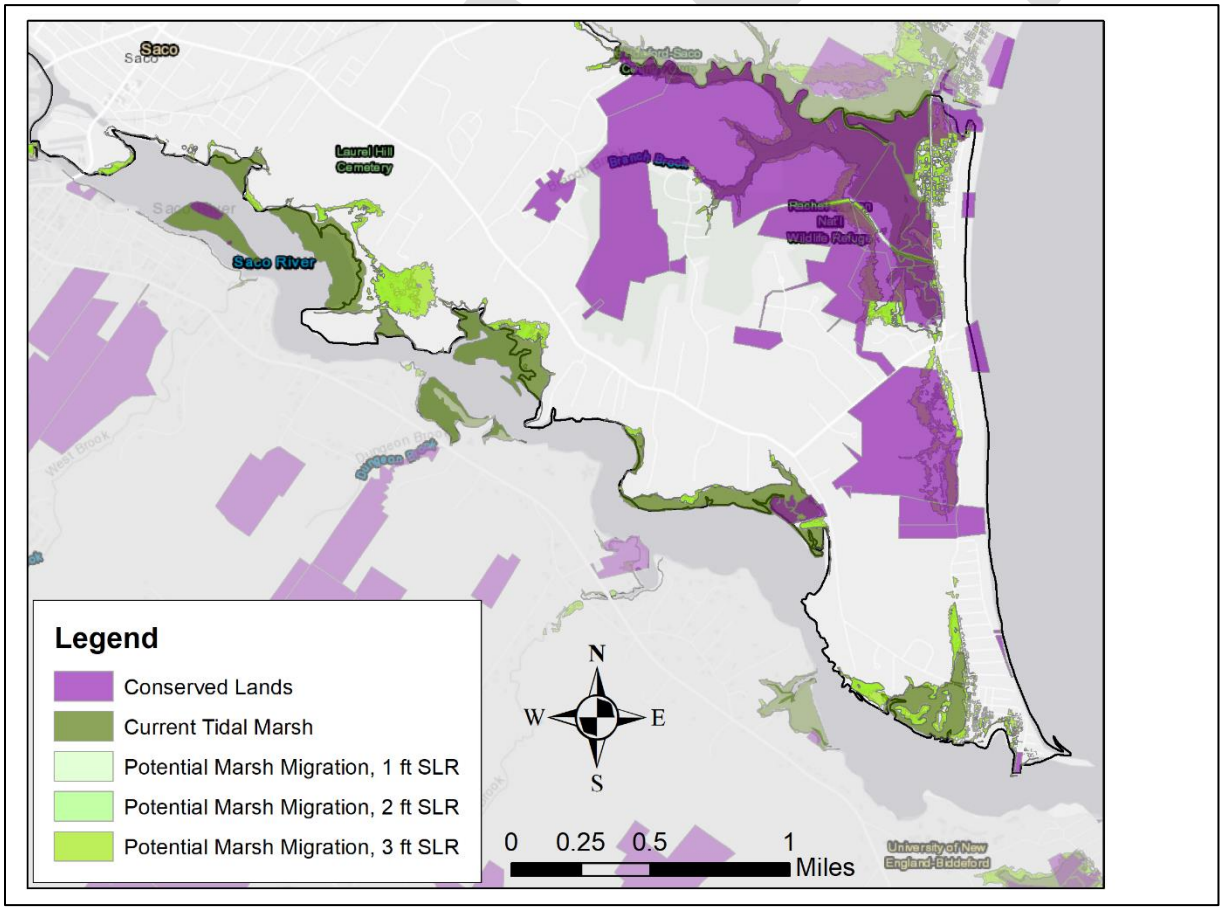
Map 16 Mapped shoreline change in Saco. This map shows the rate of beach change, in feet per year, from data collected from 2016 through 2020. A positive value (green lines) represents a rate of beach growth, while a negative value (yellow/orange/red

[25] Maine Geological survey. 2021. Unpublished analysis of the impact of sea level rise on dry beach width of Maine's sandy beaches.

lines) represents a rate of beach loss. (Source: Maine Geological Survey. Maine Beach Mapping Program. Maine Beach Mapping viewer)

While sea level rise threatens inundation of the beach system, it also has the potential to facilitate the landward expansion, or migration, of tidal marshes. However, this landward migration can only occur if saltmarshes are healthy and there are not physical barriers, such as stonewalls, roads, or buildings, that inhibit the movement of marsh vegetation as sea level increases. The Maine Natural Areas Program (MNAP) has mapped areas that could support marsh migration with future sea level rise (Map 17). Protecting these areas will be crucial for ensuring the long-term viability of local tidal marshes, which provide tremendous natural benefits and services including wildlife habitat, flood control, and water quality protection.

- Several pockets along tidal portions of the Saco River, especially near Camp Ellis, have been identified as being able to support future marsh migration. Most of those areas are not adjacent to conserved lands and some are identified as having development potential based on current zoning requirements (minimum lot size).
- Areas around Goosefare Brook and Long Pond in Ferry Beach State Park have been identified as future marsh migration areas and are adjacent to existing conserved lands, which can enable migration as there are not physical barriers (roads, buildings, etc.) inhibiting the landward movement of the marsh.



Map 17 Existing conserved lands (purple) and areas that could support future migration of existing tidal marshes with future sea level rise. The areas are non-tidal lands within existing tidal estuaries that could be inundated and facilitate the development of new areas of tidal marsh if sea level rises by 1, 2, or 3.3 feet above current highest annual tide (HAT). (Source: Maine Natural Areas Program. Sea level rise scenarios are from the Maine Geological Survey.)

Extreme Temperatures

Key Takeaways

- Maine's average annual temperature has increased by 3.2°F since 1895 and could warm an additional 2-4°F by 2050.
- Southern Maine is expected to experience roughly 4.5 times more 'extreme heat' days by the 2050s.
- Exposure to extreme heat is a significant public health concern and can be especially dangerous for older adults, infants, people with existing health conditions, and those who have limited access to air conditioning.
- Extreme heat will exacerbate the impacts of urban 'heat islands', the locations of which overlap with areas of socially vulnerable populations in Saco, such as in the downtown area.
- There are fewer days with below-freezing temperatures and snow cover, leading to an increase in pest outbreaks and prevalence vector-borne diseases like Lyme disease.

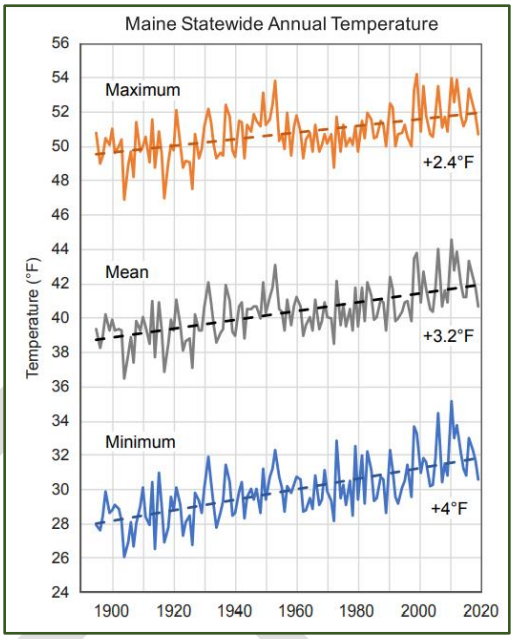


Figure 4 Maximum, mean, and minimum statewide annual temperatures from 1895 to 2019. (Source: MCC STS. 2020.)

Background Information, Trends, & Projections

Climate change is causing increased temperatures and more frequent extreme temperature occurrences. In Maine, the average annual statewide temperature has increased by 3.2°F since 1895[26] (Figure 4**Error! Reference source not found.**). Winters are warming faster than other seasons, and coastal areas have warmed more than the interior of the State. Climate models project that Maine could warm an additional 2 to 4°F by 2050 and up to 10 °F by 2100 depending on global greenhouse gas emissions. Extreme heat days are expected to be 2 - 4 times more frequent in Maine by 2050, increasing the likelihood of heatwaves. Southern Maine is expected to experience roughly 4.5 times more 'extreme heat' days, where the heat index (a combination of temperature and relative humidity that approximates the 'felt' temperature) exceeds 95°F (Figure 5)[27].

Extreme heat is one of the most significant impacts of climate change on human health and is the leading cause of weather-related deaths across the United States. Exposure to extreme heat has been linked with a wide range of health issues, including heatstroke, heat exhaustion, impacts on kidney function, dehydration, fetal health, mental health, and exacerbation of pre-existing health conditions (26). Extreme heat is also linked with increased deaths and emergency department visits. From 2011 to 2015 and 2017 to 2019, York County had the second highest number of annual emergency department

[26] MCC STS. 2020. Scientific Assessment of Climate Change and Its Effects in Maine. A Report by the Scientific and Technical Subcommittee (STS) of the Maine Climate Council (MCC). Augusta, Maine. 370 pp.
[27] Fernandez, I.J., Schmitt, C.V., Birkel, S.D., Stancioff, E., Pershing, A.J., Kelley, J.T., Runge, J.A., Jacobson, G.L. & Mayewski, P.A. (2015). Maine's Climate Future: 2015 Update. Orono, ME: University of Maine.

visits for heat-related illness across Maine, with Cumberland County seeing the highest numbers[28]. Figure 6 shows peak emergency department visits for heat-related illnesses to hospitals in York County between 2018 and 2023, the years for which monthly data is available.

Residents of cooler climates, like Maine, are less physiologically adapted to extreme heat exposure, and experience disproportionate health effects on hot days when compared to residents of warmer climates. Additionally, the prevalence of air conditioning, one of the most effective tools for preventing heat illness, is significantly lower in Maine than in the rest of the region and the country [29]. Certain populations, including older adults, infants, pregnant women, and people who have chronic diseases or who are sick already may feel much worse or have serious problems in extreme heat. Further, people with limited access to air conditioning, outdoor laborers, and unhoused populations are also more vulnerable to the impacts of extreme heat. A survey conducted by the Maine Behavior Risk Factor Surveillance System found that in 2014, 70.8% of homes in York County had some form of air conditioning, the highest percentage of all Maine counties. However, as noted above, York County also had the second highest number of heat illness emergency department visits.

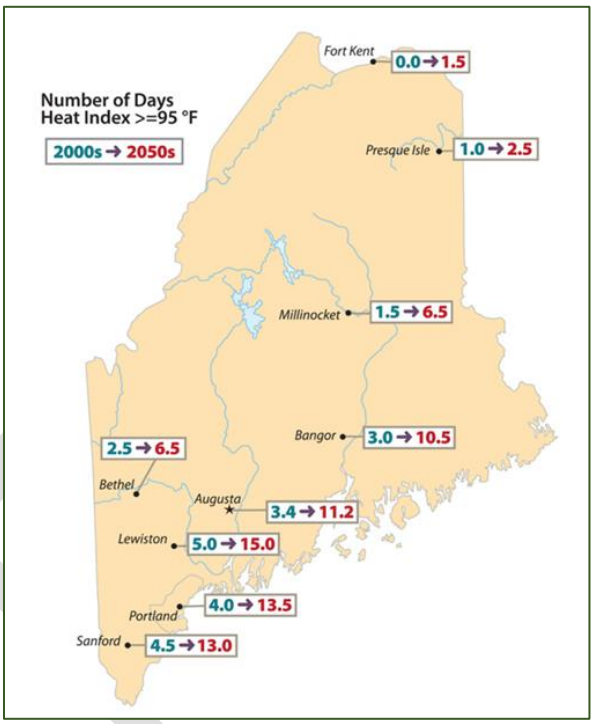


Figure 5 Average number of days when the heat index is greater than or equal to 95°F at selected sites for 2000 - 2004 and 2050 – 2054. Predicted values derived from a 48-km downscale simulation of one ensemble member of the CCSM3 model for the IPCC A2 emissions scenario. Source: Fernandez et al. (2015). (Figure from MCC STS. 2020.)

[28] Maine Health Data Organization (MHDO). Data analyzed and display prepared by the Environmental Public Health Tracking Program. Data updated: 06/2021.

[29] MCC STS. 2020. Scientific Assessment of Climate Change and Its Effects in Maine. A Report by the Scientific and Technical Subcommittee (STS) of the Maine Climate Council (MCC). Augusta, Maine. 370 pp.

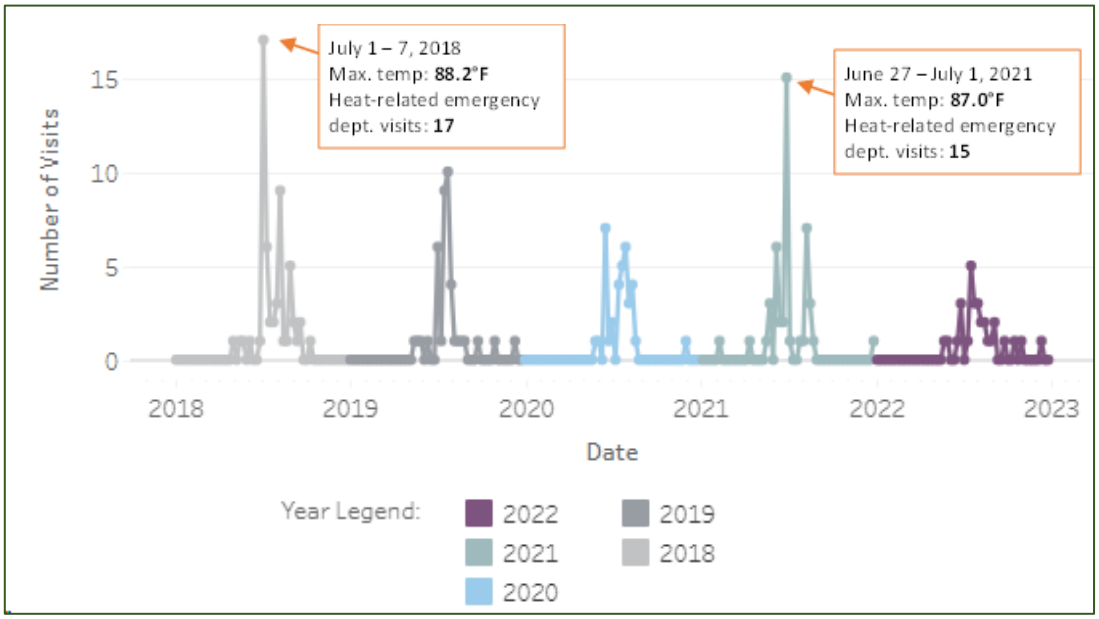


Figure 6 Number of heat illness visits to emergency departments in York County from 2018 to 2023. (Source: Maine Center for Disease Control and Prevention, Maine Tracking Network.)

Five of the ten warmest years on record have occurred within the past ten years, based on average annual temperatures from National Weather Service (NWS) data collected between 1989 and January of 2023 in Kennebunkport, the NWS data collection station closest to Saco (Table 8). The warmest average monthly temperatures for the summer months (June, July, and August) have also occurred within the past ten years and have been 3.1 – 4.3°F warmer than the monthly mean temperature. (Table 9). 2023 was the warmest January on record, with an average temperature of 31.9°, which is 8.5° warmer than the January mean temperature.

Table 8 The top ten warmest years based on average annual air temperatures measured in Kennebunkport, 1989 – January 2023. (Source: National Weather Service).

	Year	Average Annual Temperature (°F)
1	1989	49.9°
2	1998	49.0°
3	2021	47.8°
4	2010	47.7°
5	2012	47.6°
6	2020	47.2°
7	1999	47.0°
8	2006	47.0°
9	2022	46.8°
10	2016	46.7°

Table 9 The warmest average monthly temperatures of the three summer months and years in which they occurred compared with the mean monthly temperatures for those months measured in Kennebunkport, 1989 – January 2023. (Source: National Weather Service.)

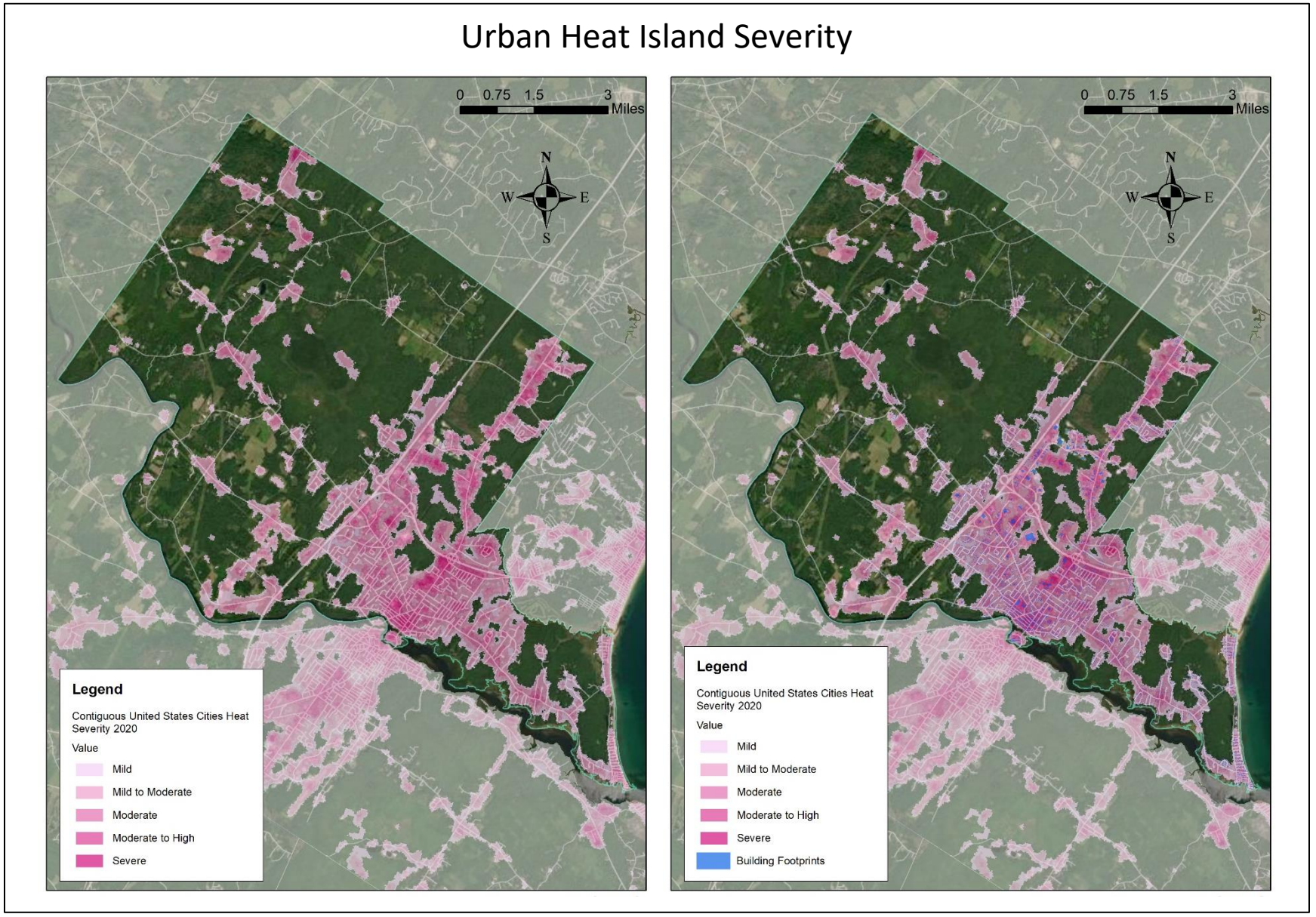
Month	Year	Average Temperature (°F)	Mean Temperature (°F), 1989 - 2022	Difference Between Mean and Average of Warmest Month
June	2021	65.7°	61.6°	+4.1°
July	2013	70.5°	67.4°	+3.1°
August	2018	70.4°	66.1°	+4.3°

Urban Heat Islands

Extreme heat days in Maine will exacerbate the severity and impacts of "heat islands", or areas with a lot of impervious surfaces, such as buildings and pavement, that absorb and re-emit heat. The Trust for Public Land notes that extreme heat exacerbated by urban heat islands can lead to increased respiratory difficulties, heat exhaustion, and heat stroke.

The two maps below show areas in Saco that are hotter than the average temperature for the community as a whole. The map on the right shows the location of building footprints in relation to heat islands. The maps show the relative heat severity measured on a scale of 1 to 5, with 1 being a relatively mild heat area (slightly above the mean for the city), and 5 being a severe heat area (significantly above the mean for the city). (*Heat island temperature data: 30-meter resolution based on data derived from Landsat 8 imagery band 10 (ground-level thermal sensor) from the summers of 2019 and 2020*.)

In Saco, the majority of the southern portion of the city is identified as having moderate to severe heat island effect in relation to the rest of the community (Map 18). Areas in and around the downtown, along I-95, Route 9, Route 112 between Route 1 and I-95, on Factory Island, and along the immediate coastline are mapped as having elevated ground temperatures in relation to the rest of the community. The downtown, areas along the northeaster portion of Main Street, and areas along Ferry Road/Route 9 that are mapped as moderate to severe heat severity also have elevated social vulnerability. Additionally, areas along the Saco River and coastline of elevated heat severity are also exposed to flood hazards, making these areas particularly vulnerable. Knowing where areas of high heat are located can inform mitigation and adaptation strategies.



Map 18 Urban heat island severity (left) overlaid with building footprints (right). Heat island severity data source: Trust for Public Land. Map created by SMDPC

Public Health Impacts

Extreme heat is one of the most significant impacts of climate change on human health and is the leading cause of weather-related deaths across the United States. Exposure to extreme heat has been linked with a wide range of health issues, including heatstroke, heat exhaustion, impacts on kidney function, dehydration, fetal health, mental health, and exacerbation of pre-existing health conditions (26). Extreme heat is also linked with increased deaths and emergency department visits. From 2011 to 2015 and 2017 to 2019, York County had the second highest number of annual emergency department visits for heat-related illness across Maine, with Cumberland County seeing the highest numbers[30]. Figure 19 shows peak emergency department visits for heat-related illnesses to hospitals in York County between 2018 and 2023, the years for which monthly data is available.

Residents of cooler climates, like Maine, are less physiologically adapted to extreme heat exposure, and experience disproportionate health effects on hot days when compared to residents of warmer climates. Additionally, the prevalence of air conditioning, one of the most effective tools for preventing heat illness, is significantly lower in Maine than in the rest of the region and the country [31]. Certain populations, including older adults, infants, pregnant women, and people who have chronic diseases or who are sick already may feel much worse or have serious problems in extreme heat. Further, people with limited access to air conditioning, outdoor laborers, and unhoused populations are also more vulnerable to the impacts of extreme heat. A survey conducted by the Maine Behavior Risk Factor Surveillance System found that in 2014, 70.8% of homes in York County had some form of air conditioning, the highest percentage of all Maine counties. However, as noted above, York County also had the second highest number of heat illness emergency department visits.

[30] Maine Health Data Organization (MHDO). Data analyzed and display prepared by the Environmental Public Health Tracking Program. Data updated: 06/2021.

[31] MCC STS. 2020. Scientific Assessment of Climate Change and Its Effects in Maine. A Report by the Scientific and Technical Subcommittee (STS) of the Maine Climate Council (MCC). Augusta, Maine. 370 pp.

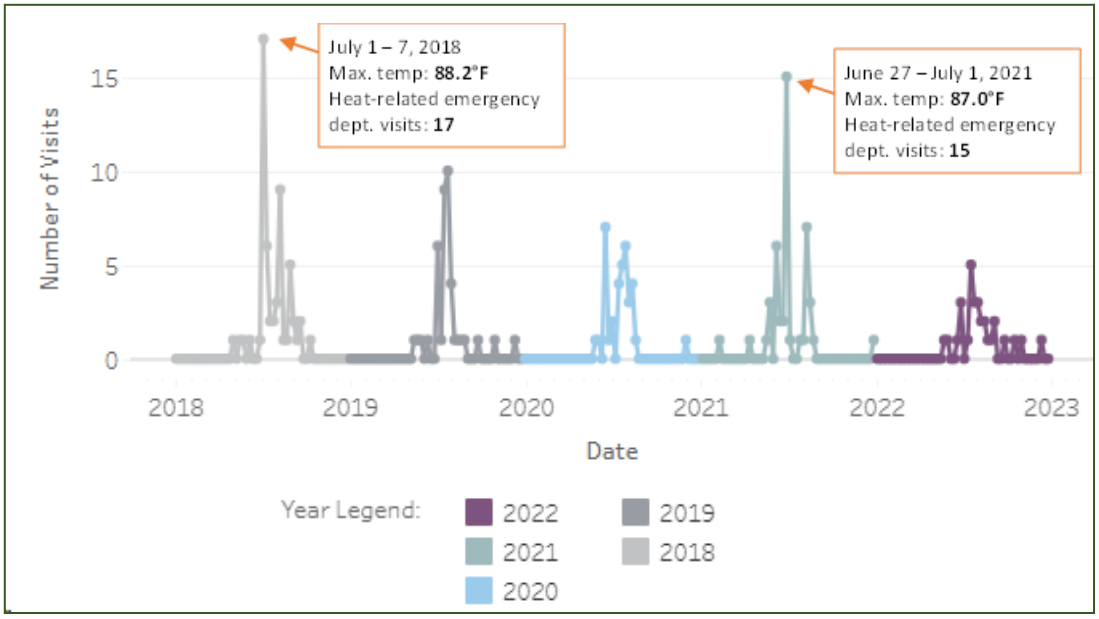


Figure 19. Number of heat illness visits to emergency departments in York County from 2018 to 2023. (Source: Maine Center for Disease Control and Prevention, Maine Tracking Network.)

Climate change can impact air quality and lead to worsening air pollution. Atmospheric warming associated with climate change has the potential to increase ground-level ozone in many regions, which may cause public health issues and present challenges for compliance with the ozone standards in the future. The impact of climate change on other air pollutants, such as particulate matter, is less certain, but research is underway to address these uncertainties.[32] Figure 7 shows the number of days in York County with an 8-hour average ozone concentration that exceeded the National Ambient Air Quality Standard of 0.070 ppm, established December 28, 2015. Previous standards were set at .075 ppm from 2008-2015 and .080 prior to 2008. Research for this assessment could find no cause of the relatively high number of exceedances between 2001 and 2007. An analysis by the Maine Department of Environmental Protection affirmatively demonstrates that Maine emissions are insignificant contributors to non-attainment of ozone for the 8-hour ozone air quality standards[33]. Regardless of the cause, individuals with existing health conditions, older populations, and children are especially vulnerable to poor air quality.

[32] US Environmental Protection Agency. Air Quality and Climate Change Research webpage.
[33] State of Maine Clean Air Act Section 176A(a)(2) Petition. 2020.

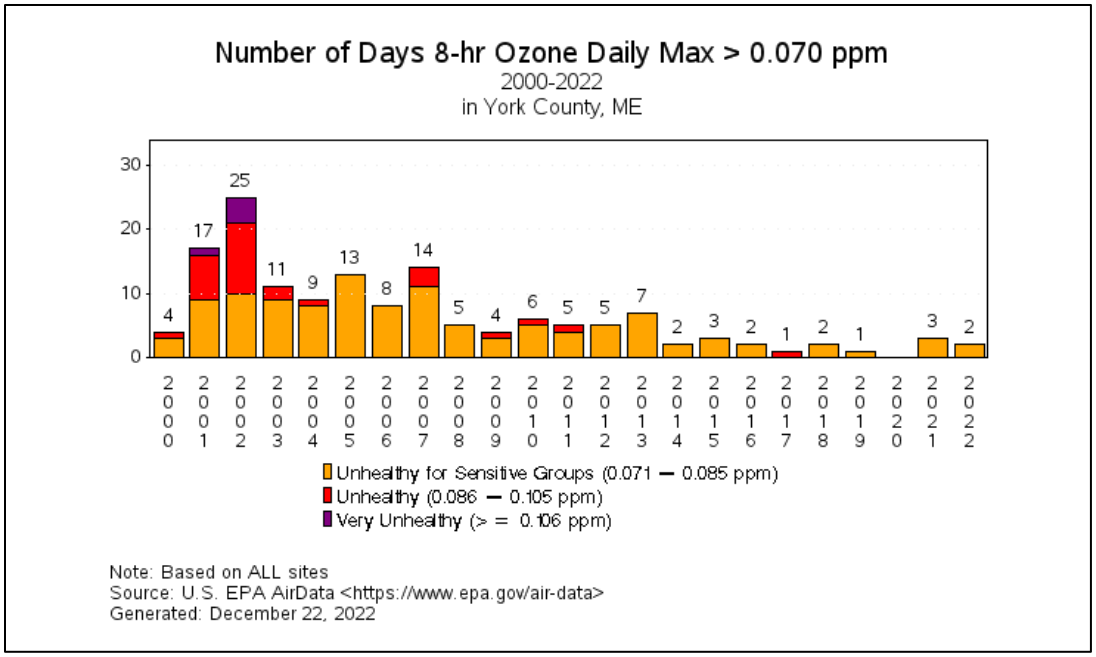


Figure 7 Number of days during which the 8-hour average ozone concentration exceeded national air quality standards. (Source: US EPA AirData portal)

The prevalence of tickborne diseases, including Lyme, anaplasmosis, and babesiosis, has increased in York County in recent years. Figure 8 shows that rates of all three diseases have increased since 2001. Table 10 shows the incidence rate (per 100,000 people) of confirmed and probable cases of tickborne disease in Saco. Between 2016 and 2020, Saco had the third lowest rate of anaplasmosis and fifth lowest rate of Lyme of all York County communities.

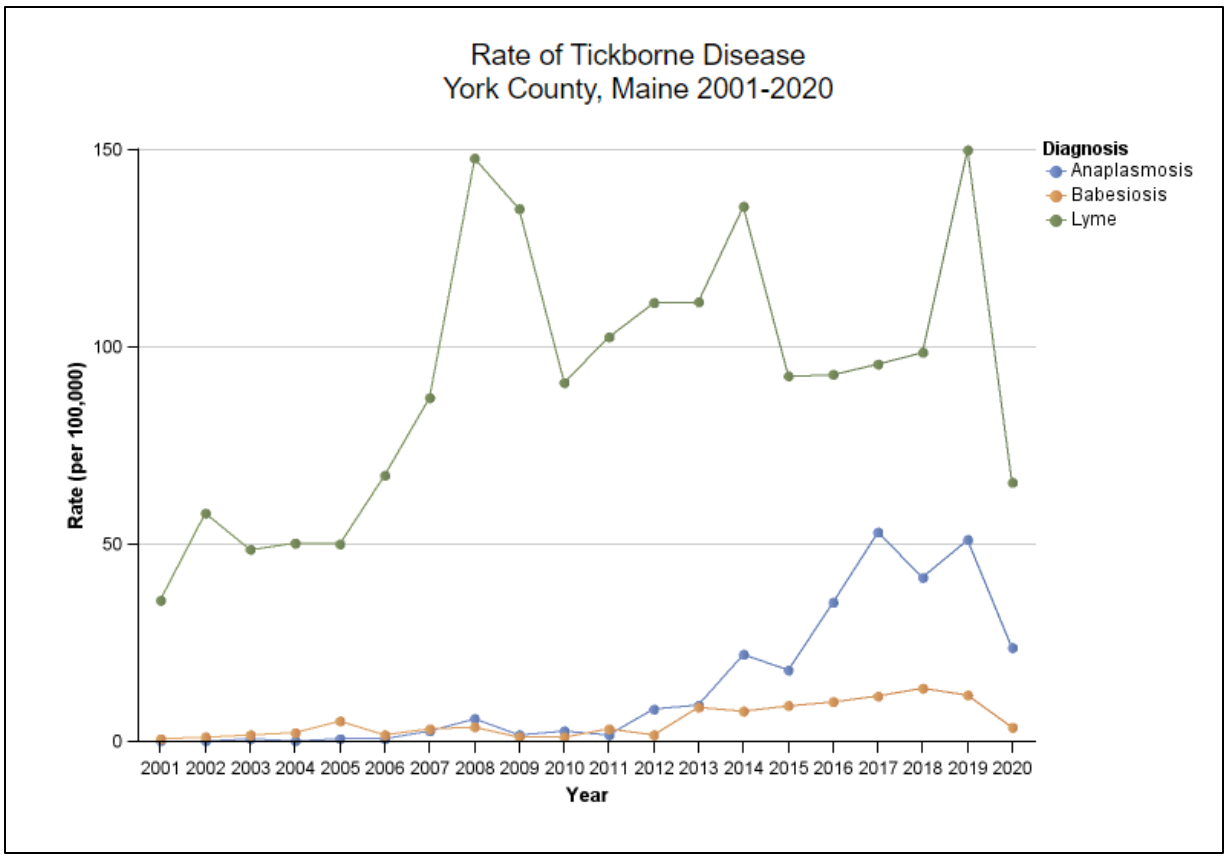


Figure 8 Annual incidence rate (per 100,000 people) of confirmed and probable cases of tickborne diseases of the population in York County. Maine CDC's Infectious Disease Program obtained these data through notifiable conditions surveillance based upon reports from healthcare providers, laboratories, and other healthcare partners. (Data Source: Maine CDC's Infectious Disease Program collected and analyzed population data from the U.S. Census Bureau to calculate state and county rates of tickborne disease. Maine CDC used population data from Maine CDC Data, Research, and Vital Statistics (DRVS) to calculate town-level rates of tickborne disease. The Maine Environmental Public Health Tracking Program prepared the data display. Data updated: 05/2021. Display updated: 05/2021.

Rate and Number of Tickborne Diseases in Saco, 2016 - 2020			
	Anaplasmosis	Babesiosis	Lyme
Confirmed and probably cases	9	3	50
Rate (per 100,000 people)	9.4	3.1	52.1

Table 10 Rate and number of confirmed and probable cases of tick-borne disease in Saco, 2016 -2020. (Source: Maine Center for Disease Control and Prevention. Infection Disease Program. Maine Tracking Network Data Portal.)

Impacts to the Natural Environment

Increasing and shifting temperatures will impact the natural environment and Maine's wildlife and vegetation. Shorter winters, less snow, a rapid expansion of pests (e.g., winter ticks), presence of parasites previously only found further south, heat stress, more frequent and higher flooding of tidal marshes, invasive species, and changes in available prey species all threaten local species and natural

areas. Increasing temperatures impact biodiversity and affect ranges where species can live. Scientists predict that 34%–58% of species will go extinct given current climate change scenarios if they are unable to disperse to new locations, while 11–33% will still go extinct even if they can disperse to future areas that are within their current climatic niche (26). Rising temperature and shorter winters will impact to Saco's natural areas, vegetation, and wildlife, in addition to how the community interacts with those areas and species.

While Maine's growing season has lengthened overall due to warming temperatures, some years have seen killing frosts in late spring and early fall. It is uncertain whether such events will become more or less frequent in the future, but the trend of longer growing seasons and warmer falls is expected to continue. Climate model projections indicate that in the future, it is likely that increased evaporation will dry surface soil layers, particularly in the warm season[34]. These changes will impact local agricultural activities as well as home gardeners.

Drought

Key Takeaways

- Despite wetter conditions overall, changing precipitation patterns caused by climate change have contributed to the emergence of drought conditions in southern Maine in recent years.
    - There have been four periods of severe to extreme drought in York County since 2000, 3 of which have occurred in the last 7 years.
- Average annual snowfall across the state has decreased about 2 inches since 1895 because more precipitation is falling as rain rather than snow. Lower spring snowpack reduces aquifer recharge, contributing to the emergence of drought.
    - Historic snowfall data in Saco are limited but align with the statewide trend of decreasing annual snowfall amounts.
- Communities supplied by groundwater wells, rivers, or smaller lakes are at greater risk of water quantity and quality impacts from drought.
    - Streamflow in the Saco River, Saco's sole public water source, reached historically low levels during 3 of the most recent droughts.
    - There are 842 private wells in Saco. Groundwater levels in York County were historically low during the 4 most recent droughts. In 2020 and 2022, 45 and 15 dry wells were reported in York County respectively.
- Wildfire risk may increase with more frequent, severe, and intense droughts, and though the likelihood of wildfires may remain low such an event could have major impacts on the community.
    - Between 1992 and 2018, Biddeford and Saco were a hotspot for wildfire occurrences compared to the rest of the county.

[34] MCC STS. 2020. Scientific Assessment of Climate Change and Its Effects in Maine. A Report by the Scientific and Technical Subcommittee (STS) of the Maine Climate Council (MCC). Augusta, Maine. 370 pp.

Background Info, Trends, & Projections

Annual precipitation in York County has increased 6.9 inches since 1895 (see Extreme Storms & Precipitation) and is expected to continue to increase with climate change. Despite wetter conditions overall, changing precipitation patterns caused by climate change have contributed to the emergence of drought conditions in southern Maine in recent years.[35] During the winter, precipitation is increasingly falling as rain rather than snow. Average annual snowfall across the state has decreased about 2 inches since 1895, and reduced snowpack depth has been even more pronounced in southern, coastal areas.[36] Spring snowmelt recharges freshwater aquifers, so less snowpack in the spring diminishes spring recharge and results in a lower water table. Low rainfall during the spring and summer along with higher-than-average temperatures can further deplete the water table, increasing the risk of summer and fall droughts.[37]

In the last few years Maine has experienced some of the driest periods in over a century. The driest May to September period since 1895 occurred during the 2020 drought, and September 2020 was the driest month since 1895.[38] In York County, there have been four periods of severe to extreme drought since 2000. These droughts occurred during the summer and fall months of 2001-2002, 2016, 2020, and 2022. There was also an extended period of moderate drought in 2015 (Figure 9).

- 2001-2002: 73%-100% of the county was in a severe drought for 28 weeks from the end of October to May 2002
- 2016: 67%-100% of the county was in a severe drought for 22 weeks from August to December, and 95% of the county was in an extreme drought for 4 weeks from the end of September to mid-October
- 2020: 74%-100% of the county was in a severe drought for 12 weeks from September to December, and 70%-76% of the county was in an extreme drought for 6 weeks from late September to the end of October
- 2022: 66% of the county was in a severe drought for 4 weeks in August

[35] ME Drought Task Force Report, 10/6/2022: https://www.maine.gov/mema/hazards/drought-task-force
[36] University of Maine, Maine's Climate Future, 2020: https://climatechange.umaine.edu/climate-matters/maines-climate-future/
[37] ME Drought Task Force Report, 10/6/2022: https://www.maine.gov/mema/hazards/drought-task-force
[38] ME Climate Council, Maine Climate Science Update 2021: http://climatecouncil.maine.gov/reports

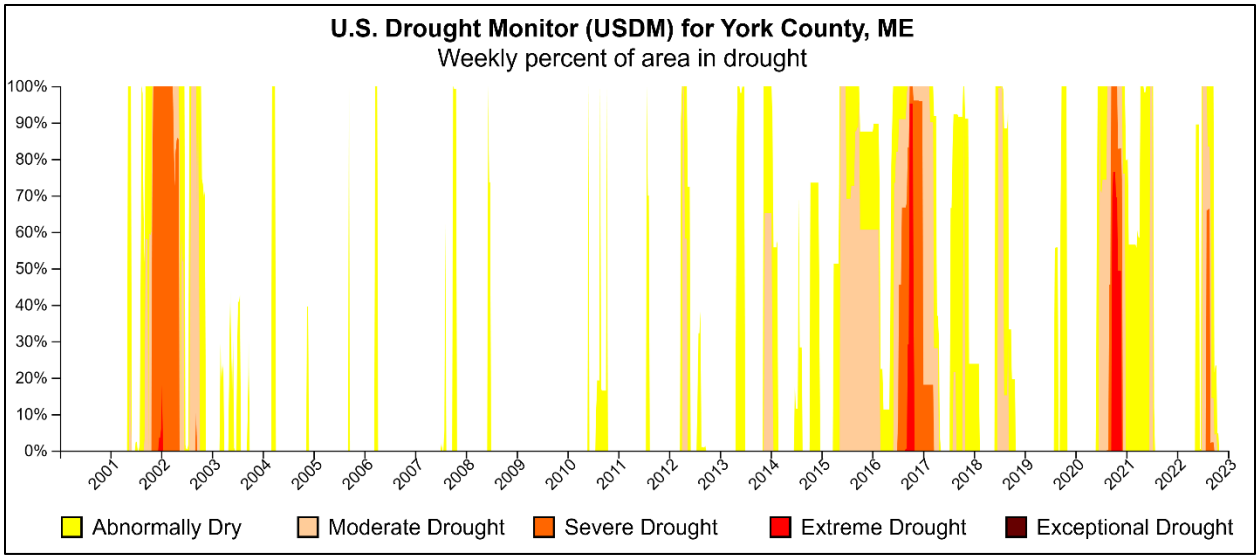


Figure 9 Drought conditions in York County from 2000 to 2022. Four severe to extreme droughts have occurred over the last 20 years and droughts have occurred more frequently in the last decade. Data source: U.S Drought Monitor.

There is limited data for snowfall and snowpack depth in Saco. From 1994 to 2017, snowpack depth was collected at the Tannery Waste Pits site in Saco and reported to the Maine Geological Survey as part of the Maine Cooperative Snow Survey (Figure 10). Historically, March has been the snowiest month in this area. Though data are limited in more recent years, the maximum monthly snowfall amounts recorded at this site in February 2012 and April 2017 were 0 inches.

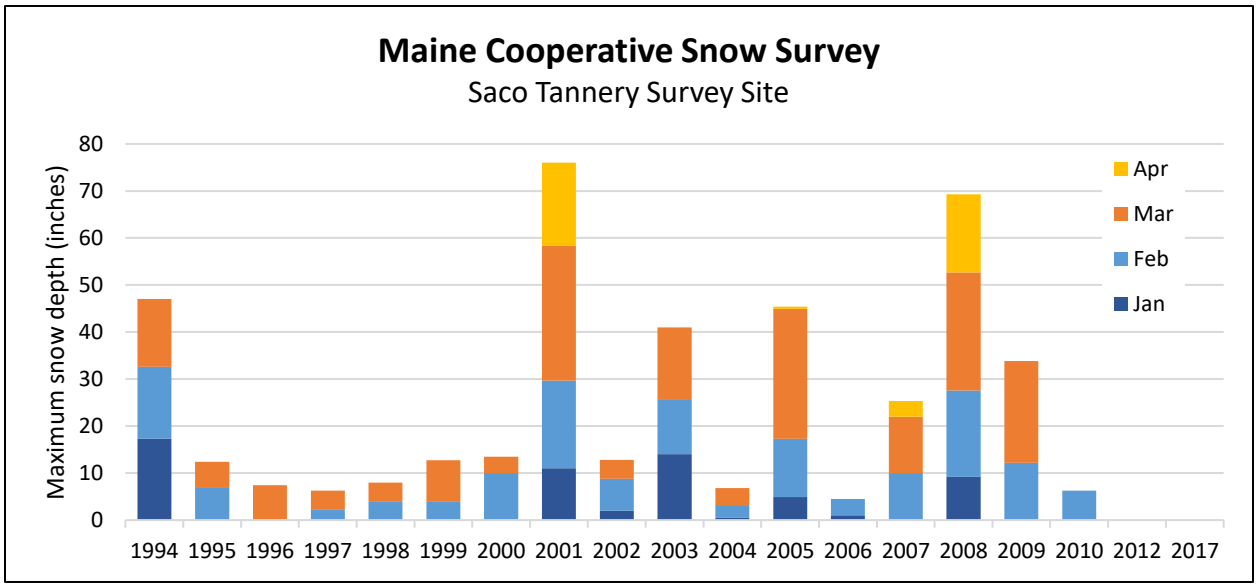


Figure 10 Maximum snow depth at Saco Tannery Survey Site, 1994-2017. Data source: Maine Geological Survey Cooperative Snow Survey

Combined snowfall amounts in Saco during the winters of 2020-21 and 2021-22 were about 2-4 feet less than the previous 30 years, based on data from the Maine Drought Task Force. The snowfall deficit over the last two winters resulted in reduced spring snowpack and aquifer recharge, contributing to the

emergence of a summer and fall drought in 2022.[39] As future precipitation patterns in southern Maine continue to shift towards more rain and less snow, the risk of drought will likely increase.

Water Supply Impacts

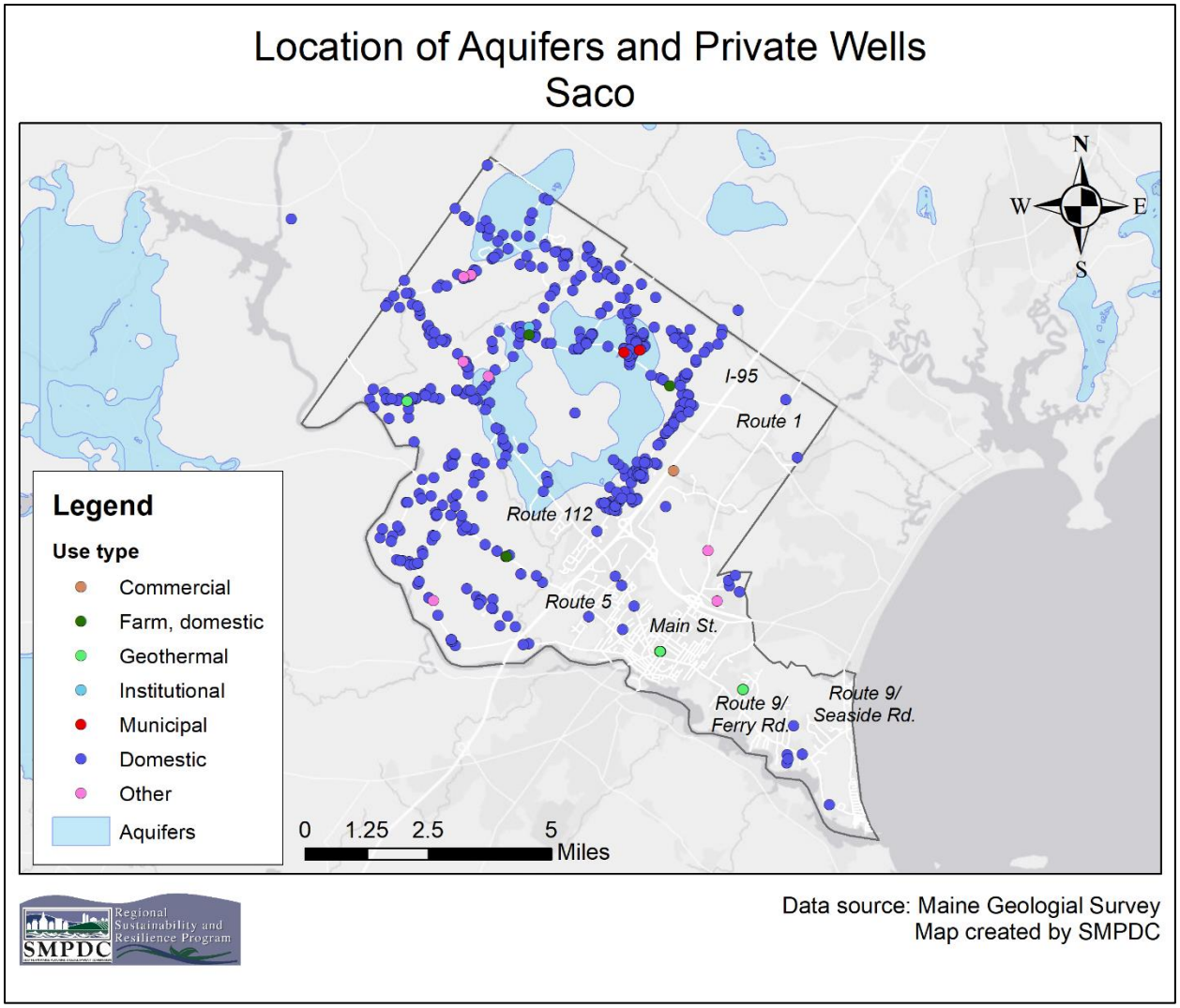
Intense and prolonged droughts have the potential to diminish surface and groundwater supplies and degrade water quality.[40] Communities supplied by groundwater wells, rivers, or smaller lakes are at greater risk of water quantity and quality impacts from drought.[41] The City of Saco is serviced by the Biddeford and Saco Division of the Maine Water Company, and the Saco River is the sole source of Saco's public water supply.[42]

The United States Geological Survey (USGS) monitors daily streamflow conditions in the Saco River. Since 2000, the lowest recorded streamflows occurred in September 2002, October 2016, and September 2020, coinciding with the three most prolonged and intense droughts in the region.[43]

To date, it does not appear that the Biddeford and Saco Division of the Maine Water Company has experienced significant water quality or quantity issues because of drought.[44] However, the Maine CDC Drinking Water Program did receive reports of low water quantity from public water suppliers during the 2022 summer drought.[45] Additionally in the summer of 2022, the public water supply in Berwick, sourced by the Salmon Falls River, contained elevated levels of manganese due to low water levels, making it unsafe for children to drink.[46] In the future, more frequent, prolonged, or intense droughts have the potential to cause similar types of issues with Saco's public water supply.

Drought can also impact water quantity and quality in private wells. There are a total of 842 private wells in Saco (476 wells have location data and are displayed on Map 19), and 95% of these wells are for domestic use.

[39] ME Drought Task Force Report, 10/6/2022: https://www.maine.gov/mema/hazards/drought-task-force
[40] ME Climate Council, Maine Climate Science Update 2021: http://climatecouncil.maine.gov/reports
[41] Casco Bay Estuary Partnership, Climate Trends in Casco Bay, 2015: https://www.cascobayestuary.org/publication/climate-trends-in-the-casco-bay-region/
[42] Maine Water Company, Biddeford and Saco 2021 Water Quality Report: https://www.mainewater.com/water-quality/water-quality-report
[43] USGS Streamflow monitoring data: https://waterdata.usgs.gov/monitoring-location/01066000/#parameterCode=00065&period=P7D
[44] EPA Safe Drinking Water Information System: https://ordspub.epa.gov/ords/sfdw/f?p=SDWIS_FED_REPORTS_PUBLIC:PWS_SEARCH:::::PWSID:ME0090170
[45] ME Drought Task Force Report, 8/4/2022: https://www.maine.gov/mema/hazards/drought-task-force
[46] Maine Public, 8/4/2022: https://www.mainepublic.org/environment-and-outdoors/2022-08-04/berwick-issues-drinking-water-advisory-due-to-ongoing-drought-conditions



Map 19 Location of aquifers and private wells in Saco, including well use type. Data source: Maine Geological Survey

The USGS monitors groundwater levels in York County at an index well in Sandford (Figure 11). Since 2000, the lowest recorded groundwater levels occurred in November 2002, October 2015, and October 2016, coinciding with the 2002 and 2016 droughts. Groundwater levels were also low in October 2020, coinciding with the 2020 drought, though not as low as the previous two droughts.

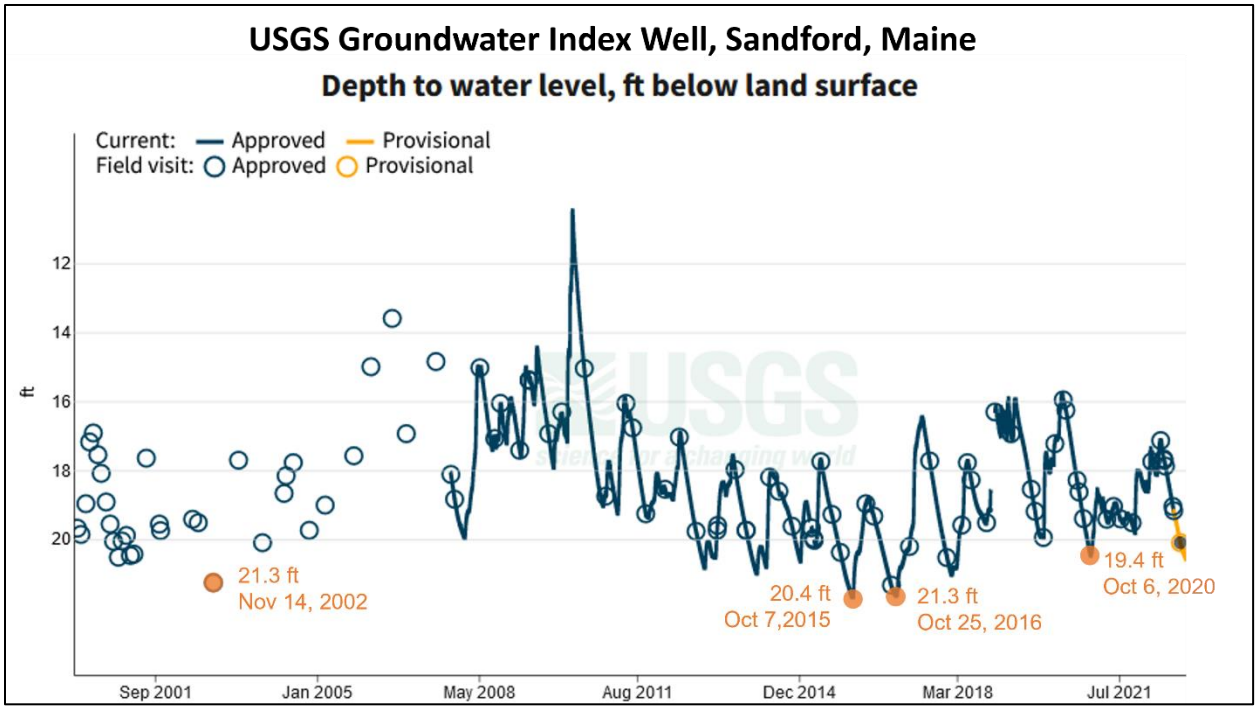


Figure 11 Groundwater levels in York County measured at an index well in Sandford, 2001-2021. Data source. United States Geological Survey

Since 2020, the Maine Drought Task Force has collected data about wells that run dry due to drought (Table 11). In 2020, 45 wells in York County ran dry compared to 2 in 2021, and 15 in 2022. Though these data are limited, they correlate with the intensity of the 2020 drought compared to the 2022 drought. In the future, more frequent, prolonged, or intense droughts could pose a risk to the hundreds of homeowners and businesses in Saco who rely on groundwater wells as their water source.

Table 11 Number of dry wells reported in York County, 2020-2022. Data source: Maine Emergency Management Agency

Maine Dry Well Survey			
Year	**2020**	**2021**	**2022**
York County	45	2	15

Impacts to the Natural Environment

Some of the environmental impacts of drought are listed in Table 12.

Table 12 Environmental impacts of drought. Data source: 2018 York County Hazard Mitigation Plan, Pennsylvania

Damage to animal species	Damage to plant communities
• lack of feed and drinking water • disease • loss of biodiversity • migration or concentration • degradation of fish and wildlife habitats	• loss of biodiversity • loss of trees from urban landscapes and wooded conservation areas • Increased number and severity of fires • Reduced soil quality

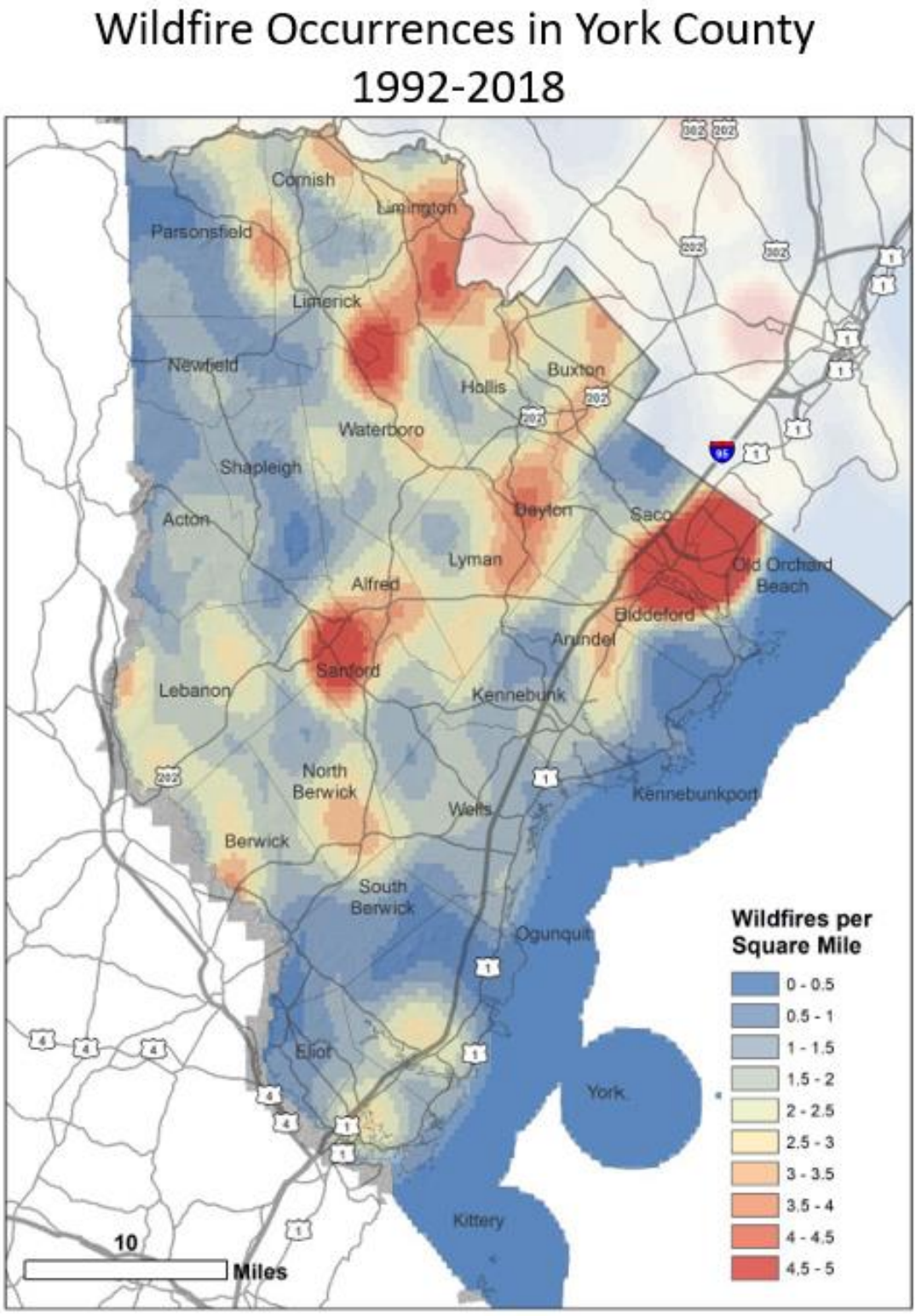
Although wildfire risk may seem small in Maine compared to the western U.S., wildfires do occur and are often associated with periods of drought. In 1947, drought induced wildfires burned over 200,000 acres across the state.[47] The Maine Drought Task Force reported a higher number of wildfires in 2020, compared to 2021 and 2022, coinciding with the long, intense drought that summer and fall (Table 13).[48]

Table 13 Annual number of wildfires statewide 2020-2022. Data source: Maine Drought Task Force 10/6/2022 Report

Maine Wildfire Occurrences			
Year	**2020**	**2021**	**2022**
Annual total	1,154	650	624

In neighboring Biddeford, there were two large wildfires during the 2002 summer drought which destroyed about 10 acres.[49] More recently, in April 2020 a large wildfire burned about 20 acres of wooded area and took 3 hours to get under control.[50] Between 1992 and 2018, Biddeford and Saco were a hotspot of wildfire occurrences compared to the rest of the county (Map 20).[51] In the future, more frequent, prolonged, or intense droughts have the potential to increase the risk of wildfires, posing a threat to Saco's natural environment and public safety.

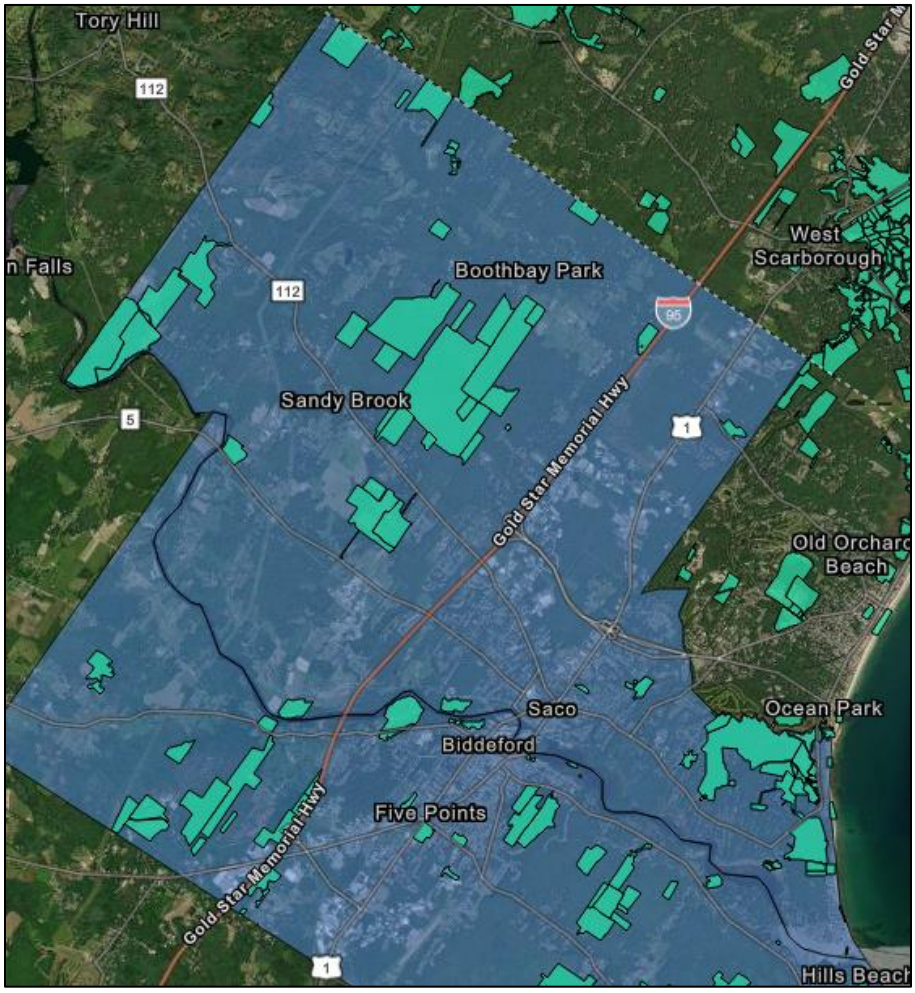
[47] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management
[48] ME Drought Task Force Report, 10/6/2022: https://www.maine.gov/mema/hazards/drought-task-force
[49] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management
[50] Portland Press Herald: https://www.pressherald.com/2020/04/06/wildfires-rage-across-maine-on-monday/
[51] York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management



Map 20 Wildfire occurrence in York County per square mile, 1992-2018. Data source: York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management

The Saco Heath Preserve, located off Route 112, is the largest swath of conserved land in Saco and is held by the Nature Conservancy (Map 21). Other significant conserved lands include Horton Woods off Route 112, and an area held by Maine Farmland Trust around the Ecology School. The marsh at the mouth of Goosefare Brook is conserved by the USFWS Rachel Carson National Wildlife Refuge and Ferry Beach State Park is conserved by the State. There are several smaller pockets of conserved land throughout the community that are held either by the City of the Saco or the Saco Valley Land Trust.

The Saco Heath Preserve includes freshwater wetlands, freshwater aquifers, rare and endangered species habitat, and deer winter areas. Horton Woods and the area around the Ecology School have important river habitat, freshwater wetlands, and deer winter areas. Some of the richest habitat in Saco is located at the mouth of Goosefare Brook and is part of the National Wildlife Refuge. This area includes tidal marshes, freshwater wetlands, rare and endangered species habitat, important river habitat, tidal waterfowl and wading bird habitat, and deer wintering areas. Further south along the shore, Ferry Beach State Park and the banks of the Saco River have important habitat areas including tidal marshes, freshwater wetlands, rare and endangered species habitat, and tidal waterfowl and wading bird habitat. In the future, more frequent, prolonged, or intense droughts have the potential to degrade these critical habitat areas.



Map 21 Conserved lands in Saco are indicated by the green polygons. Data source: Maine Natural Areas Program. Map source: Climate Ready Coast Southern Maine

Agricultural Impacts

Drought can impact agricultural operations due to shifts in the growing season, crop losses, and increased costs associated with irrigation. During the 2022 drought, the Maine Drought Task Force reported that farmers had to irrigate their crops, increasing their operational costs.[52] In both 2020 and 2022, the Farm Services Administration issued emergency declarations for York County as a result of prolonged, severe drought conditions.[53] Even if farmers have irrigation systems, water supply can still be an issue. The Maine Department of Environmental Protection restricts irrigation withdrawals when stream and river levels fall below a certain threshold.[54]

Saco is known for its beautiful beaches and picturesque downtown, but the City has a strong agricultural heritage as well. There are several operating farms in Saco that grow fruits and vegetables and raise goats and horses. Every Saturday during the summer and fall a farmer's market is held at the Saco Valley Shopping Center. In the future, more frequent, prolonged, or intense droughts have the potential to reduce local farmer's production, increase their costs, and disrupt the local food system.

Changing Marine Conditions

Key Takeaways

- In the last 40 years, ocean temperatures have risen faster in the Gulf of Maine than almost anywhere else in the world and will likely rise 1.5°F by 2050, resembling present day conditions in southern New England.
    - There is limited commercial fishing and aquaculture activity in Saco, however the individuals who rely on these commercial fishing for their livelihoods are vulnerable to the economic impacts of changing marine conditions.
- Ocean and coastal acidification are expected to worsen due to higher amounts of carbon dioxide in the atmosphere and more frequent precipitation events.
- The dynamics of harmful algal blooms (HABs) in Maine have shifted in recent years and could continue to change in the future, posing new threats to public health.
- Eelgrass is an important nursery habitat for commercially important species and is an indicator species for overall ecosystem health.
    - Changes in eelgrass habitat suggest that water quality at the mouth of the Saco River deteriorated between 1997 and 2010, potentially because of increased stormwater runoff or changing wastewater management practices.
    - In the future, more frequent and intense precipitation and increasing invasive species have the potential to decimate eelgrass habitat, reducing the localized carbon sink and coastal resilience benefits.

Background Info, Trends, & Projections

Southern Maine is located in the Gulf of Maine which stretches from Cape Cod to Nova Scotia. Since 1982, ocean temperatures in the Gulf of Maine have risen 96% faster than the rest of the world's oceans

[52] ME Drought Task Force Report, 8/4/2022: https://www.maine.gov/mema/hazards/drought-task-force
[53] Cumberland County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.cumberlandcounty.org/231/Hazard-Mitigation
[54] Maine DEP Press Release: https://www.maine.gov/dep/news/news.html?id=8535391

due to rising air temperatures and shifting ocean currents caused by climate change.[55] Marine species ranges are shifting northward following their habitats. Lobster stocks in Long Island Sound and southern New England have collapsed, and as ocean temperatures continue to warm, Maine's lobster resource could be headed in the same direction. Warming waters have also allowed invasive species like green crabs, Asian shore crabs, and tunicates to proliferate. Future projections indicate that by 2050 ocean temperatures in Maine will likely rise 1.5°F, and the marine ecosystem will resemble present day conditions in southern New England.[56]

The oceans are also becoming more acidic. As carbon dioxide builds up in the atmosphere from the burning of fossil fuels, some of that carbon dioxide is absorbed into the ocean. Dissolved carbon dioxide changes the chemical conditions of the water, making it more acidic. In coastal areas, ocean acidification is exacerbated by nutrient rich runoff which can trigger agal blooms. As the blooms die off and decay, the water becomes more acidic. Ocean and coastal acidification primarily impact shellfish species like scallops, oysters, clams, and mussels, all of which are commercially harvested in Maine. Both ocean and coastal acidification are expected to worsen in the future with increasing fossil fuel emissions and increasing and intensifying rainfall events.[57]

It is hypothesized that warming waters and shifting currents due to climate change are changing the dynamics of harmful algal blooms (HABs) in Maine. Every summer Maine has a "red tide" when a toxin producing phytoplankton species blooms. Shellfish become contaminated with the toxin and when eaten can cause Paralytic Shellfish Poisoning. In recent years, Maine has experienced blooms of new HAB species that have different impacts on human health and the ecosystem. Currently it is unclear how HAB dynamics may shift with climate change, but coastal Maine communities are facing an uncertain future regarding the public health, economic, and ecosystem impacts of HABs.

Habitat Shifts and Carbon Sinks

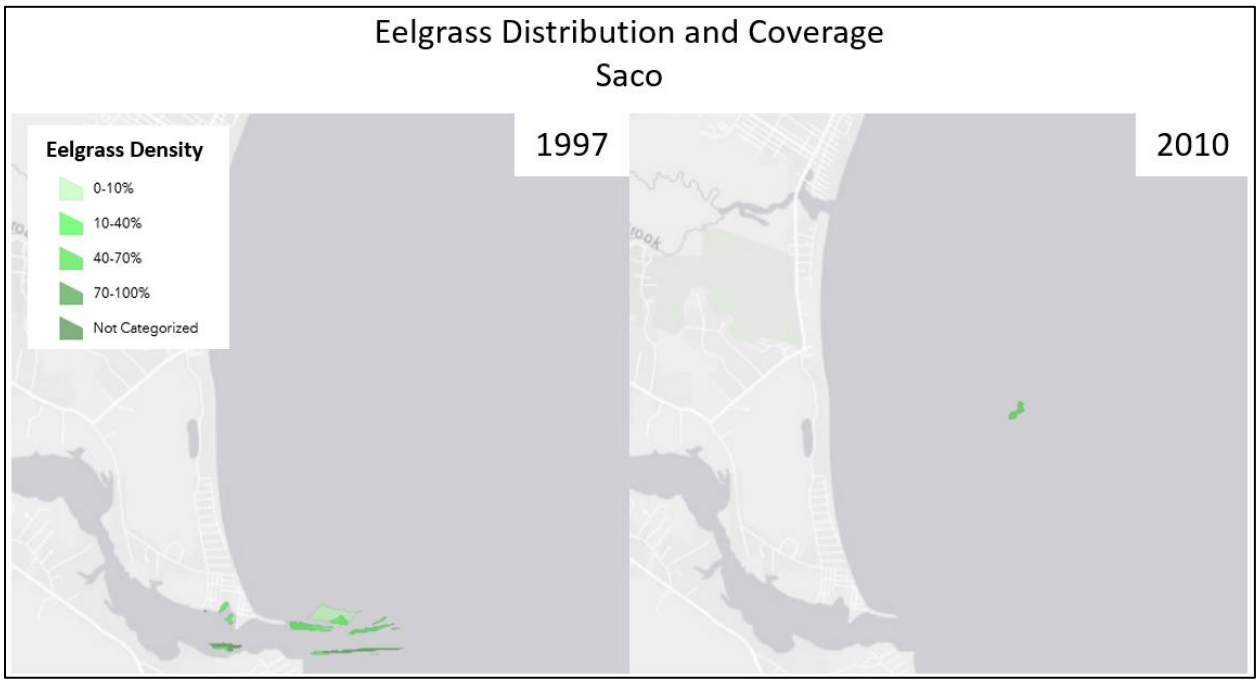
Eelgrass beds are critical marine habitat for commercially important species such as fish and shellfish. It is also vital to estuarine ecosystem functioning because it provides nursery habitat for many species. Eelgrass is sensitive to sediment loading and pollutants often caused by poor stormwater and wastewater management. Invasive species including the European green crab and various tunicate species also destroy eelgrass habitat, uprooting plants and smothering growth. As a result, eelgrass habitat loss is generally indicative of poor watershed management practices and declining ecosystem health.[58]

DMR surveyed eelgrass distribution in Saco in 1997 and again in 2010 (Map 22). In 1997, the greatest distribution and highest density of eelgrass habitat was located at the mouth the mouth of the Saco River. Between 1997 and 2010, eelgrass habitat disappeared completely in Saco expect for a small offshore patch near Eagle Island. These changes suggest that water quality in the Saco River declined

[55] https://www.gmri.org/stories/gulf-of-maine-warming-update-summer-2021/
[56] University of Maine, Maine's Climate Future, 2020: https://climatechange.umaine.edu/climate-matters/maines-climate-future/
[57] ME Climate Council, Scientific Assessment of Climate Change and Its Effects in Maine, 2020: http://climatecouncil.maine.gov/reports
[58] Piscataqua Region Estuaries Partnership: https://prepestuaries.org/eelgrass/

over this time period, potentially as a result of increasing stormwater runoff or changing wastewater management practices.

In the decade since DMR's 2010 eelgrass survey, distribution and coverage may have shifted. Substantial eelgrass habitat losses were observed in Casco Bay between 2012 and 2013 coinciding with a rapid increase in the green crab population.[59] Saco may have experienced similar losses, but there is no data available for current eelgrass habitat distribution. Regardless, the 1997 and 2010 survey data show where critical eelgrass habitat existed historically and suggest how the ecosystem has been impacted by watershed management practices.



Map 22 Distribution and coverage of eelgrass habitat in Saco in 1997 and 2010 based on the Department of Marine Resources eelgrass survey. Exact distribution ranges may have shifted in the last decade, but these data indicate the presence of historic eelgrass habitat and potential carbon sinks.

In the future, extreme precipitation events are expected to become more frequent and intense which will likely present new and increasing stormwater and wastewater management challenges. The shorefront from Kinney Shores to Camp Ellis also has a high degree of impervious surfaces (see Extreme Storms & Precipitation), which increases runoff during heavy rainfall events and degrades coastal water quality. Additionally, warming ocean temperatures favor green crab population growth which may contribute to future eelgrass habitat loss.[60]

There is evidence that eelgrass beds can serve as carbon sinks, absorbing carbon dioxide from the water and locally reducing the influence of ocean and coastal acidification. The vegetation also stabilizes sediments and reduces wave action which has the potential to buffer coastlines from intense coastal

[59] Casco Bay Estuary Partnership, Eelgrass Beds Decline as Green Crab Numbers Explode, 2015: https://www.cascobayestuary.org/wp-content/uploads/2015/10/Indicator_Eelgrass.pdf
[60] ME Climate Council, Scientific Assessment of Climate Change and Its Effects in Maine, 2020: http://climatecouncil.maine.gov/reports

storms. For these reasons, eelgrass habitat is not only important for its role in ecosystem functioning, but also for the climate mitigation and resilience benefits it provides. These ecosystem services emphasize the importance of protecting this vulnerable habitat.[61]

Economic Impacts

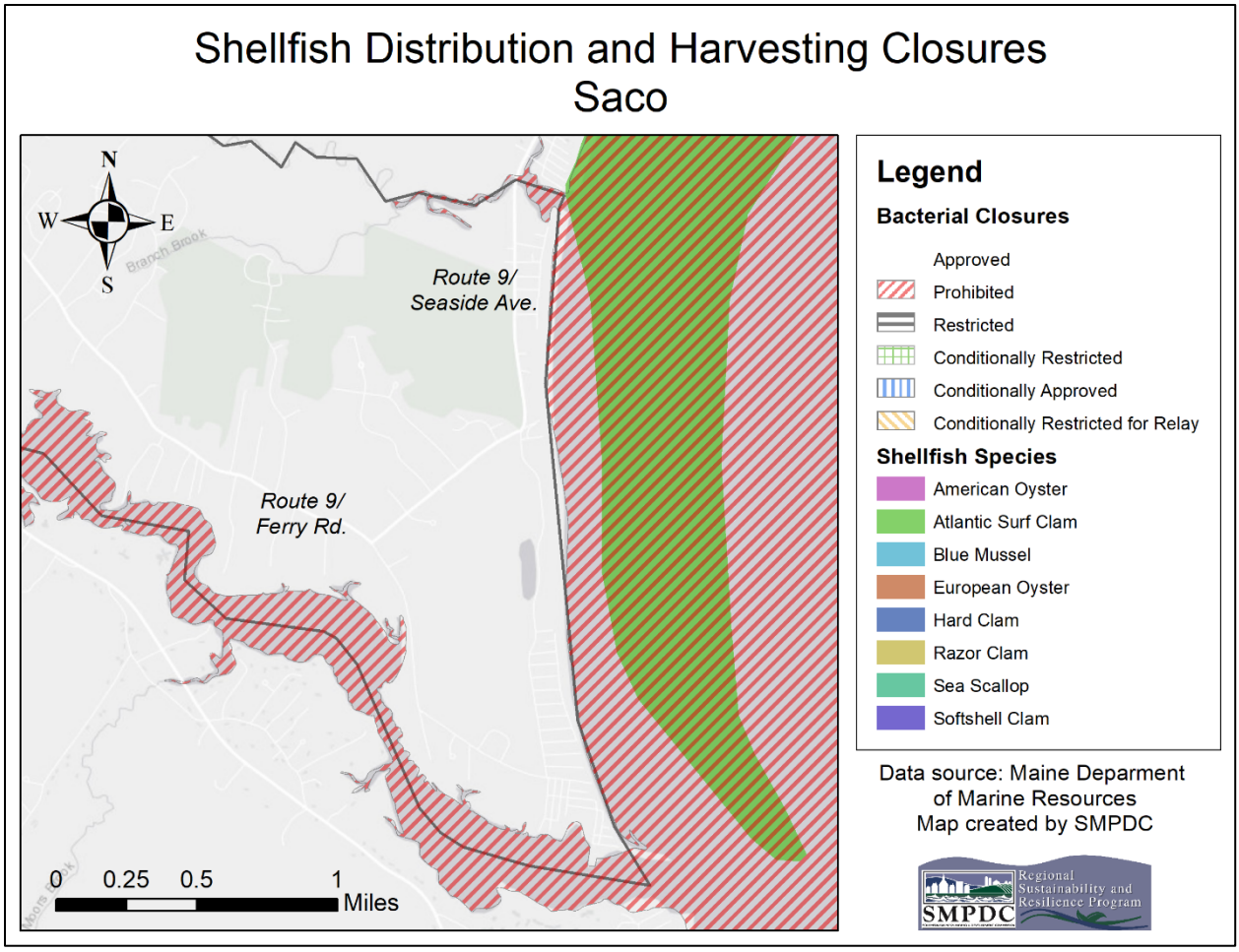
There are a total of 43 commercial fishing licenses held in Saco and 83 non-commercial licenses (Table 14). The majority of these licenses are for harvesting lobster and crab, or fish. Individuals who rely on these fisheries for their livelihoods, especially lobster, may experience economic impacts as species' ranges shift with climate change. Recreational fishing opportunities for non-commercial license holders may also be impacted, representing a significant cultural loss for the community's identity.

Table 14 Commercial and non-commercial fishing licenses in Saco. Data source: Maine Department of Marine Resources.

Commercial and Non-Commercial Fishing Licenses	
Commercial	**Number of Licenses**
Lobster/crab	19
Fishing	15
Menhaden	3
Shellfish	2
Scallop dragger	2
Green crab	1
Elver	1
Total	*43*
Non-Commercial	
Lobster/crab	42
Saltwater fishing	41
Total	*83*

In 2010, the Maine Department of Marine Resources (DMR) conducted a survey of shellfish habitat across the state. Based on that survey, there was a significant Atlantic surf clam bed along Saco's coastline (Map 23). However, shellfish harvesting is prohibited in Saco's coastal waters and the Saco River estuary. As a result, wild shellfish harvesting is limited in Saco and there are only 2 commercial shellfish harvesters in Saco. The community is therefore less economically vulnerable to the impacts of climate change on shellfish species. However, warmer waters, ocean acidification, and HABs have the potential to impact these species which are a critical part of the marine ecosystem.

[61] ME Climate Council, Scientific Assessment of Climate Change and Its Effects in Maine, 2020: http://climatecouncil.maine.gov/reports



Map 23 Distribution of shellfish species based on a survey conducted by the Maine Department of Marine Resources in 2010. Areas that are prohibited for shellfish harvesting based on poor water quality from bacterial contamination are also indicated. Data source: Maine Department of Marine Resources.

In the last decade aquaculture has exploded in Maine, particularly in southern Maine where the impacts of the declining lobster fishery have been felt more acutely. Aquaculture is viewed as a climate resilient alternative to wild harvest fisheries like lobster. There are no shellfish farms in Saco, likely because coastal waters are closed to shellfish harvesting. The only aquaculture activity is an experimental lease site off Ram Island for growing sugar kelp held by the University of New England. Shifting marine conditions due to climate change have the potential to impact aquaculture operations, however based on current limited aquaculture activity, Saco is not directly vulnerable to these economic impacts.