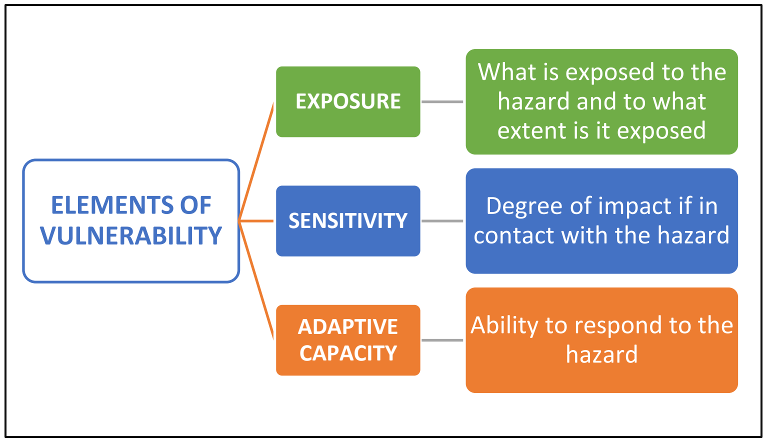
Climate Change Vulnerability Assessment Summary

BIDDEFORD

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.



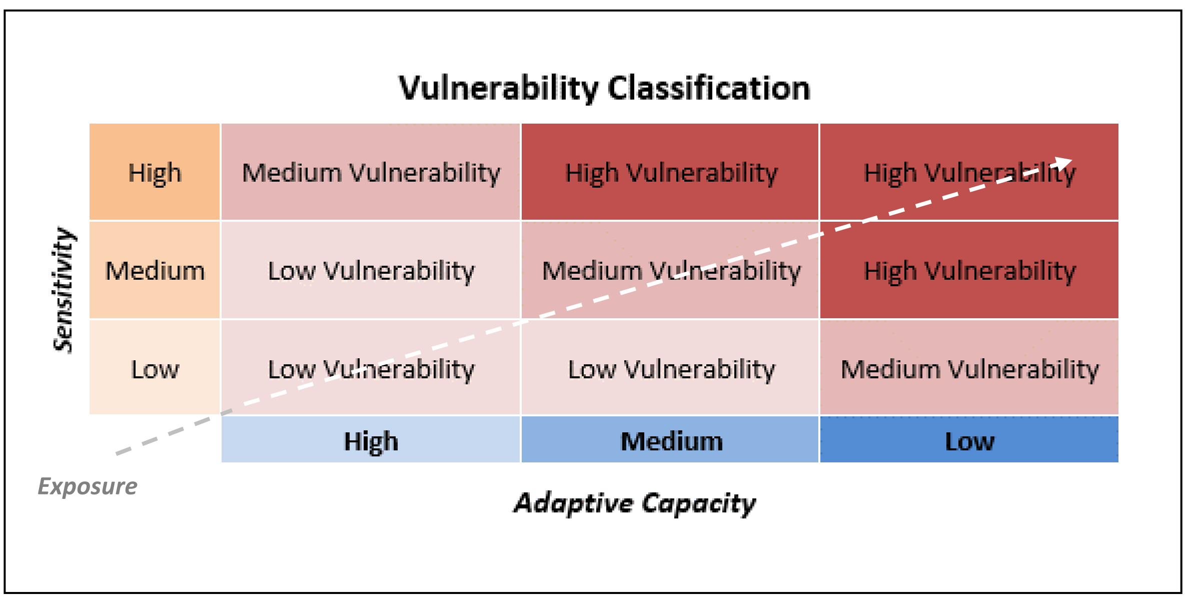


Figure adapted from NOAA. 2022. Implementing the Steps to Resilience: a Practitioner's Guide.

This draft vulnerability assessment summary presents an overview of climate hazards and associated impacts and vulnerabilities for the community of Biddeford. 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 climate hazard exposure within each Cohort community. 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 over the next several months. The project team will support the gathering of that information through input and feedback from the community Task Force and the broader community through engagement activities. **This assessment will be updated and refined by the project team throughout the CAP process.**

Key Takeaways

- Biddeford'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, or are age 65+ and living alone.
- The downtown area also is designated as 'disadvantaged' by the US Council on Environmental Quality due to the area's low life expectancy, elevated rates of asthma, and low household income relative to national conditions and co-occurring climate and/or environmental hazards, including heat and flooding. Biddeford is the only community in southern Maine with a designated 'disadvantaged' area and the designation carries priority for certain federal funding programs.
- Extreme heat and temperatures are increasing in Biddeford 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 Biddeford, especially Biddeford, Pool, Fortunes Rocks, and Granite Point, as well as low-lying areas along the Saco River, 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 older individuals and structures built before modern building codes, making them more sensitive to flood hazards.
- 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 small 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 19 block groups in Biddeford. The locations of Biddeford's 19 block groups are shown in Figure 1.

The ACS is conducted annually on an ongoing basis throughout the year to collect information about 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

[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

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]

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 Biddeford (block groups 4-14) is the most socially vulnerable area based on the 17 demographic indicators. This area has elevated social vulnerability across all indicators except for the percent of the block group population that is over the age of 65.
- The neighborhood around the downtown USPS Post Office (block group 5) has the highest percentage of the population and households within the block group that have a disabled person, are below the national poverty level, have an annual income below the EPA climate change and social vulnerability threshold, are below the County and State median incomes, have no vehicle, are living alone, and are age 65 or older living alone. This block group also has an elevated percentage of households with no internet access compared to the rest of the community.
- The neighborhood around Springs Island, east of Biddeford High School (block group 7) has an elevated percentage of households within the block group that have a disabled person, are below the national poverty level, single parent households, below the EPA climate change and social vulnerability income threshold, below the County and State median incomes, and have no vehicle or internet access compared to the rest of the community.
- The neighborhood around the old mill buildings between Main Street and Elm Street (block group 13) has an elevated percentage of the population within the block group that are minorities, speak English less than well, have no high school diploma, and are unemployed compared to the rest of the community.
- Across the entire community 32% percent of households have at least one disabled person, 41% are below the EPA climate change and social vulnerability income threshold, and the majority of households are below the County and State median incomes.

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

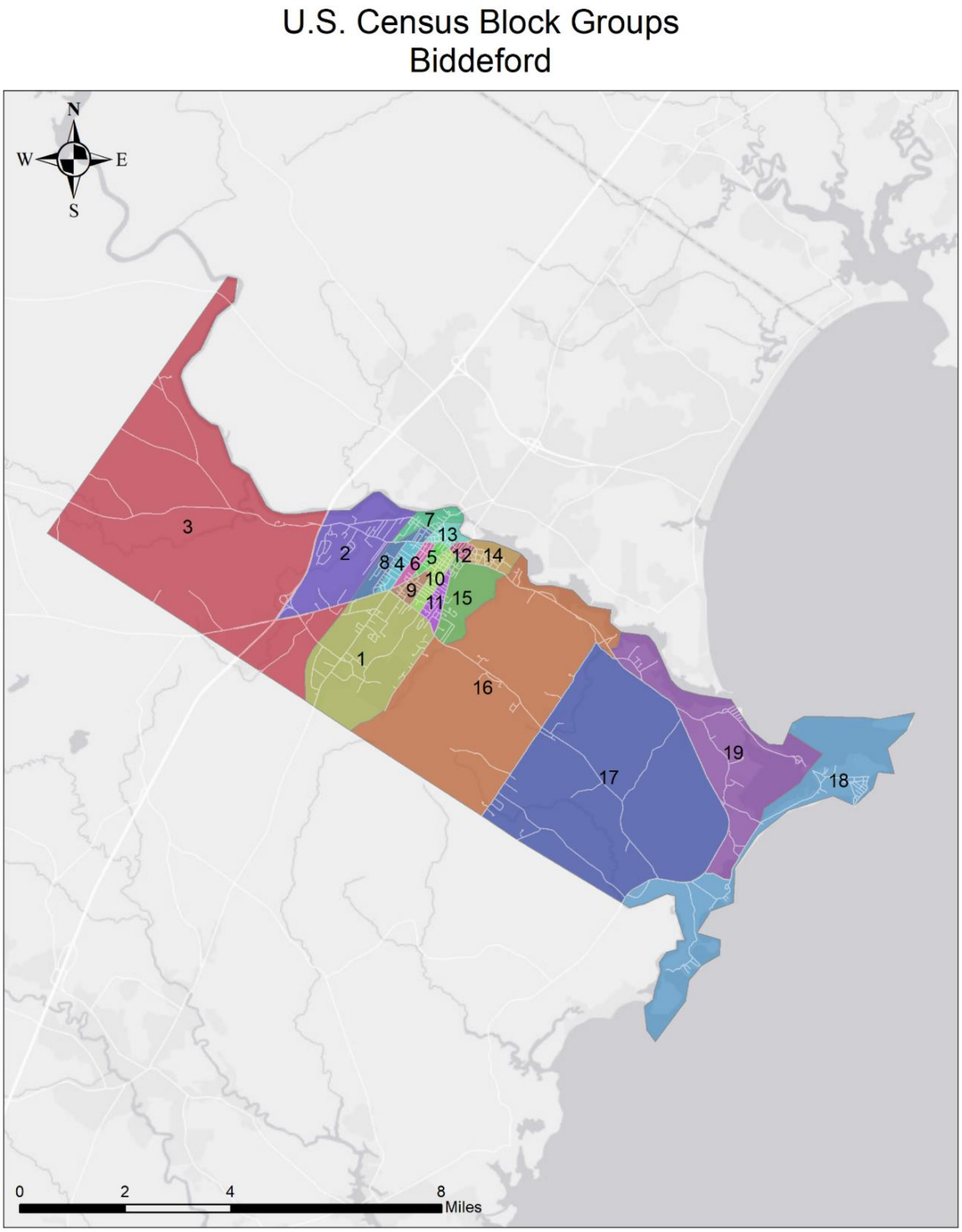


Figure 1. Census block groups in Biddeford. Data source: U.S. Census Bureau 2021 American Community Survey

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	14	15	16	17	18	19
Total Population	22,331	1,603	1,264	715	1,443	337	1,130	917	1,365	697	1,167	820	971	1,215	1,491	1,691	1,820	1,522	370	1,793
Total Households	9,198	694	463	303	769	192	589	463	508	393	675	251	464	591	414	631	652	503	215	428
Age <18	3,407	240	266	80	201	0	82	165	144	11	93	299	119	163	560	215	349	366	9	45
% total population	15%	15%	21%	11%	14%	0%	7%	18%	11%	2%	8%	36%	12%	13%	38%	13%	19%	24%	2%	3%
Age 65+	3,724	347	183	81	268	103	162	124	233	124	236	120	137	49	26	223	426	262	213	407
% total population	17%	22%	14%	11%	19%	31%	14%	14%	17%	18%	20%	15%	14%	4%	2%	13%	23%	17%	58%	23%
Minority	2,083	68	523	46	50	28	44	193	193	23	305	17	38	181	45	0	113	108	10	98
% total population	9%	4%	41%	6%	3%	8%	4%	21%	14%	3%	26%	2%	4%	15%	3%	0%	6%	7%	3%	5%
Speaks English "Less than well"	133	17	1	0	0	0	7	0	7	0	2	0	0	39	0	11	21	19	0	9
% population 5+	1%	1%	0%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	3%	0%	1%	1%	1%	0%	1%
No HS Diploma	929	95	49	8	58	14	42	116	32	87	39	56	59	58	18	40	120	19	0	19
% population 25+	6%	8%	6%	1%	5%	6%	4%	21%	3%	13%	4%	13%	8%	7%	2%	4%	9%	2%	0%	2%
1+ Persons with a Disability	2,950	128	204	55	252	135	157	291	188	149	251	48	201	253	50	174	217	72	30	95
% households	32%	18%	44%	18%	33%	70%	27%	63%	37%	38%	37%	19%	43%	43%	12%	28%	33%	14%	14%	22%
Below Poverty Level	1,153	21	13	0	50	75	12	159	26	0	111	92	47	92	118	160	65	40	10	62
% households	13%	3%	3%	0%	7%	39%	2%	34%	5%	0%	16%	37%	10%	16%	29%	25%	10%	8%	5%	14%
Unemployment	602	8	0	91	0	0	17	0	115	1	0	55	41	113	58	34	53	11	0	5
% population 16+	3%	1%	0%	14%	0%	0%	2%	0%	9%	0%	0%	9%	5%	10%	6%	2%	3%	1%	0%	0%
Income <$50k	3,779	226	74	86	284	185	202	345	229	71	470	94	279	425	153	145	134	147	110	120
% households	41%	33%	16%	28%	37%	96%	34%	75%	45%	18%	70%	37%	60%	72%	37%	23%	21%	29%	51%	28%
Income <$60k	4,761	291	106	96	347	185	222	426	247	182	494	141	356	549	219	296	148	168	110	178
% households	52%	42%	23%	32%	45%	96%	38%	92%	49%	46%	73%	56%	77%	93%	53%	47%	23%	33%	51%	42%
Income <$75k	5,714	395	171	117	504	185	400	442	260	253	537	141	374	549	311	348	191	192	115	229
% households	62%	57%	37%	39%	66%	96%	68%	95%	51%	64%	80%	56%	81%	93%	75%	55%	29%	38%	53%	54%
No Internet	842	105	0	0	85	36	45	76	45	44	106	25	11	120	13	42	27	9	4	49
% households	9%	15%	0%	0%	11%	19%	8%	16%	9%	11%	16%	10%	2%	20%	3%	7%	4%	2%	2%	11%
No Vehicle	554	0	13	0	137	37	48	33	44	0	15	23	41	93	0	16	36	0	5	13
% households	6%	0%	3%	0%	18%	19%	8%	7%	9%	0%	2%	9%	9%	16%	0%	3%	6%	0%	2%	3%
Single Parent	870	0	115	0	23	0	0	103	87	0	8	84	24	80	138	141	7	46	8	6
% households	9%	0%	25%	0%	3%	0%	0%	22%	17%	0%	1%	33%	5%	14%	33%	22%	1%	9%	4%	1%
Living Alone	2,636	202	90	45	316	125	203	188	29	218	289	60	190	207	63	110	102	17	87	95
% total population	12%	29%	19%	15%	41%	65%	34%	41%	6%	55%	43%	24%	41%	35%	15%	17%	16%	3%	40%	22%
65+ Living Alone	1,018	103	31	0	220	86	7	50	29	30	76	25	95	19	0	56	74	17	75	25
% total population	5%	6%	2%	0%	15%	26%	1%	5%	2%	4%	7%	3%	10%	2%	0%	3%	4%	1%	20%	1%

Lowest Value *Highest Value*

"Disadvantaged" Designation of Biddeford's Downtown Area

The Council on Environmental Quality developed a Climate and Economic Justice Screening Tool which combines environmental and climate hazard data with demographic data to identify where elevated hazards and social vulnerability occur. This tool used data at the census tract level, which is a larger geographic unit than block groups. Census tracts are statistical subdivisions of a county and contain between 1,2000 to 8,000 people. The tools ranked census tracts ranked at the national level based on indicators representing environmental, climate, health and other hazards as well as socioeconomic indicators of social vulnerability. Thresholds were established for each indicator to designate heightened hazards or social vulnerability. Census tracts are considered disadvantaged if they meet the threshold for at least one environmental, climate, or other hazard, and meet the threshold for social vulnerability.

There are two census tracts in Biddeford—containing block groups 4 through 15—that are identified as disadvantaged (highlighted in blue in Figure 2). **This area is designated as disadvantaged because of low life expectancy, elevated rates of asthma, and low household incomes**. This means that the downtown area of Biddeford has high health hazards co-occurring with elevated social vulnerability and is therefore overburdened and underserved compared to the rest of the country. Areas with disadvantaged designations will be given priority for federal funding though the [Justice40 Initiative]().

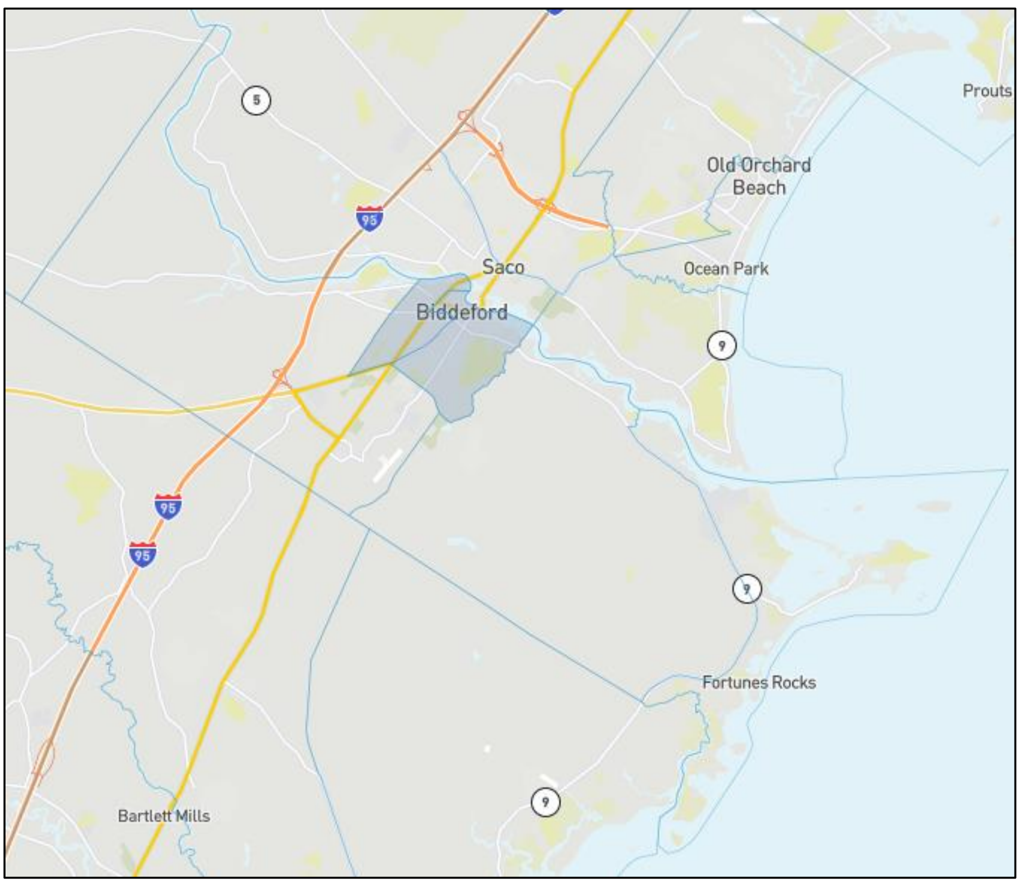


Figure 2. The heart of Biddeford's downtown is encompassed by the two highlighted census tracts, which the Council on Environmental Quality's Climate and Economic Justice Screening Tool identifies as disadvantaged.

Housing Characteristics

The maps and tables in this section show data about housing characteristics including information about the structures and household type. These characteristics 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. 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.

The maps and table in this section (Figure 3 and Table 2) show data about primary heating fuel types, which provides context about where fossil fuels are used most heavily and where electrified heating is more common.

Key Takeaways

- In block group 13, 100% of households are renter occupied and 100% of housing units are multi-unit structures.
- Compared to the rest of the community, block groups 5, 7, 12, and 13 have elevated percentages of renter occupied households and multi-unit structures.
- Mobile homes are 1% of all housing units in Biddeford (88 units community wide) and are only present in block groups 1, 3, 6, and 16. The highest number of mobile homes are in block group 3
- The highest concentrations of buildings constructed before 1970, when some building and natural resource protection codes went into effect, are located in the downtown area and along the coastline, which are also areas of elevated social vulnerability and flood vulnerability.

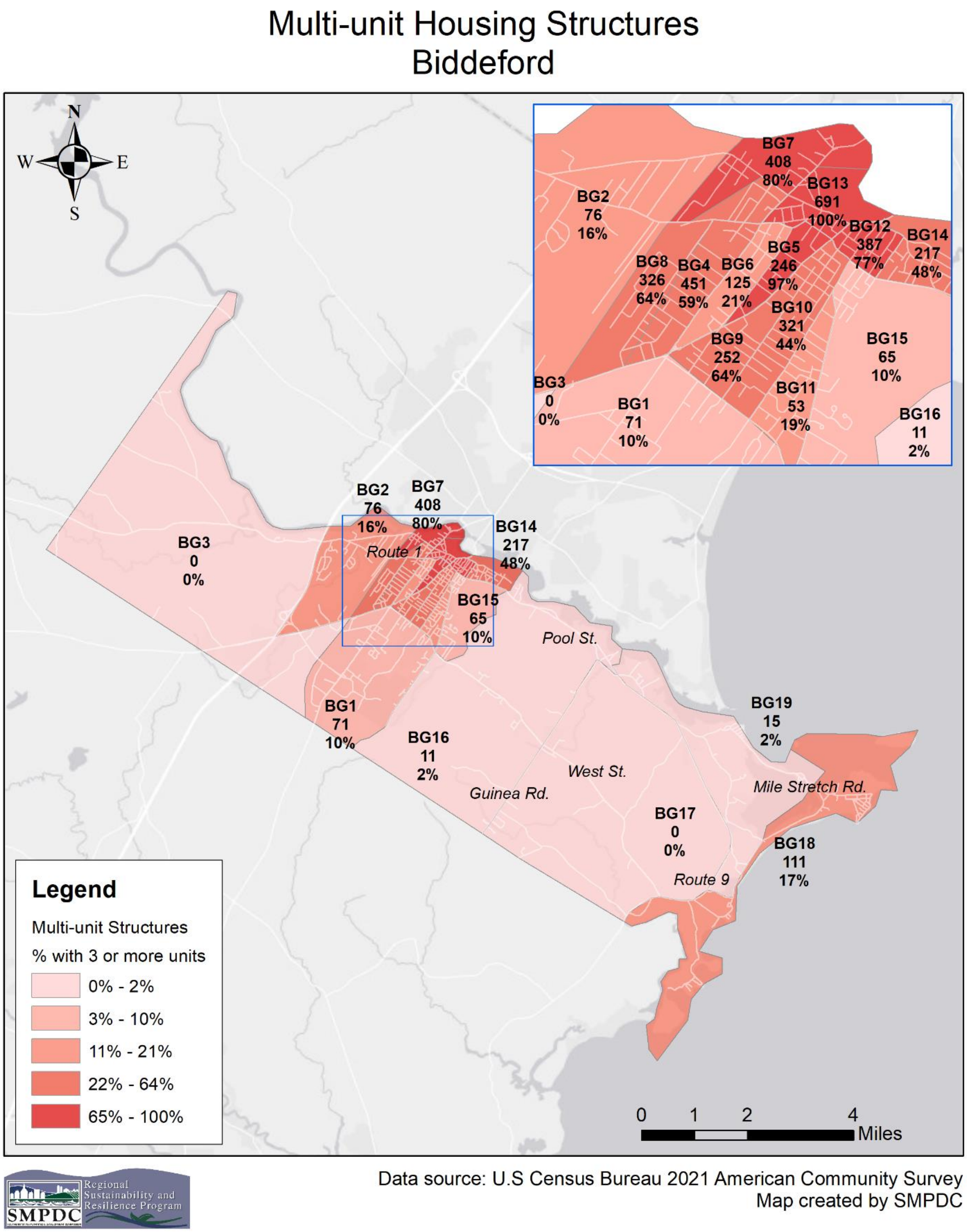


Figure 3A. Breakdown of multi-unit (3 or more units) housing units in Biddeford by block group. Housing units include occupied households as well as vacant units and represent the total housing stock in Biddeford. The block group is labeled (BG#) as well as the total number of multi-unit housing units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

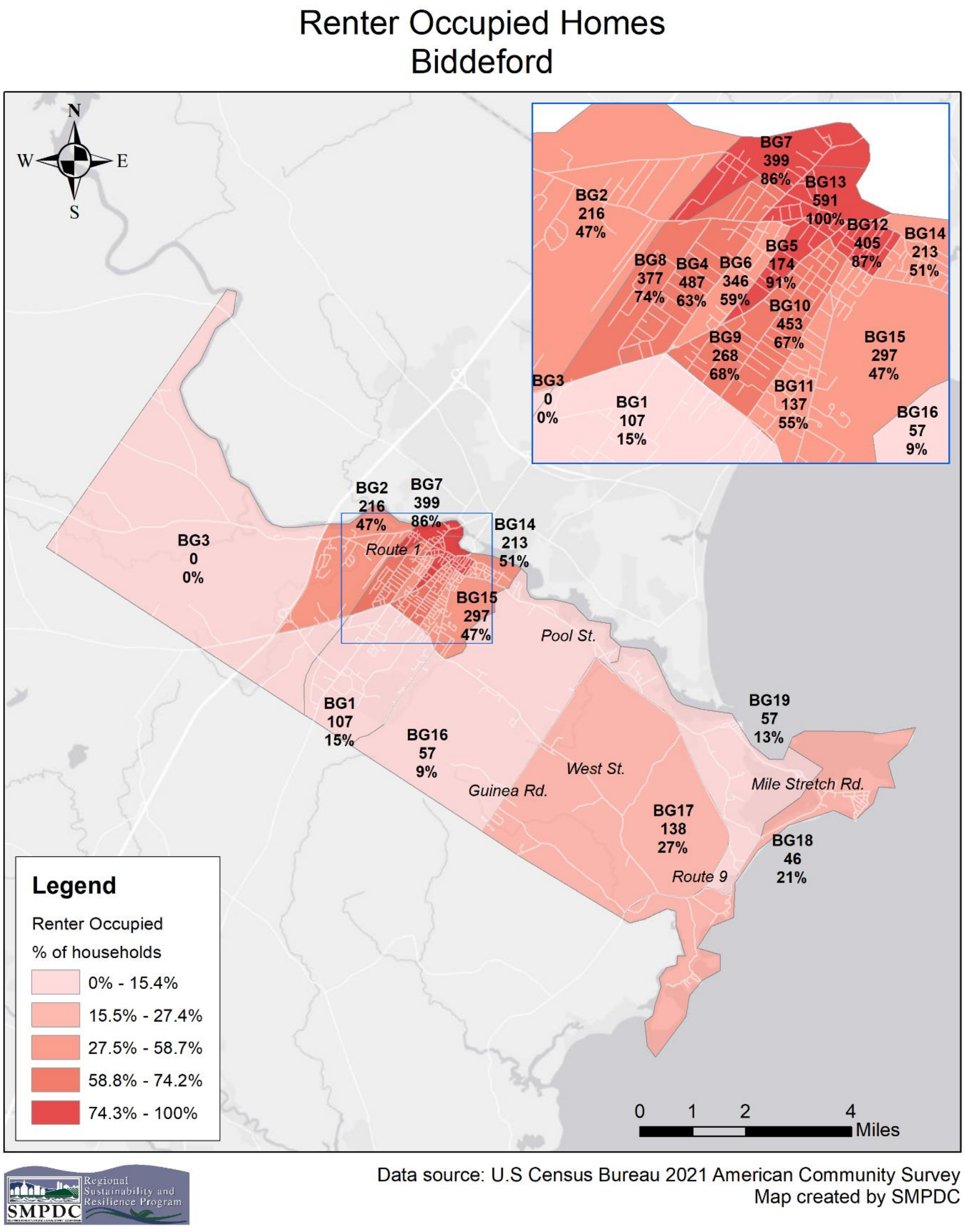


Figure 3B. Breakdown of renter occupied households in Biddeford by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Biddeford. The block group is labeled (BG#) as well as the total number of renter occupied households in the block group and the percent of renter occupied households within the block group. Data source: U.S. Census Bureau 2021 American Community Survey

Table 2. Community wide and block group level housing characteristics in Biddeford. Housing units include occupied households as well as vacant units and represent the total housing stock in Biddeford. 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	14	15	16	17	18	19
Total Housing Units	10,350	733	463	331	769	253	589	507	508	393	731	272	505	691	454	656	652	503	635	705
Total Households	9,198	694	463	303	769	192	589	463	508	393	675	251	464	591	414	631	652	503	215	428
Renter Occupied	4,768	107	216	0	487	174	346	399	377	268	453	137	405	591	213	297	57	138	46	57
% households	52%	15%	47%	0%	63%	91%	59%	86%	74%	68%	67%	55%	87%	100%	51%	47%	9%	27%	21%	13%
Multi-unit	3,826	71	76	0	451	246	125	408	326	252	321	53	387	691	217	65	11	0	111	15
% total with 3+ units	37%	10%	16%	0%	59%	97%	21%	80%	64%	64%	44%	19%	77%	100%	48%	10%	2%	0%	17%	2%
Mobile Homes	88	7	0	35	0	0	28	0	0	0	0	0	0	0	0	0	18	0	0	0
% total units	1%	1%	0%	11%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	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.

Figure 6 shows the percentage of structures, at the block group level, built before 1970. In Biddeford, 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.

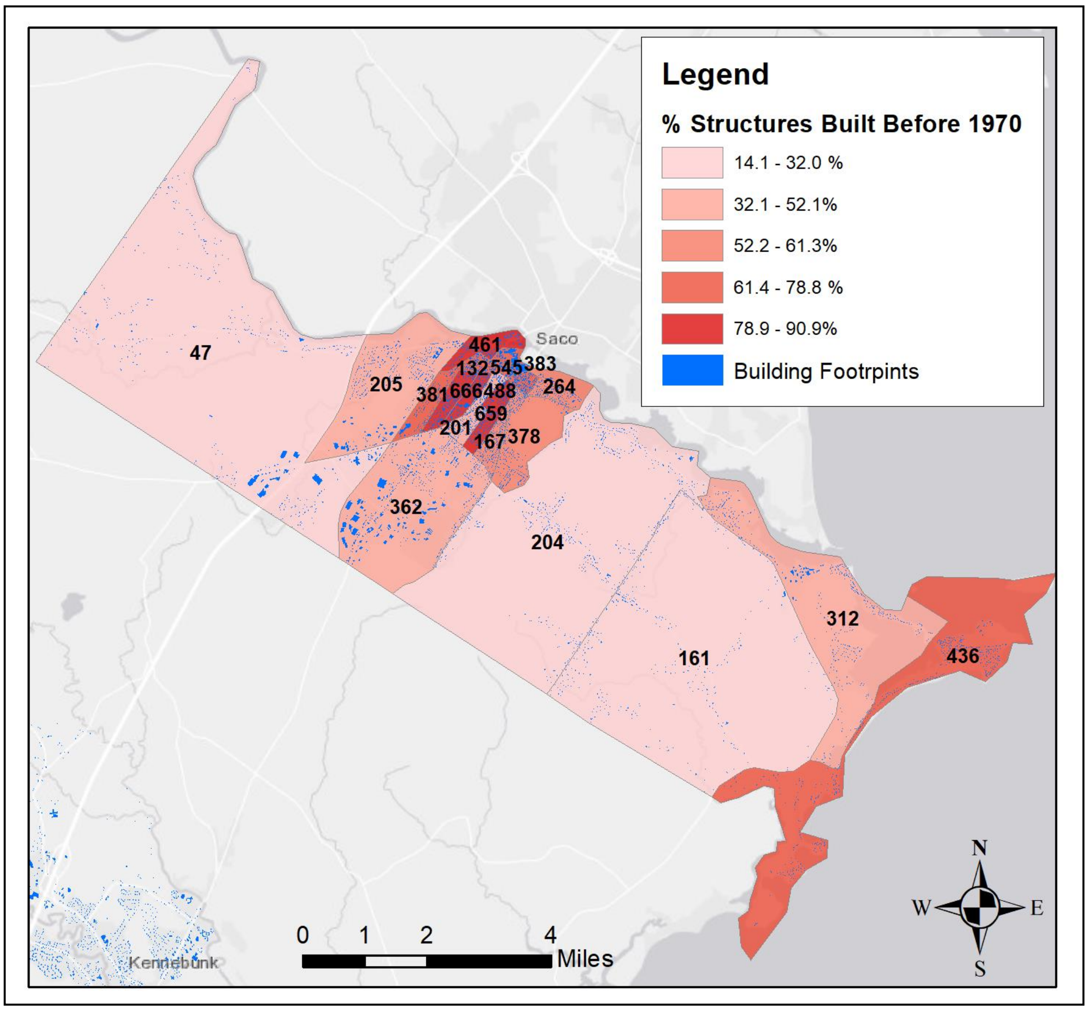


Figure 6. Percent and actual number of structures built before 1970 presented at the block group level. The block groups are color-coded by the percentage of structures built before 1970 and are labelled with the number of structures built before 1970. (Data source: year structures built: US Census American Community Survey; building footprints: Microsoft)

Household Heating Fuel Types

Key Takeaways

- The vast majority of households (74%) are primarily heated using fuel oil or kerosene followed by natural gas, propane, and electricity.
- The highest percentage of households using fuel oil and kerosene occurs in block group 6, followed by block groups 11, 1, and 7.
- The highest percentage of households using propane occurs in block group 5.
- The highest percentage of households using natural gas occurs in block group 8 followed by 5.
- The highest percentage of households using electricity occurs in block groups 8 and 15.

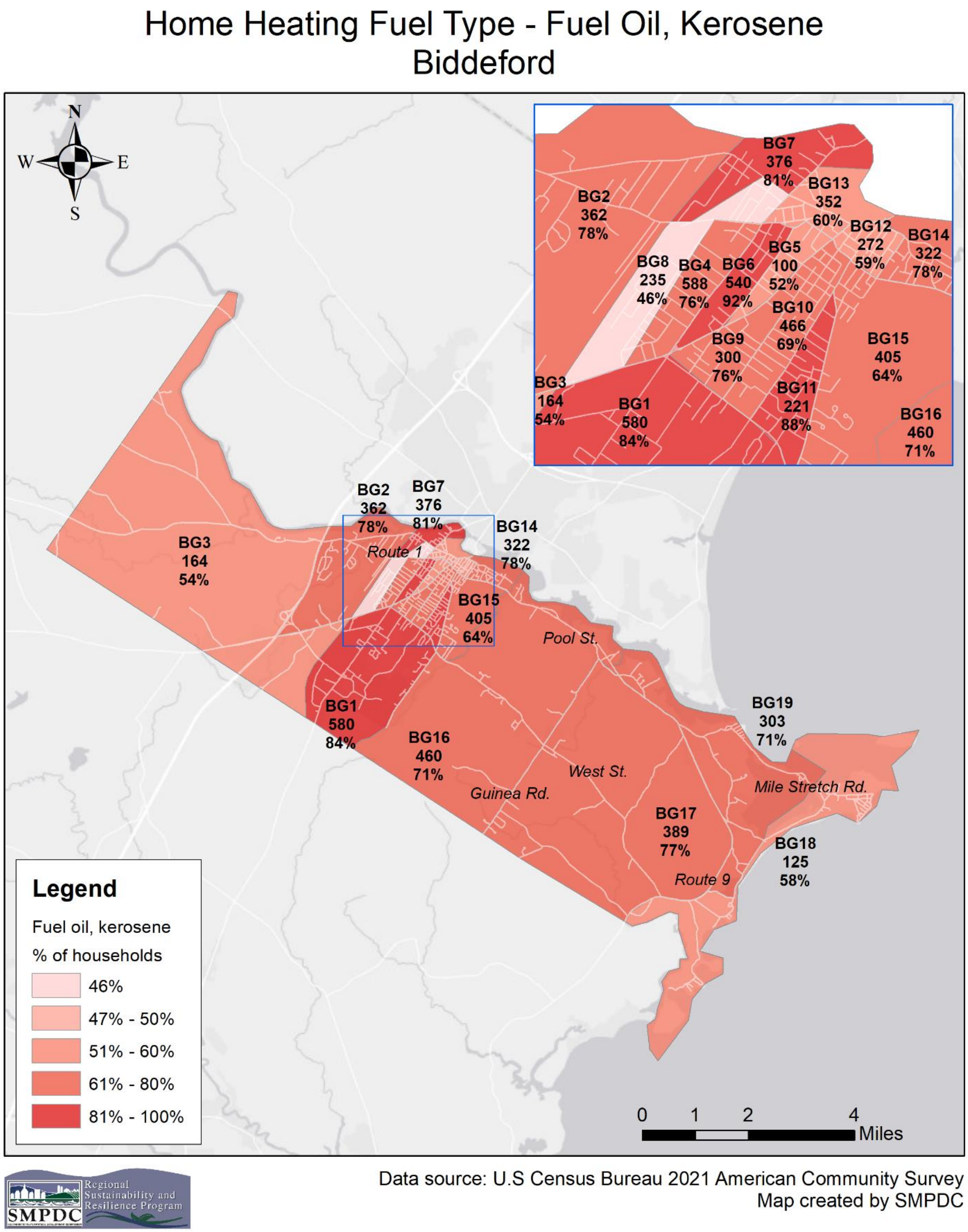


Figure 4A. Breakdown of households in Biddeford that use fuel oil or kerosene for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Biddeford. The block group is labeled (BG#) as well as the total number of households within the block group that use fuel oil or kerosene for heating and the percent of households within the block group that use fuel oil or kerosene for heating. Data source: U.S. Census Bureau 2021 American Community Survey

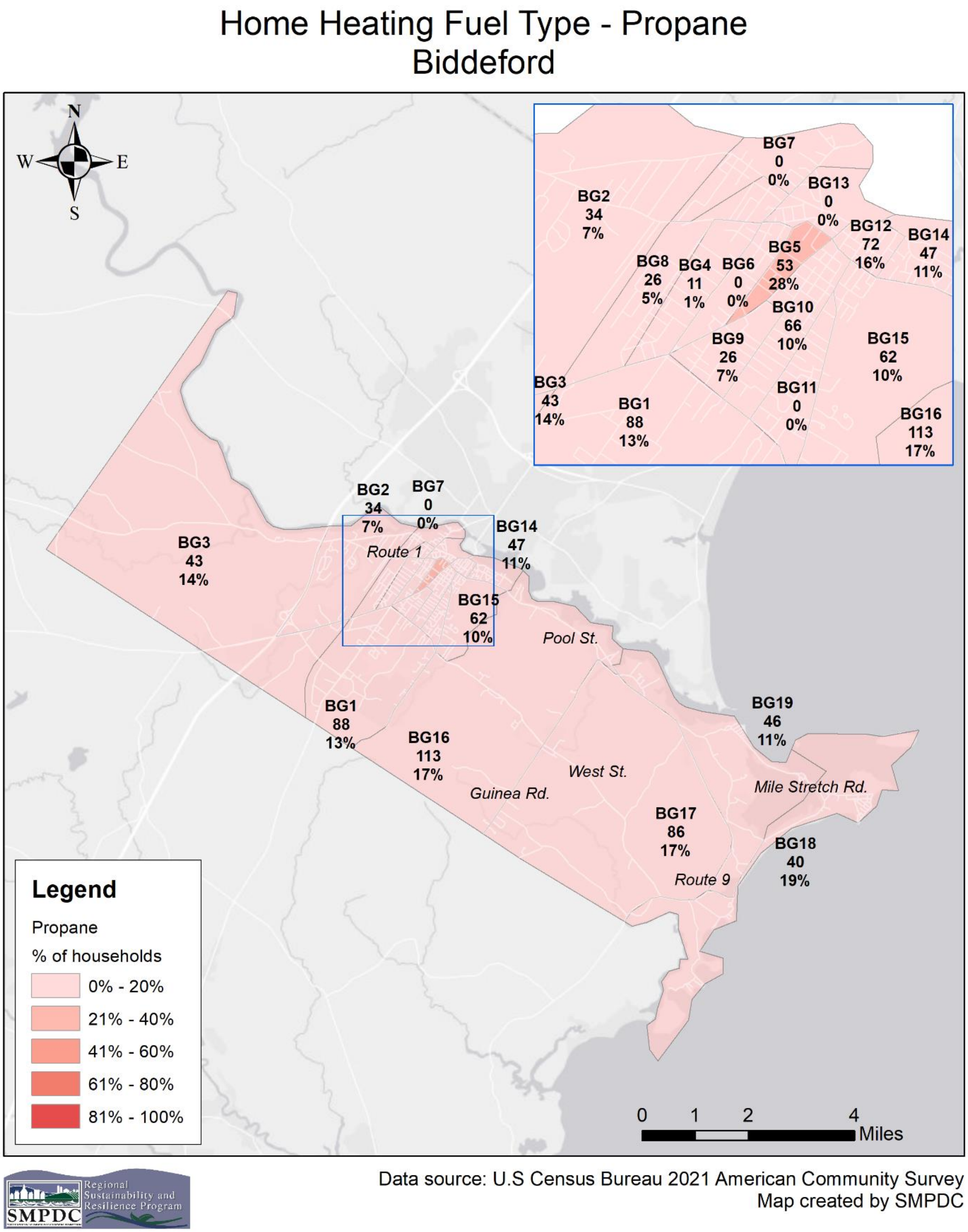


Figure 4B. Breakdown of households in Biddeford that use propane for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Biddeford. The block group is labeled (BG#) as well as the total number of households within the block group that use propane for heating and the percent of households within the block group that use propane for heating. Data source: U.S. Census Bureau 2021 American Community Survey

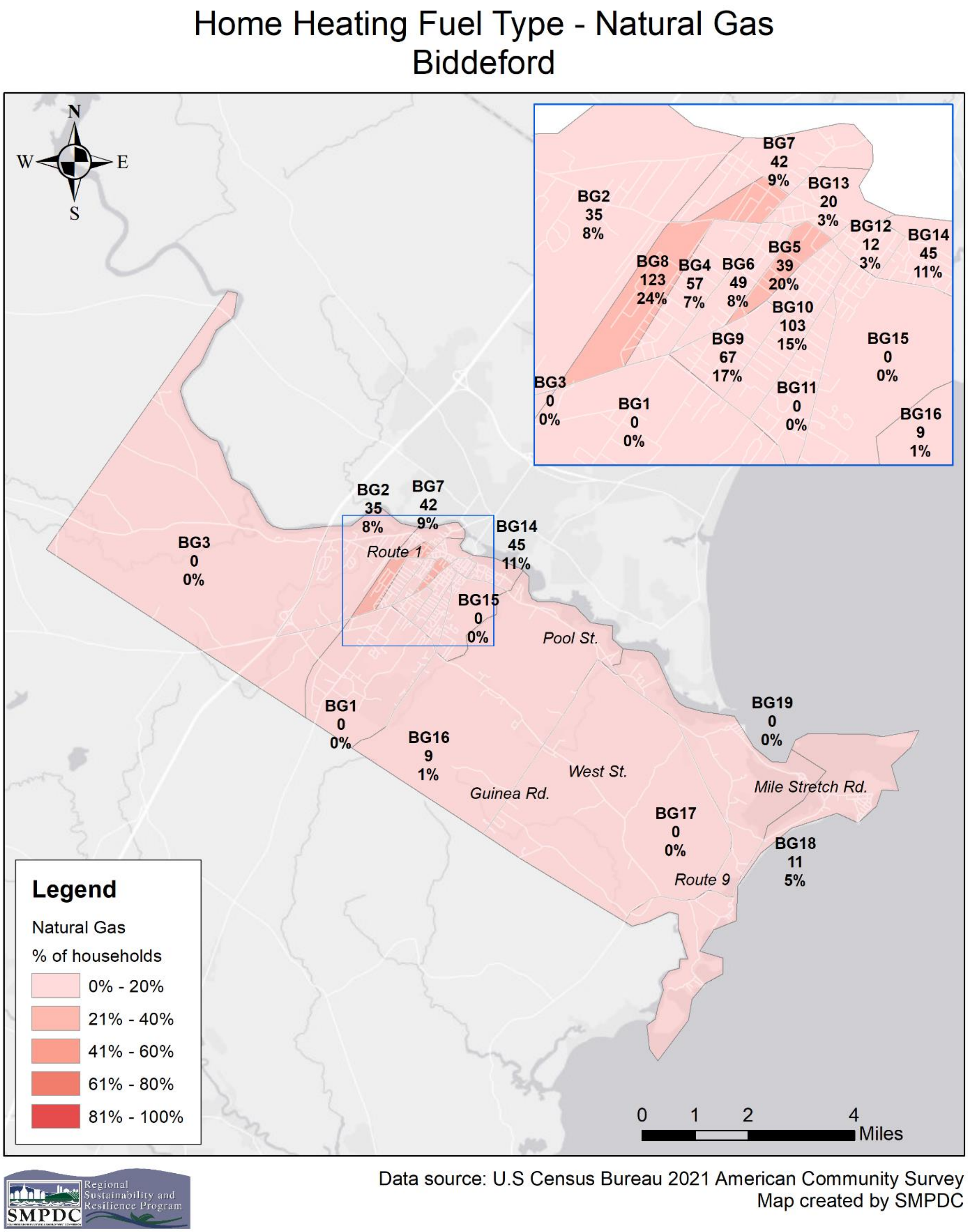


Figure 4C. Breakdown of households in Biddeford that use natural gas for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Biddeford. The block group is labeled (BG#) as well as the total number of households within the block group that use natural gas for heating and the percent of households within the block group that use natural gas for heating. Data source: U.S. Census Bureau 2021 American Community Survey

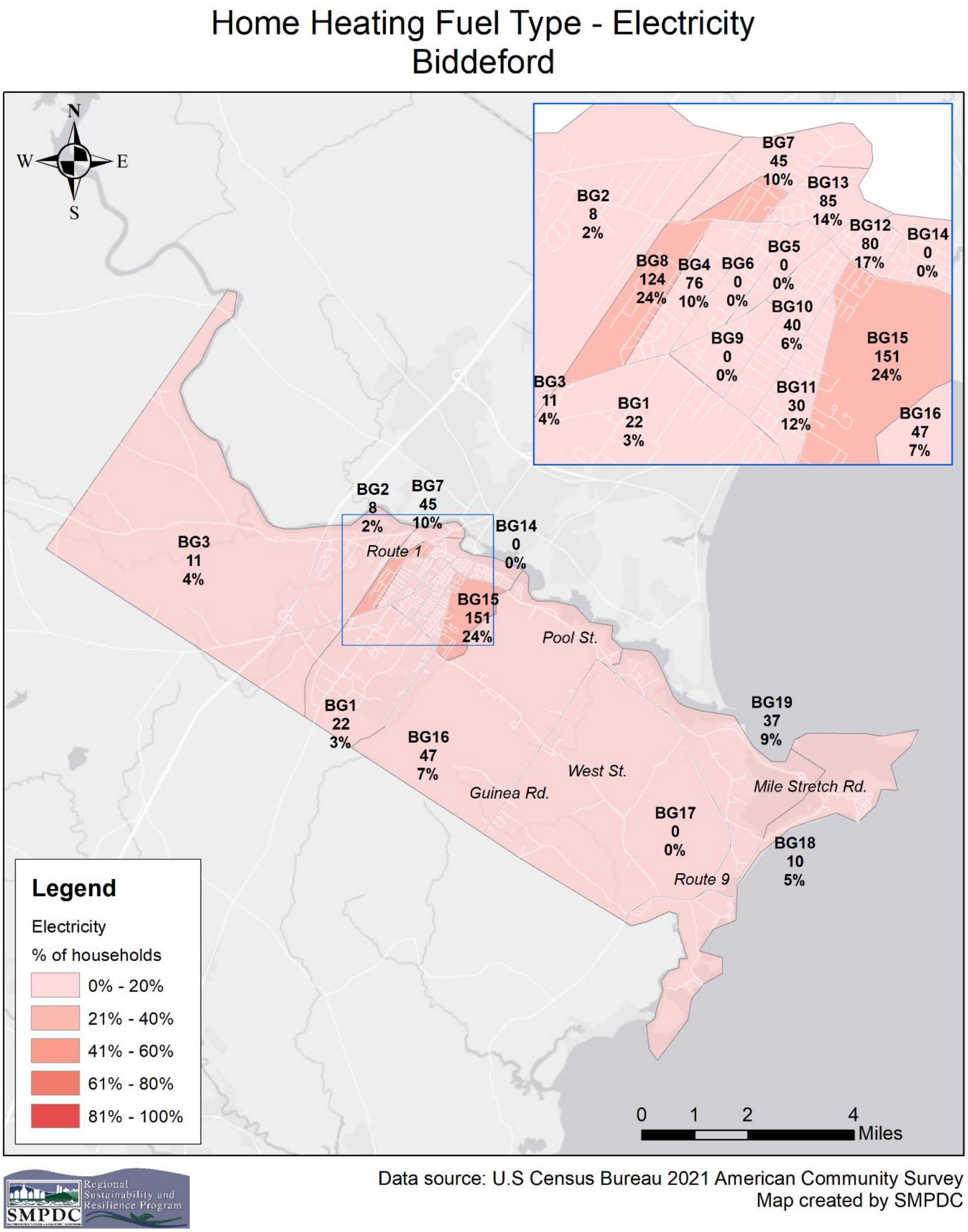


Figure 4D. Breakdown of households in Biddeford that use electricity for heating by block group. Households do not include vacant housing units, so this data is representative of occupied housing units in Biddeford. The block group is labeled (BG#) as well as the total number of households within the block group that use electricity for heating 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 Biddeford Households do not include vacant housing units, so this data is representative of occupied housing units in Biddeford. 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	14	15	16	17	18	19
Total Households	4,374	694	463	303	769	192	589	463	508	393	675	251	464	591	414	631	652	503	215	428
Fuel oil, kerosene	3,245	580	362	164	588	100	540	376	235	300	466	221	272	352	322	405	460	389	125	303
% households	74%	84%	78%	54%	76%	52%	92%	81%	46%	76%	69%	88%	59%	60%	78%	64%	71%	77%	58%	71%
Propane	281	88	34	43	11	53	0	0	26	26	66	0	72	0	47	62	113	86	40	46
% households	6%	13%	7%	14%	1%	28%	0%	0%	5%	7%	10%	0%	16%	0%	11%	10%	17%	17%	19%	11%
Natural gas	412	0	35	0	57	39	49	42	123	67	103	0	12	20	45	0	9	0	11	0
% households	9%	0%	8%	0%	7%	20%	8%	9%	24%	17%	15%	0%	3%	3%	11%	0%	1%	0%	5%	0%
Electricity	286	22	8	11	76	0	0	45	124	0	40	30	80	85	0	151	47	0	10	37
% households	7%	3%	2%	4%	10%	0%	0%	10%	24%	0%	6%	12%	17%	14%	0%	24%	7%	0%	5%	9%

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 (Figure 5) is provided for reference to show where areas zoned for commercial, industrial, and residential uses are located.

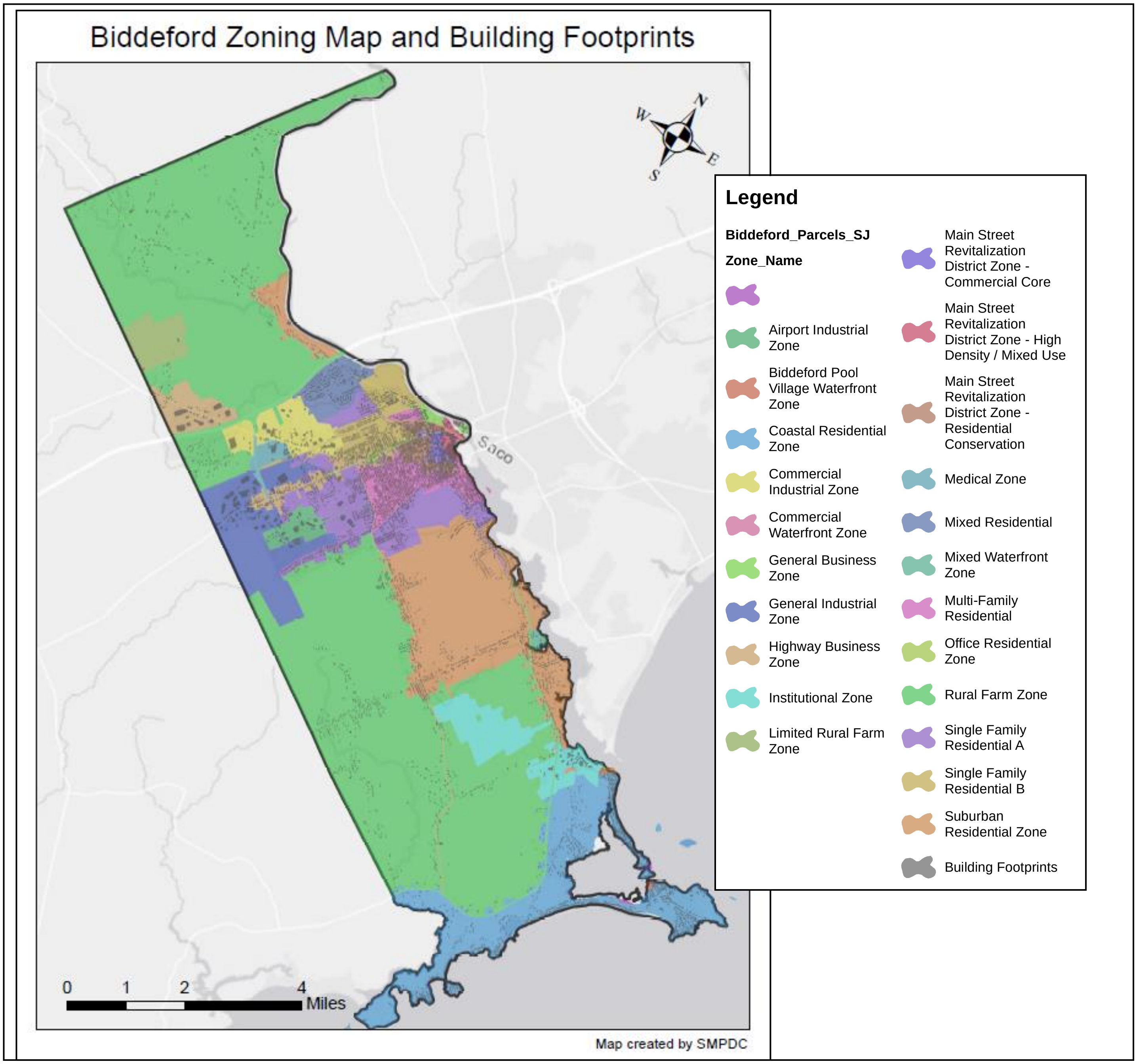


Figure 5. Biddeford's adopted zoning map.

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 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. Figure 7 shows the change in forested land coverage in Biddeford from 1996 to 2016. Biddeford has experienced more forest loss than gain, especially in on the periphery of the downtown area.

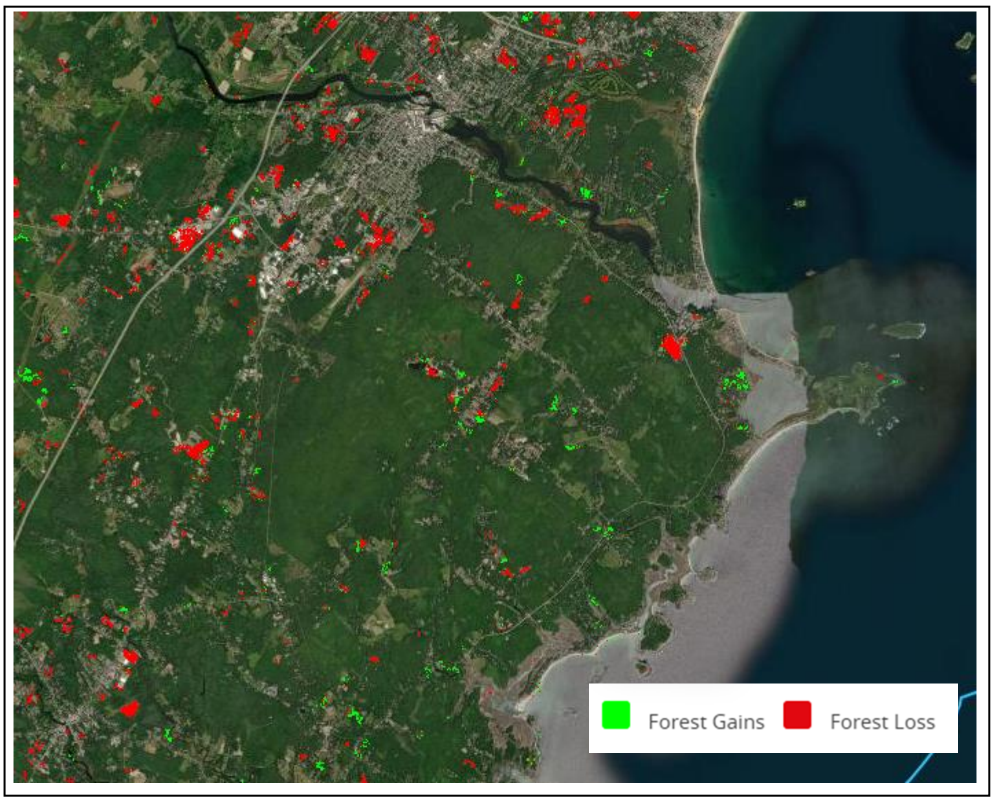


Figure 7. Changes in forested land cover from 1996 to 2016. Green areas indicate a transition of non-forested land to forested, while red areas indicate a transition from forested land to a different type of land cover (e.g., impervious, grassland, wetland, shrub-scrub habitat, etc.). Source: NOAA Coastal 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

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

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 Biddeford is particularly vulnerable to flooding and stormwater overflow during extreme precipitation events because of a high degree of impervious surfaces. This area is also the area of highest social vulnerability in the community.
- The Biddeford Pool and Fortunes Rocks Beach also have a high degree of impervious surfaces and are more vulnerable to the combined 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 Biddeford.

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 8), 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 Biddeford 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 that considers the wind speeds they will likely face over the next 30 years.[7]

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[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

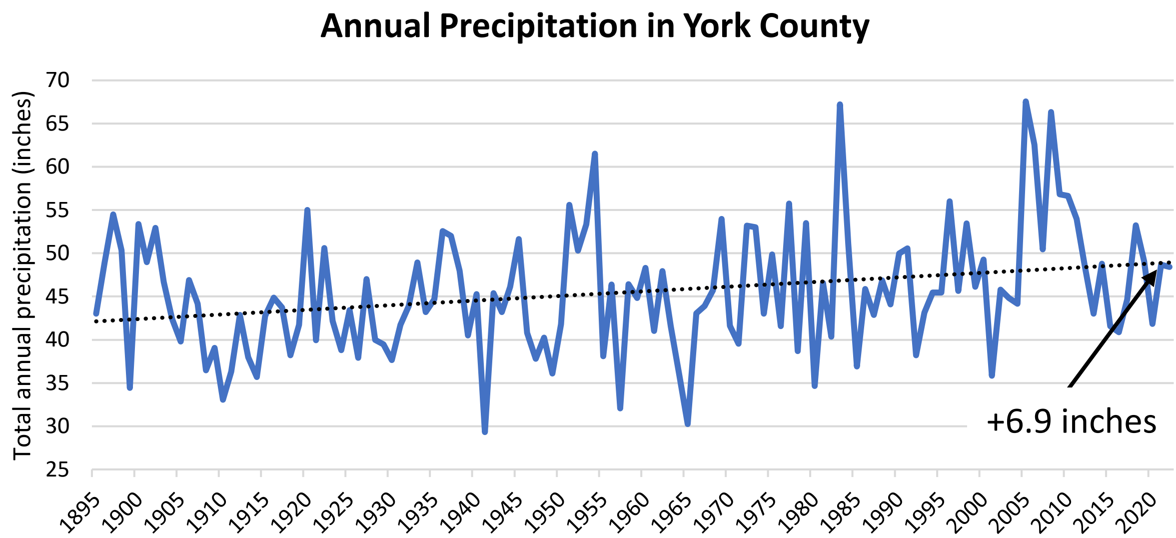

Figure 8.Total annual precipitation in York County from 1895 to 2022 based on monthly data from the [NOAA National Centers for Environmental Information](). Over this time period total annual precipitation has increased by 6.9 inches.

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**

Recent notable storms include:

[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/

- 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, 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 was washed away during the storm causing millions of dollars in damage. It also caused widespread power outages and flooded roads. [10]
- Norasters, 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 in the future, Biddeford 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 Biddeford) occurred during the Blizzard of 1978 and exceeded 14 feet MLLW (Figure 9). 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 displayed on the graph) a water level of 13.72 feet MLLW was recorded in Portland, about an inch lower

[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

than the 2018 nor'easter storm tide.[16] In Biddeford, coastal neighborhoods like the Biddeford Pool and Fortunes Rocks Beach have experienced the most coastal flooding impacts.

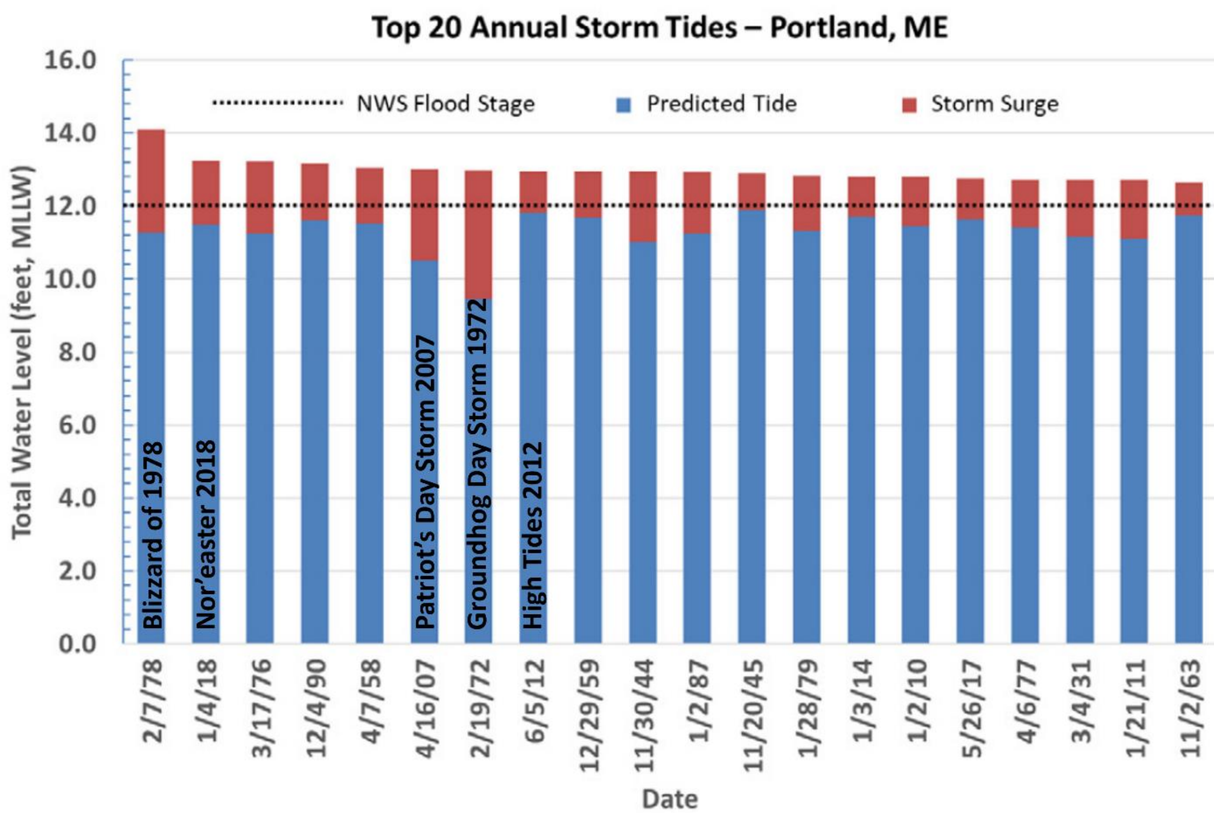

Figure 9. Major storm events and top 20 annual storm tides recorded at the Portland, ME tide gauge from 1912-2019. The National Weather Service Flood Stage of 12 feet MLLW is shown as a dashed line. This threshold indicates when elevated water levels begin to create a hazard to public safety, property, 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 uncommon in Maine, but in October 2021 a flash flood dropped 6.7 inches of rain on Biddeford in 6

[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

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 Biddeford. [18]

Biddeford's proximity to the Saco River and its tributaries increases the community's risk of inland flooding. Furthermore, Biddeford's downtown is highly impervious as are the corridors along Alfred Road and Route 1 (Figure 10). There is also a higher degree of imperviousness along the Saco River east of the downtown, in the Biddeford Pool neighborhood, and along Fortunes Rocks Beach. There is an elevated risk of flooding from extreme precipitation and stormwater overflow in these areas, and in the coastal areas of the Biddeford Pool and Fortunes Rocks Beach may exacerbate the impacts of coastal flooding. In the future, with more intense storms and extreme precipitation events these areas will be at a higher risk of flooding.

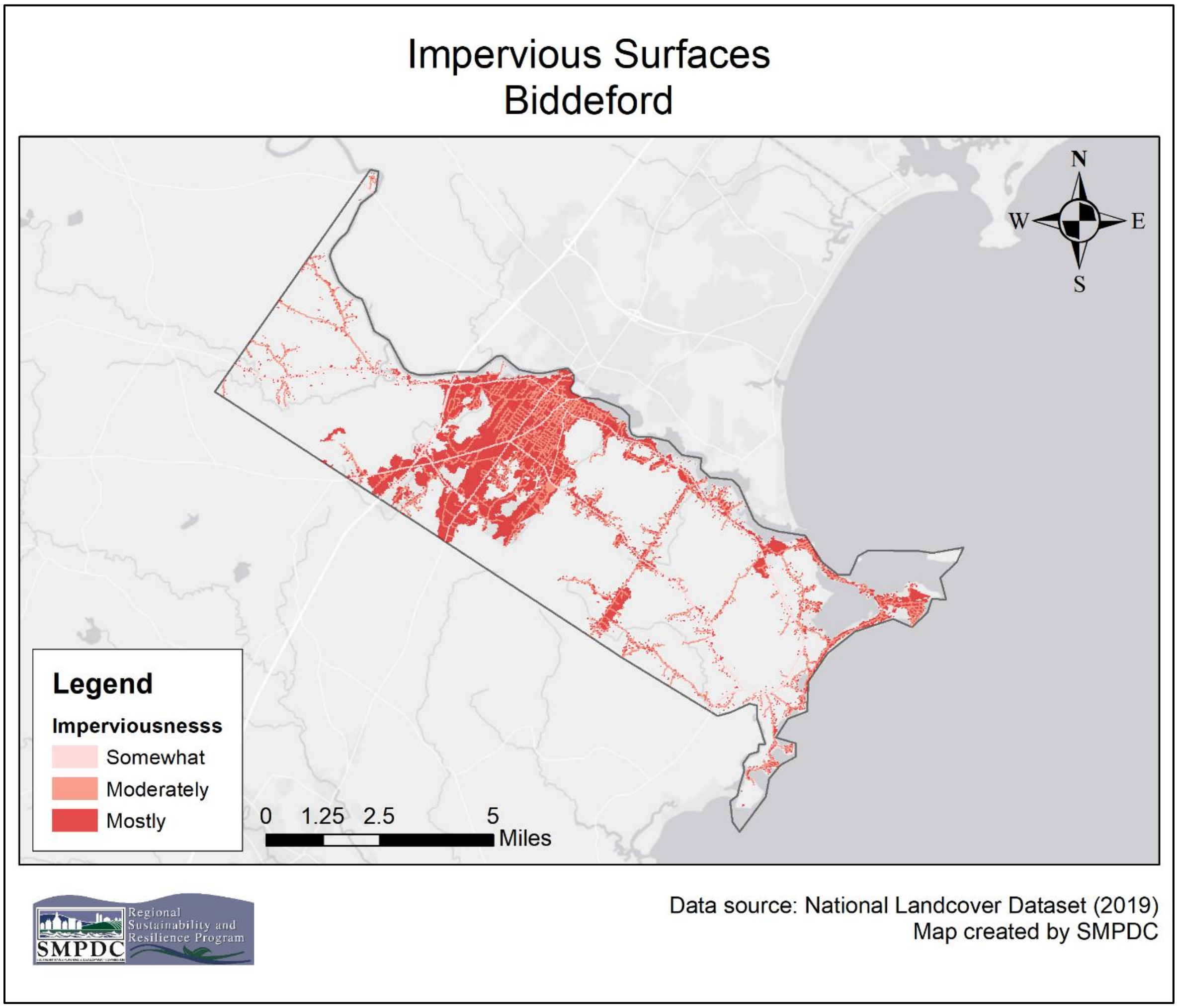

Figure 10. Impervious surfaces in Biddeford based on their level of imperviousness (somewhat, moderately or mostly impervious). Data is from the [2019 National Landcover Dataset](https://www.mrlc.gov).

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

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 Biddeford, the leading cause of power outages is motor vehicle accidents (45% of all customer outage hours in 2021), followed by tree limbs falling on power lines due to high winds or heavy ice or snow loads on trees (30%). Tree limbs can cause outages by leaning on conductor lines, pulling lines down completely, or by damaging utility poles.[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 Biddeford is served by several CMP substations. One is located on Morin St. while another 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. Some of coastal Biddeford is served by a CMP substation located on School Street in Kennebunk, which could be potentially vulnerable to extreme flooding of Grist Mill Pond due to extreme precipitation or storm surge.

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[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

Flooding: Sea Level Rise and Storm Surge

Key Takeaways

- Neighborhoods and infrastructure located around Biddeford Pool, Fortunes Rocks, Timber Point, 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 social vulnerability and a high percentage of structures built before 1970, meaning that the are likely not constructed to modern building codes increasing sensitivity to flooding.
- The Biddeford Pool area (block group 18) has the highest percentage of 65+ population (58%), with 20% of the people in that block group 65+ and also living alone. Additionally, 50% of the people in this block group have incomes less than $50k. This suggests that community members most vulnerable to coastal flooding impacts are older, more likely to live alone, and potentially on a fixed income. These factors increase their sensitivity to storm impacts and also limit their adaptive capacity.
- Tourism activity driven by Biddeford'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. $391 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 11.1% of the city-wide assessed property value.
- Road access to 56 parcels will be cut off by flooding with the 1.6 ft scenario and 260 will be cut -off with the 3.0 ft scenario, putting the people who live there and emergency access to them at risk.
- Route 208/Mile Stretch Road, a designated evacuation route, is vulnerable to sea level rise and is the only access route in and out of the Biddeford Pool neighborhood, which is an area of elevated social vulnerability based on the percentage of the population over the age of 65 living alone and percentage of households with an annual income of less than the state and county median income as well as the EPA climate change and social vulnerability income threshold.
- The Timber Point walking trail, an important recreational area for residents and visitors, is vulnerable to flooding from both the 1.6 ft and 3.0 ft scenarios.
- In Biddeford, future sea level rise will cause regular inundation of low-lying coastal areas during high tide, likely leading to contamination of groundwater aquifers and wells from saltwater intrusion, and increased erosion of sandy beaches, dunes, and salt marshes.
- Most coastal properties in Biddeford have private wells which are at risk of saltwater intrusion from rising seas, placing drinking water supplies for those homes at risk.
- The majority of engineered coastal structures (e.g., seawalls, riprap, etc.) along Ocean Avenue, Biddeford Pool, and the middle and southern portions of Hills Beach are vulnerable to overtopping by water from the 1% annual chance event.
- Areas along Biddeford Pool, Little River, and the mouth of the Saco River have been identified as being able to support future marsh migration.

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.

[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.

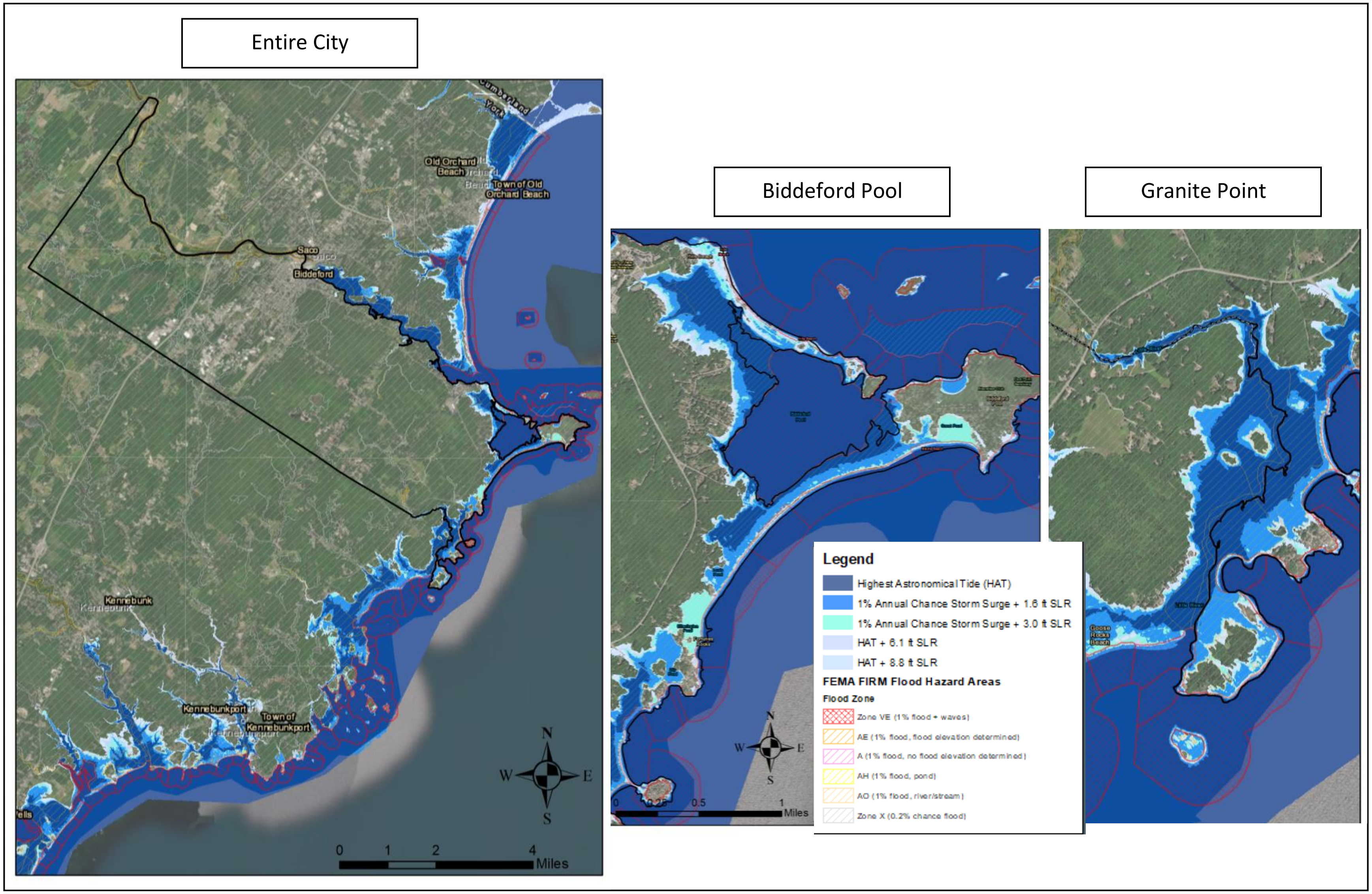

Figure 11a. Modeled inundation from sea level rise (SLR), storm surge, and the 1% annual chance storm event (Special Flood Hazard Area depicted on the FEMA-Issued Flood Insurance Rate Map).

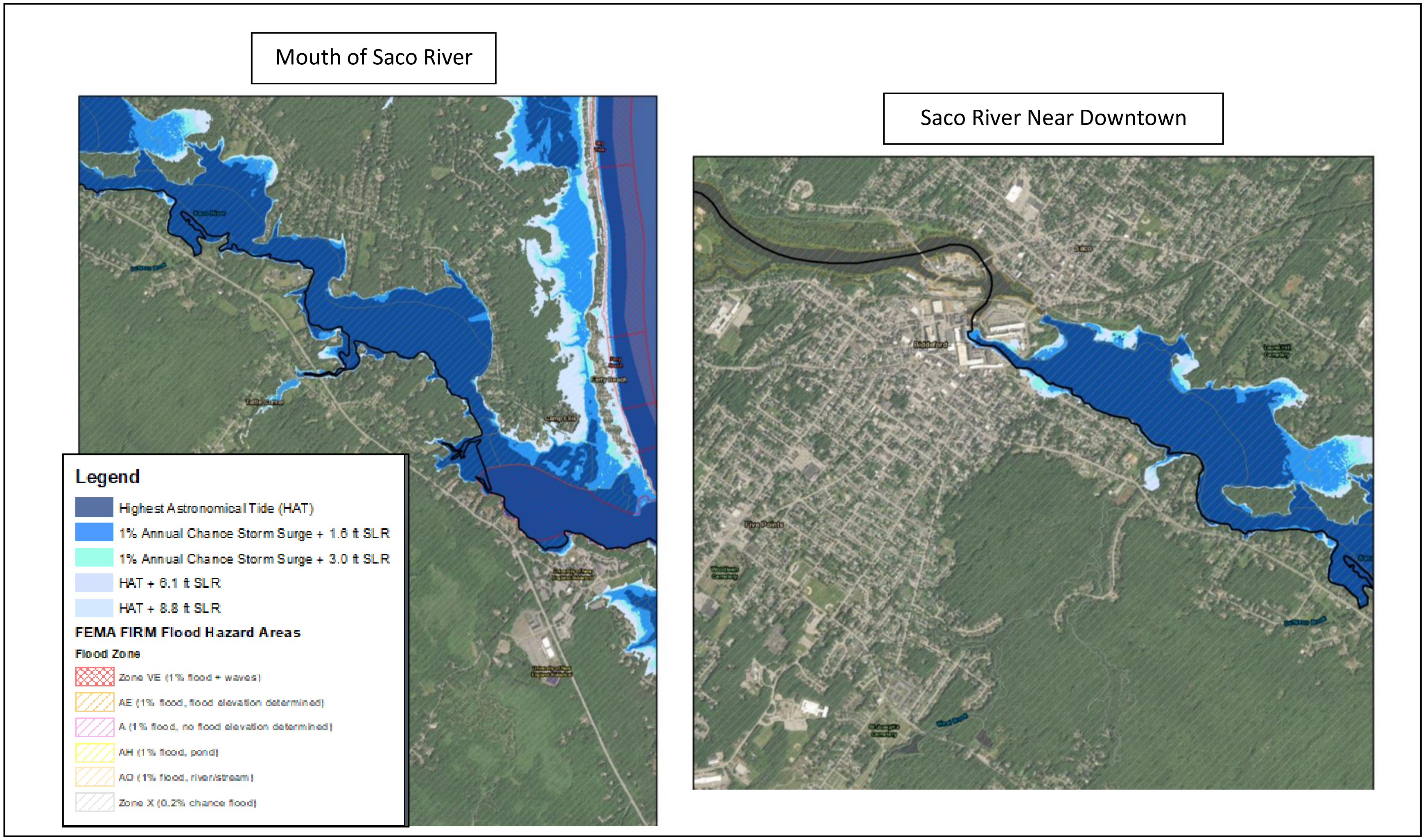

Figure 11b. Modeled inundation from sea level rise (SLR), storm surge, and the 1% annual chance storm event (Special Flood Hazard Area depicted on the FEMA-Issued Flood Insurance Rate Map).

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. Biddeford'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.

Error! Reference source not found. 14 shows the locations of buildings and facilities that are critical for community safety, function, and well-being, and the location of historic properties. It also shows parcels that are vulnerable to, or 'impacted' by, projected flooding from the two modeled scenarios.

- There are designated historic properties along the Saco River and in Biddeford Pool 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.
- Parcels that are expected to be impacted by flooding with the 1.6 ft sea level rise scenario total slightly more than $391 million in assessed property value, representing 11.1% of the city-wide assessed property value (Table 5).
- Road access to 56 parcels will be cut off by flooding with the 1.6 ft scenario and 260 will be cut off with the 3.0 ft scenario, putting the people who live there and emergency access to them at risk.
- Properties along Hills Beach, Biddeford Pool, Fletcher Neck, Fortunes Rocks Beach, Granite Point, and Timber Point are vulnerable to flooding from the open Ocean and the tidal Little River from both the 1.6 ft and 3.0 ft scenarios. These areas also have elevated social vulnerability and a high percentage of structures built before 1970, meaning that they are likely not constructed to modern building codes increasing sensitivity to flooding.
- The Timber Point walking trail, an important recreational area for residents and visitors, is vulnerable to flooding from both the 1.6 ft and 3.0 ft scenarios.

[22] Shi, L., Varuzzo, A. M. (2020). *Surging seas, rising fiscal stress: Exploring municipal fiscal vulnerability to climate change*. Cities 100 (2020) 102658.

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.)

	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	$45,475,401	$345,621,800	$391,097,201	11.1%
Storm surge + 3.0 ft SLR	$47,957,468	$492,041,100	$539,998,568	15.3%

Infrastructure Impacts

- **Stormwater and sewer infrastructure:** Storm and sewer infrastructure vulnerable flooding are located along Mile Stretch Road, Pool Street near the UNE campus, at the end of Lafayette Street, in the downtown area along the mill buildings adjacent to the Saco River, and at the wastewater treatment facility (Table 6, Figure 12.).
    - The Yates Street pump station in Biddeford Pool is vulnerable to flooding from the 1.6 ft scenario.
    - The wastewater treatment plant is vulnerable to flooding the 3.0 ft scenario.
- **Water infrastructure:** Biddeford is served by Maine Water and public water infrastructure (mains, hydrants, etc.) around Biddeford Pool, especially along Hills Beach Road, Channel Cove Lane, and Oceanview Drive, are located in areas that are vulnerable to flooding from the 1.6 ft scenario.
- **Critical facilities:** the Biddeford Pool Fire Department is not exposed to flooding from the two modeled scenarios, but access from the Department to other locations along the coast is impacted by extensive flooding of Mile Stretch Road.
- Almost 25,000 linear feet of road are vulnerable to flooding from storm surge plus 1.6 feet of sea level rise. Vulnerable roads include **Route 208/Mile Stretch Road**, **Granite Point Road**, **Fortunes Rocks Road**, **Hills Beach Road** and **Timber Point Road**. These road impacts make the coastal area of Biddeford particularly vulnerable to coastal flooding and sea level rise because they are the only access roads to their associated coastal neighborhoods and homes (Figure 13).
- **Route 208/Mile Stretch Road** is a designated evacuation route that is vulnerable to flooding. The road is projected to be flooded in the modeled scenario of storm surge plus 1. 6 feet of sea level rise. Mile Stretch Road is the only access route in and out of the Biddeford Pool neighborhood, which is a block group of elevated social vulnerability based on the percentage of the population over the age of 65 living alone and percentage of households with an annual income of less than the state and county median income as well as the EPA climate change and social vulnerability income threshold.
- There are three **tidal road crossings (culverts)** that are restrictions and vulnerable to sea level rise along the coast on Lilly Pond Road, Bridge Road, and Granite Point Road. There is also one on Pool Street near Tattle Corner.
- 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 areas along Granite Point Road.
- Most rip-rap in front of residential properties along Old Kings Highway.
- The majority of structures along Fortunes Rocks Road.
- Rip-rap along Bridge Road near its intersection with Mile Stretch and Fortunes Rocks Roads.
- Most structures along the back marsh side of Mile Stretch Road and on the ocean side of residential properties.
- The majority of structures along Ocean Avenue, Biddeford Pool, and the middle and southern portions of Hills Beach.

Table 6. Storm and sewer 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)

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**
Storm and Sewer	Wastewater Treatment Facility	-	Yes	-
	Pump Stations	1 (Yates Street Pump Station)	1 (Yates Street Pump Station)	35
	Gravity Force Mains	13,121 ft	14,503 ft	628,158 ft
	Other storm and sewer infrastructure points (manholes, grates, *etc.*)	63	86	4,3777

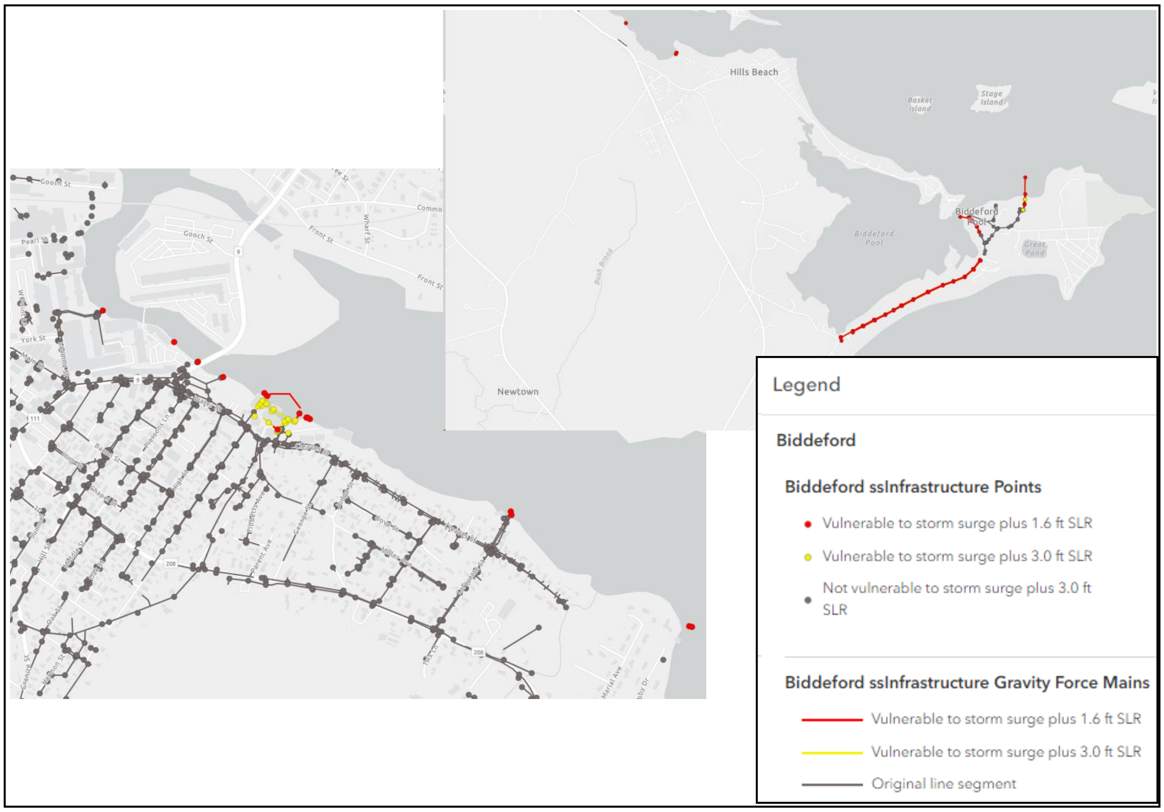

Figure 12. Water, stormwater, and sewer infrastructure vulnerable to flooding. (Source: SMPDC. 2022 coastal economic resilience assessment, phase 2. Unpublished.)

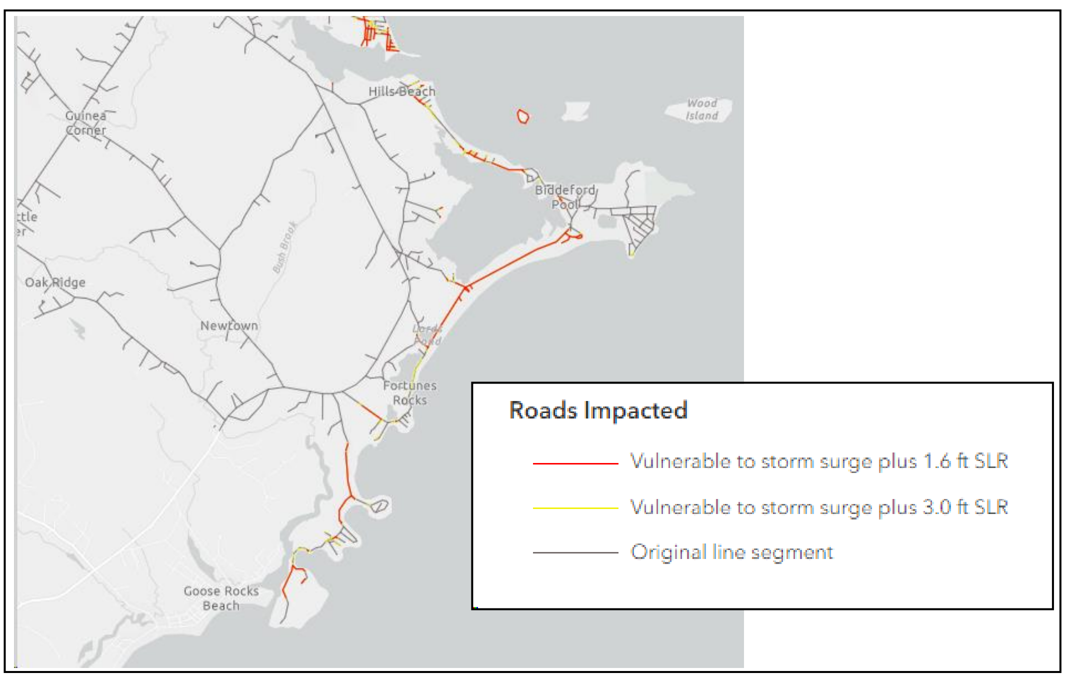

Figure 13. Roads impacted by storm surge plus sea level rise.(Source: SMPDC. 2022 coastal economic resilience assessment, phase 2. Unpublished.))

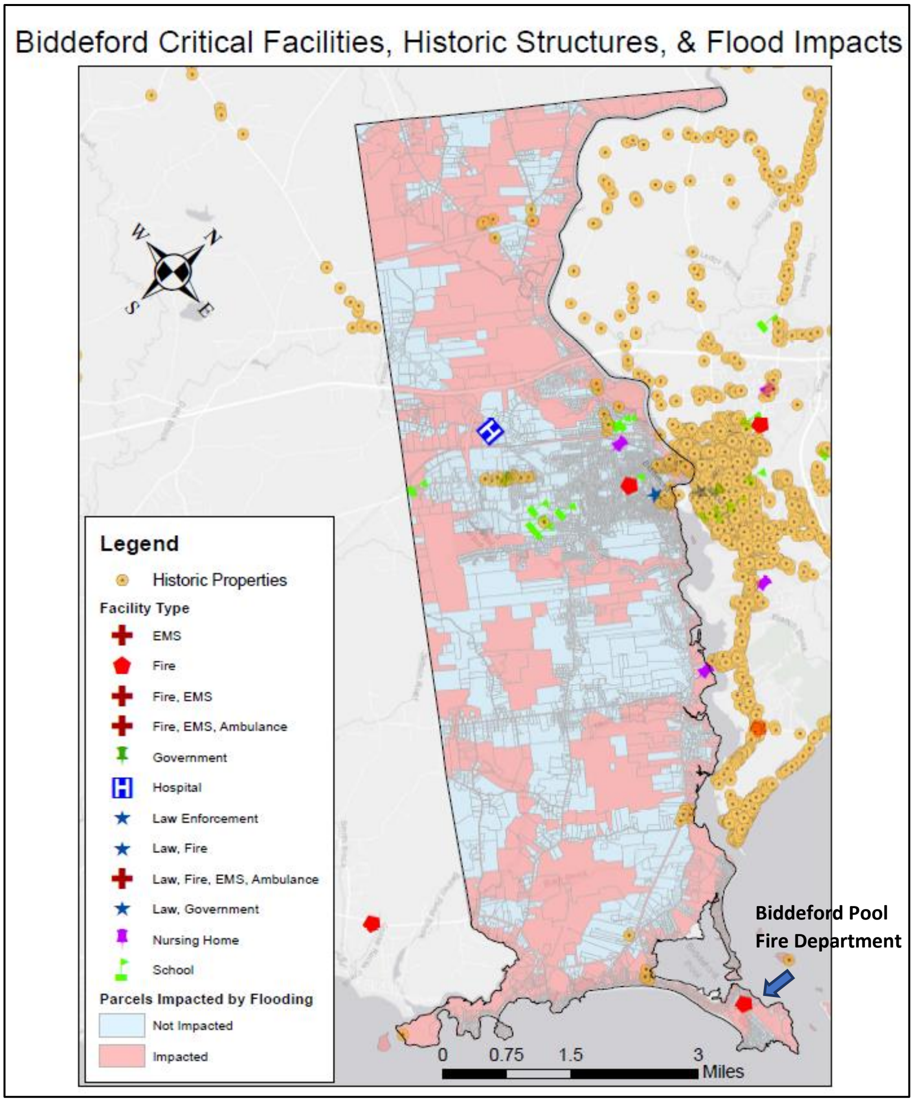

Figure 14. Mapped locations of historic properties, emergency management and public health facilities, and schools. Parcels are color-coded based on if they are projected to be directly impacted by flooding from the 1%-annual chance event (e.g., the FEMA regulatory floodplain), 1.6 feet of sea level rise, and/or 3.9 feet of sea level rise. (Source: SMPDC EDA disaster grant study, phase 2)

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, Biddeford's dry beach width (distance from the mean high water to seawall or dune edge) is projected to decrease by 7.9 acres, or by roughly 47% from existing conditions. With 3.9 feet of sea level rise, the dry beach width is projected to decrease by 86%[23].
- Sea level rise is expected to lead to loss of coastal habitat. Along Biddeford'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 Fortunes Rocks Beach, most of Middle Beach, and most of Hills Beach have been relatively stable in terms of measured beach width over the past several years (2016 – 2020). However, the middle segment of Middle Beach and middle and southern segments of Hills Beach have experienced erosion. Sea level rise will likely exacerbate erosion in areas already experiencing it and lead to additional erosion along all beach areas.

Figure 15. Mapped shoreline change along Goose Rocks Beach. 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 lines) represents a rate of beach loss. (Source: Maine Geological Survey. Maine Beach Mapping Program. Maine Beach Mapping viewer)

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

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 marsh movement. The Maine Natural Areas Program (MNAP) has mapped areas that could support marsh migration with future sea level rise (Figure 16**Error! Reference source not found.**). 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.

- Areas along Biddeford Pool and Little River have been identified as being able to support future marsh migration. Some of those areas are adjacent to existing conserved lands, however, areas in the Granite Point area and Fortunes Rocks Beach could support migration and are not yet conserved.
- Several pocket areas along tidal portions of the Saco River have also been identified as being able to support future marsh migration.

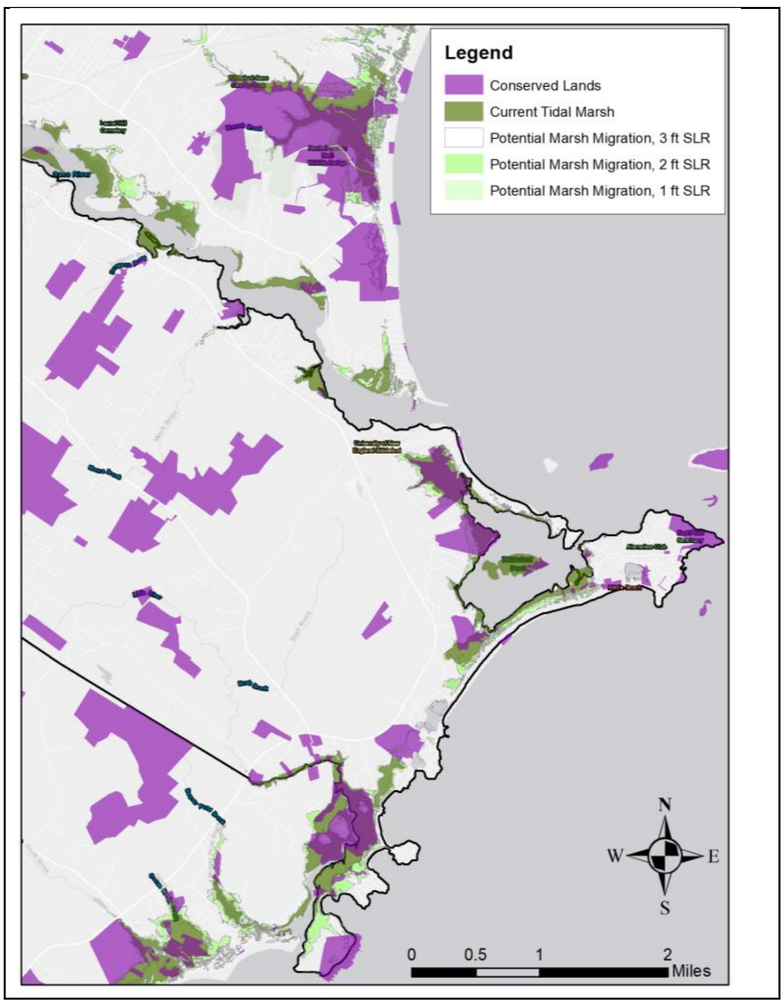

Figure 16. Existing conserved lands (purple) and areas that could support future migration of existing tidal marshes with future sea level rise. The areas are non-tidal lands within existing tidal estuaries that could be inundated and facilitate the development of new areas of tidal marsh if sea level 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 & Air Quality

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 Biddeford, 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 of vector-borne diseases like Lyme disease.

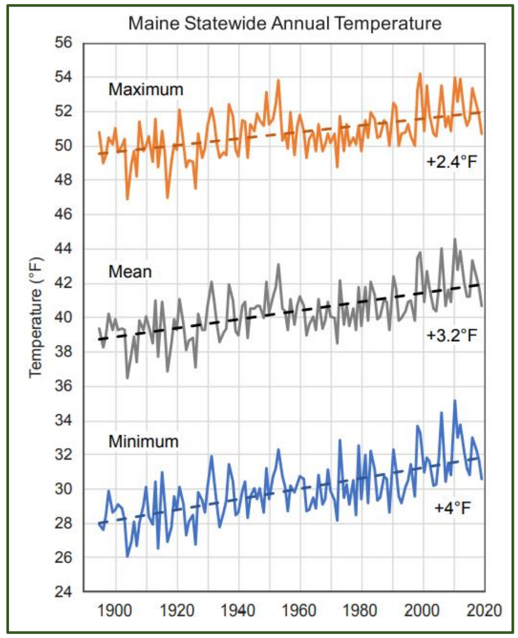

Figure 17. Maximum, mean, and minimum statewide annual temperatures from 1895 to 2019. (Source: MCC STS. 2020.)

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[24] (Figure 17). 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 to 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 18)[25]. In addition to extreme heat, there is research showing that more short-term temperatures variability and volatility may be happening as a result of climate change.

[24] 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.

[25] 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.

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 Biddeford (Table 7). 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 8). 2023 was the warmest January on record, with an average temperature of 31.9°, 8.5° warmer than the January mean temperature.

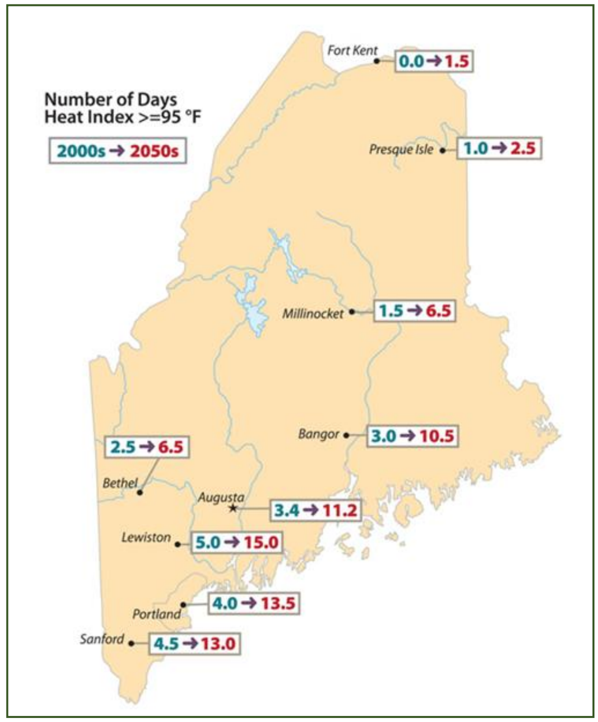

Figure 18. Average number of days when the heat index is greater than or equal to 95°F at selected sites for 2000 - 2004 and 2050 – 2054. Predicted values derived from a 48-km downscale simulation of one ensemble member of the CCSM3 model for the IPCC A2 emissions scenario. Source: Fernandez et al. (2015). (Figure from MCC STS. 2020.)

Table 7. 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 8. 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 (Figure 20) show areas in Biddeford 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 Biddeford, areas in the downtown, along Route 208, Guinea Road, East Point/Biddeford Pool, and in the northwestern portion of the city are mapped as having elevated ground temperatures in relation to the rest of the community. The downtown and Biddeford Pool areas that are mapped as moderate to severe heat severity also have elevated social vulnerability and vulnerabilities to flood hazards. The northwestern portion of the city does not have a high concentration of buildings, but has moderate to severe heat island severity. Knowing where areas of high heat are located can inform mitigation and adaptation strategies.

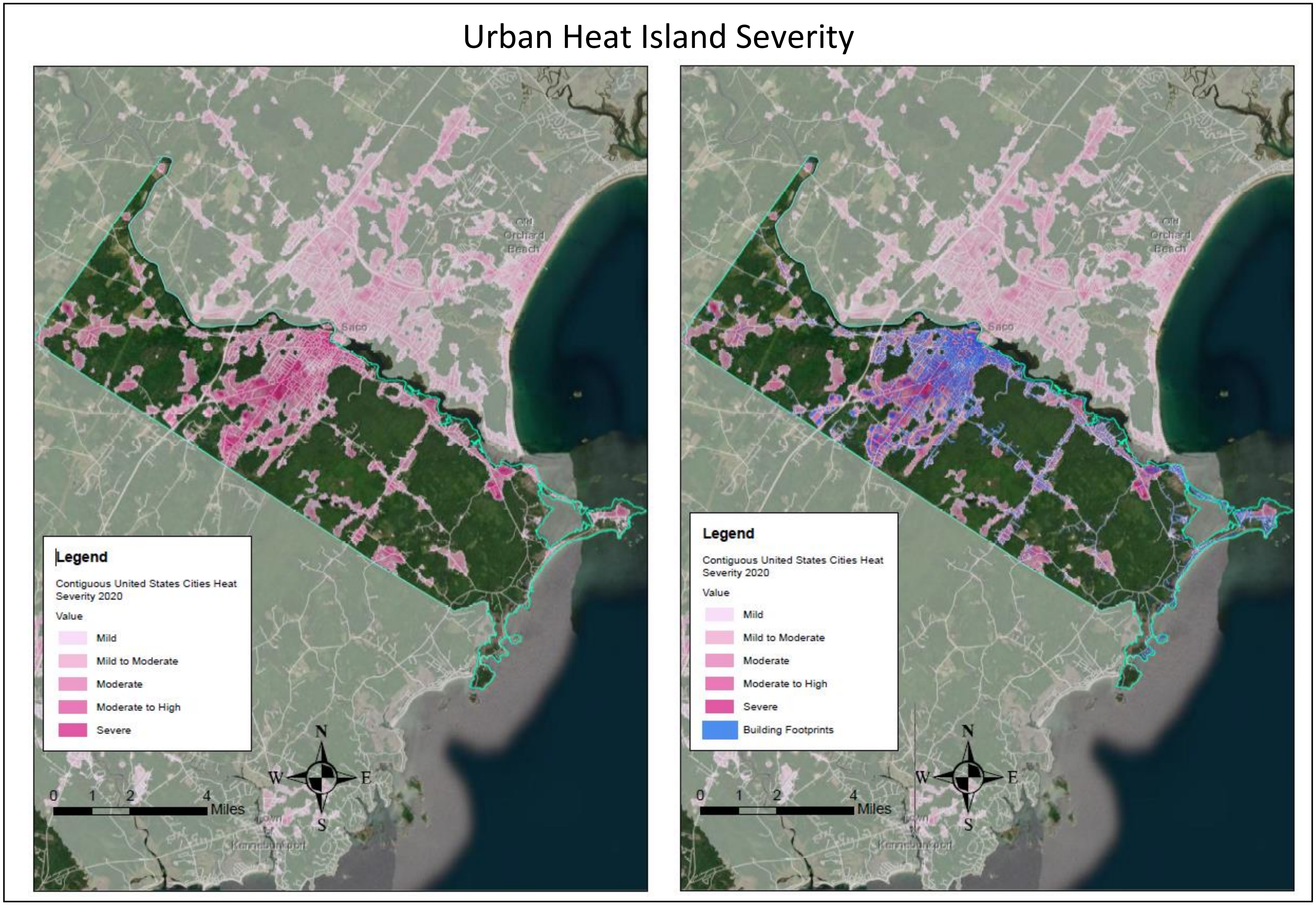

Figure 20. Urban heat island severity (left) overlaid with building footprints (right). Heat island severity data source: Trust for Public Land. Map created by SMDPC

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 (24). 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[26]. 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 [27]. 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.

[26] Maine Health Data Organization (MHDO). Data analyzed and display prepared by the Environmental Public Health Tracking Program. Data updated: 06/2021.
[27] 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.

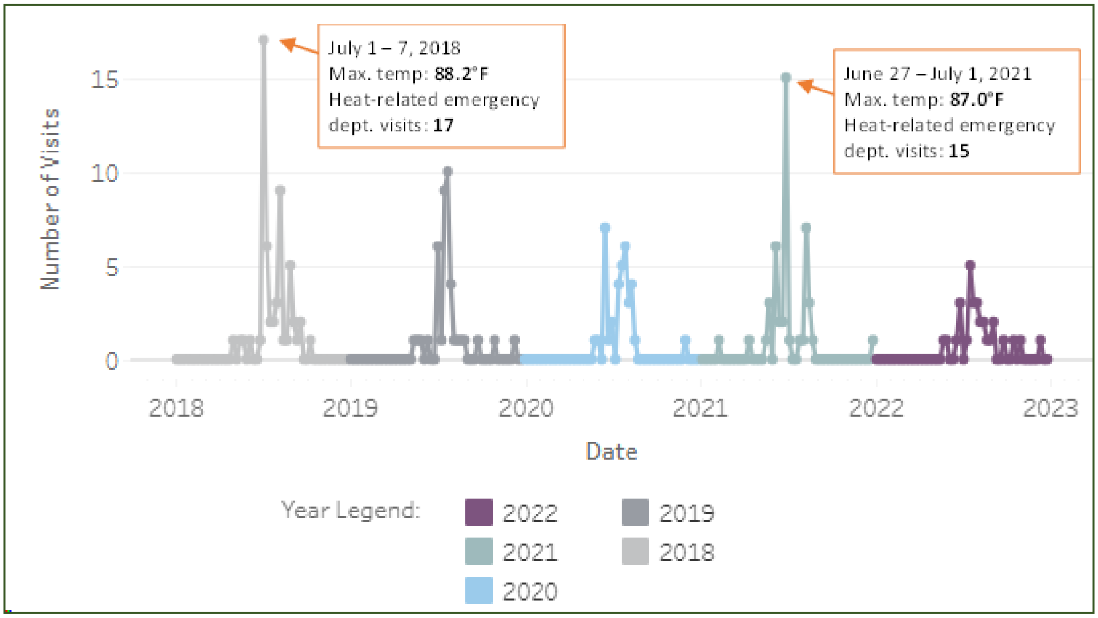

Figure 19. Number of heat illness visits to emergency departments in York County from 2018 to 2023. (Source: Maine Center for Disease Control and Prevention, Maine Tracking Network.)

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.[28] Figure 21 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[29]. Regardless of the cause, individuals with existing health conditions, older populations, and children are especially vulnerable to poor air quality. Residents of Biddeford's downtown area may be especially vulnerable to poor air quality due to high rates of asthma.

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

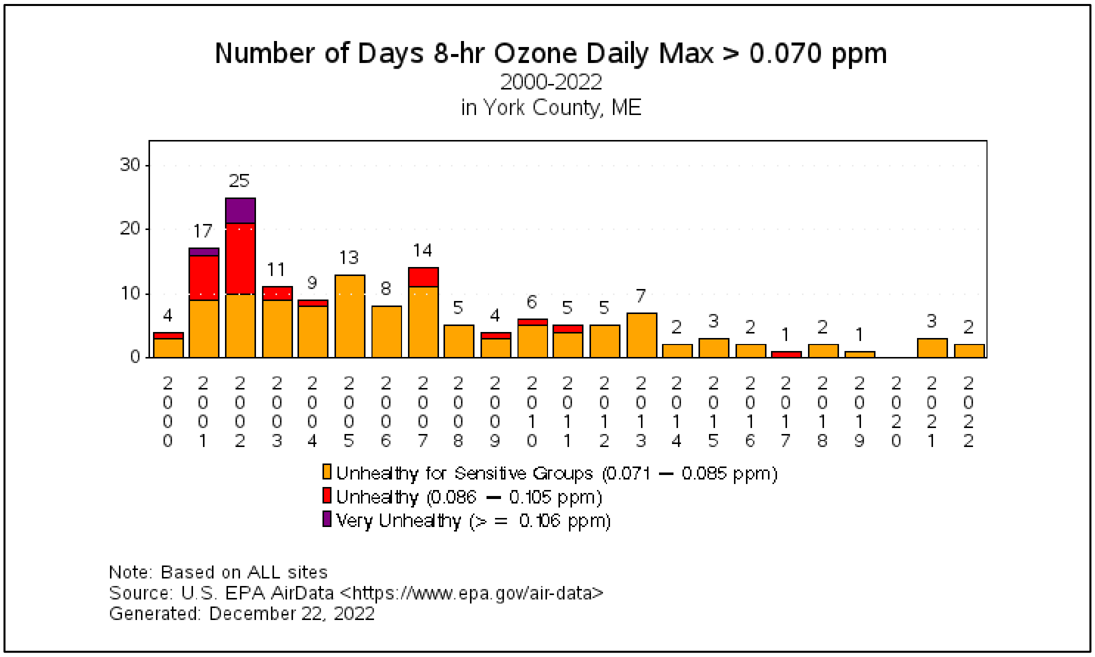

Figure 21. Number of days during which the 8-hour average ozone concentration exceeded national air quality standards. (Source: US EPA AirData portal)

The prevalence of tickborne diseases, including Lyme, anaplasmosis, and babesiosis, has increased in York County in recent years. Figure 22 shows that rates of all three diseases have increased since 2001. Table 9 shows the incidence rate (per 100,000 people) of confirmed and probable cases of tickborne disease in Biddeford. Between 2016 and 2020, Kittery had the second lowest rate of anaplasmosis and fourth lowest rate of Lyme of all York County communities.

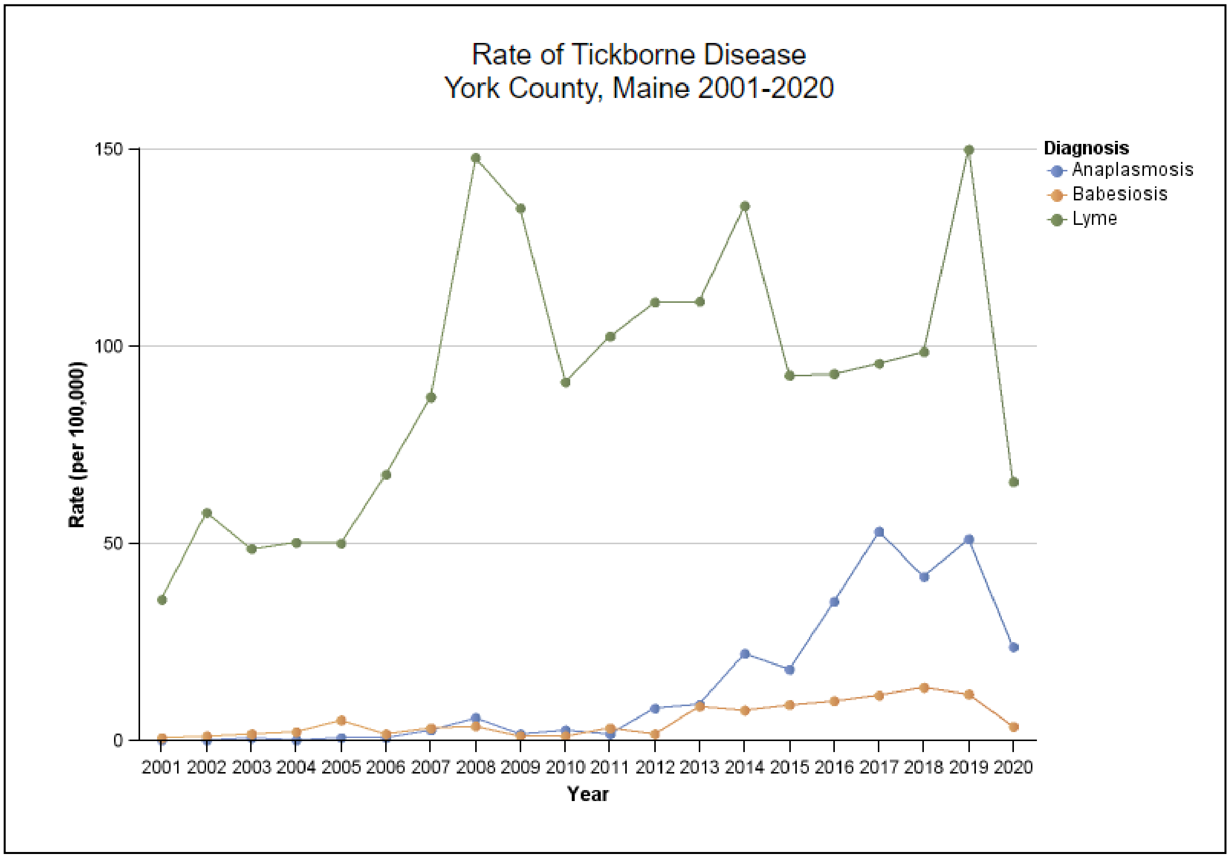

Figure 22. Annual incidence rate (per 100,000 people) of confirmed and probable cases of tickborne diseases of the population in York County. Maine CDC's Infectious Disease Program obtained these data through notifiable conditions surveillance based upon reports from healthcare providers, laboratories, 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.

Table 9. Rate and number of confirmed and probable cases of tick-borne disease in Biddeford, 2016 -2020. (Source: Maine Center for Disease Control and Prevention. Infection Disease Program. Maine Tracking Network Data Portal.)

Rate and Number of Tickborne Diseases in Biddeford, 2016 - 2020			
	Anaplasmosis	Babesiosis	Lyme
Confirmed and probably cases	9	3	47
Rate (per 100,000 people)	8.3	2.8	43.1

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 (24). Rising temperature and shorter winters will impact Biddeford'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[30]. 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 near Biddeford 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 levels in the Saco River, Biddeford's sole public water source, were historically low during recent droughts.
    - There are 470 private wells in Biddeford. Groundwater levels were historically low during all the most recent droughts and 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.

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

[30] 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.

drought conditions in southern Maine in recent years.[31] 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.[32] 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.[33]

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.[34] In York County, there have been four periods of severe to extreme drought since 2000, which 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 23).

- 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 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

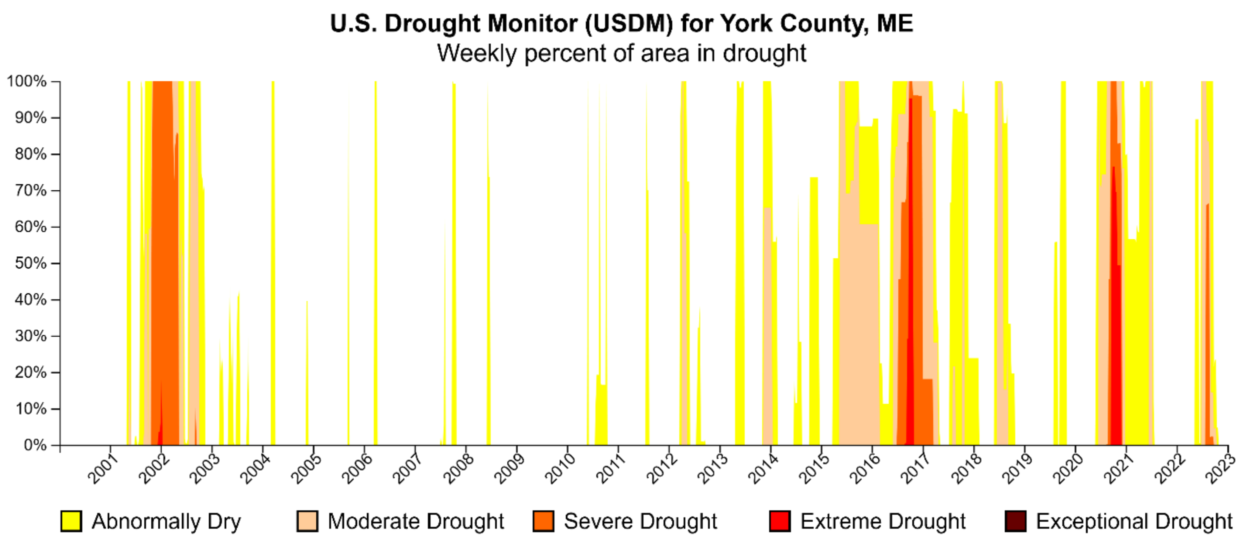

Figure 23. Drought conditions in York County from 2000 to 2022. Four severe to extreme droughts have occurred over the last 20 years and have been more frequent in the past decade. Data source: [U.S Drought Monitor](#).

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

There is limited data for snowfall and snowpack depth in Biddeford. From 1994 to 2017, snowpack depth data 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 24). Historically, March has been the snowiest month in this area. Though data are limited in more recent years, a snowpack depth of 0 inches was reported in February 2012 and April 2017.

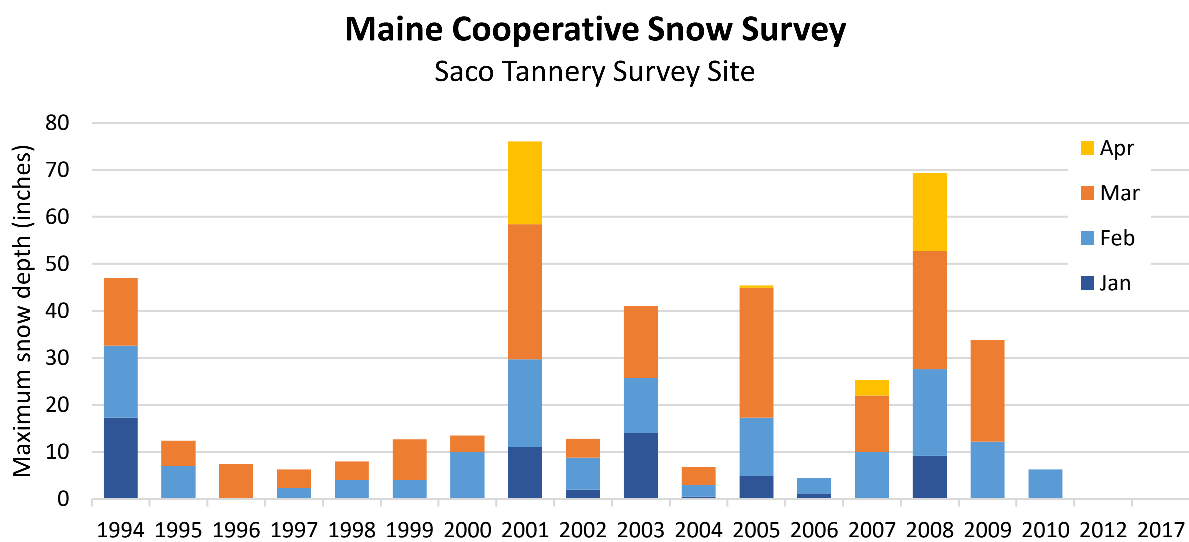

Figure 24. Maximum snow depth at Saco Tannery Survey Site, 1994-2017. Data source: Maine Geological Survey Cooperative Snow Sruvey

Combined snowfall amounts in Biddeford 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 depth and aquifer recharge and contributed to the emergence of a summer and fall drought in 2022.[35] 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.[36] Communities supplied by groundwater wells, rivers, or smaller lakes are at greater risk of water quantity and quality impacts from drought.[37] The City of Biddeford is serviced by the Biddeford and Saco Division of the Maine Water Company, and the Saco River is the sole source of Biddeford's public water supply.[38]

[35] ME Drought Task Force Report, 10/6/2022: https://www.maine.gov/mema/hazards/drought-task-force
[36] ME Climate Council, Maine Climate Science Update 2021: http://climatecouncil.maine.gov/reports
[37] Casco Bay Estuary Partnership, Climate Trends in Casco Bay, 2015: https://www.cascobayestuary.org/publication/climate-trends-in-the-casco-bay-region/
[38] Maine Water Company, Biddeford and Saco 2021 Water Quality Report: https://www.mainewater.com/water-quality/water-quality-report

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.[39]

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.[40] However, the Maine CDC Drinking Water Program did receive reports of low water quantity from public water suppliers during the 2022 summer drought.[41] 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.[42] In the future, more frequent, prolonged, or intense droughts have the potential to cause similar types of issues with Biddeford's public water supply.

Drought can also impact water quantity and quality in private wells. There are a total of 470 private wells in Biddeford (259 wells have location data and are displayed in Figure 25), and 93% of these wells are for domestic use.

[39]USGS Streamflow monitoring data: https://waterdata.usgs.gov/monitoring-location/01066000/#parameterCode=00065&period=P7D
[40] EPA Safe Drinking Water Information System: https://ordspub.epa.gov/ords/sfdw/f?p=SDWIS_FED_REPORTS_PUBLIC:PWS_SEARCH:::::PWSID:ME0090170
[41] ME Drought Task Force Report, 8/4/2022: https://www.maine.gov/mema/hazards/drought-task-force
[42] 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

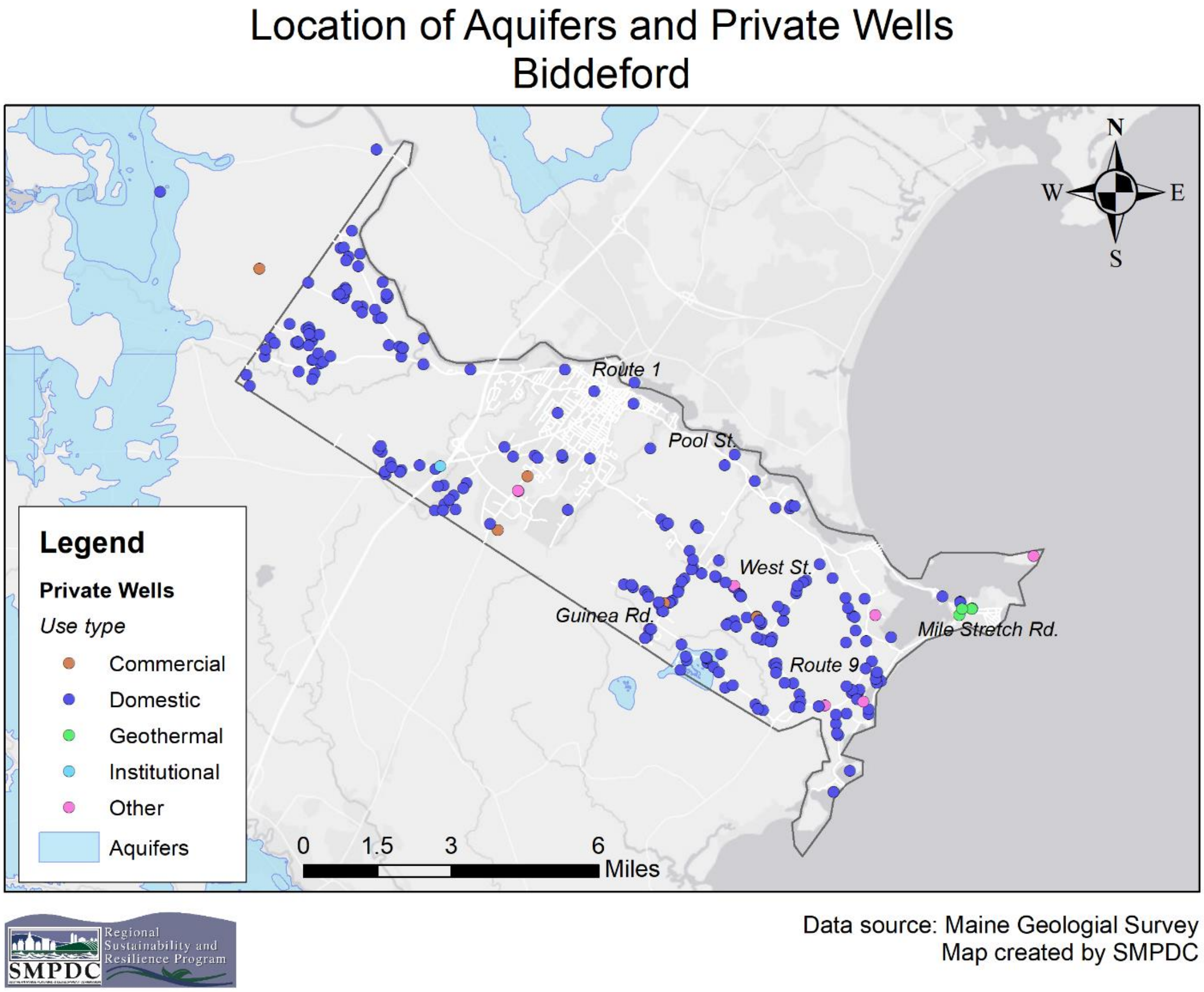

Figure 25. Location of aquifers and private wells in Biddeford as well as well use type. Data source: Maine Geological Survey

The USGS monitors groundwater levels in York County at an index well in Sandford (Figure 26). 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.

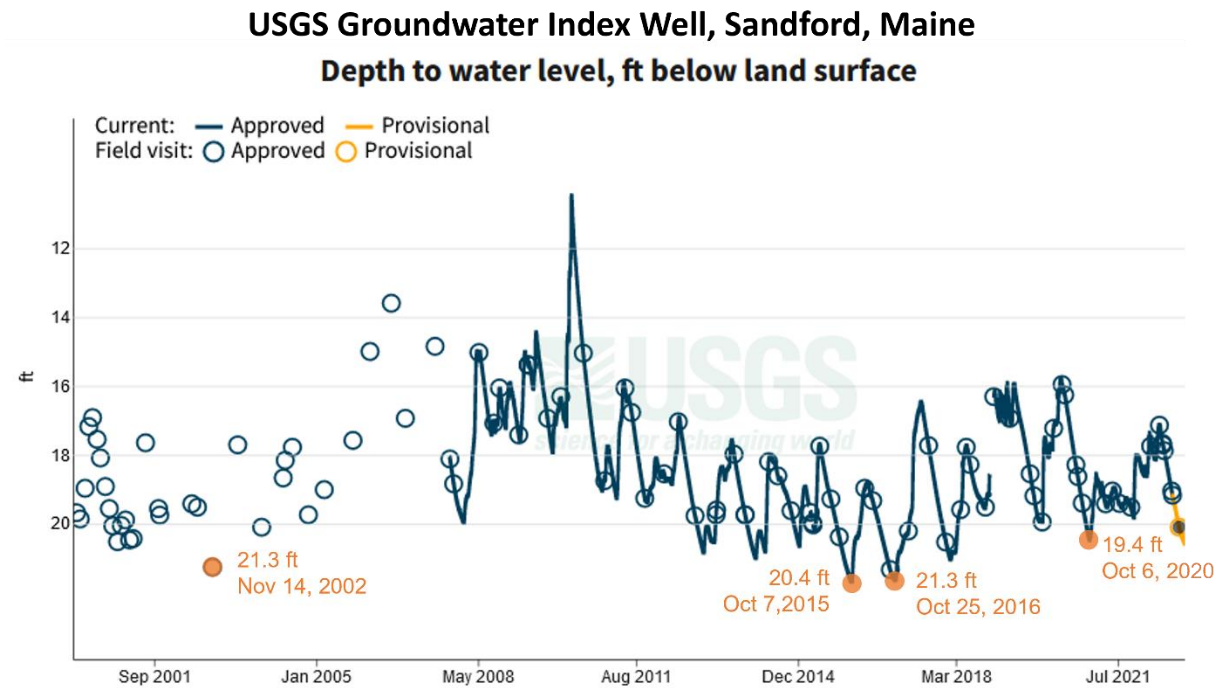

Figure 26. Groundwater levels in York County measured at an index well in Sandford, 2001-2021. Data source. United Stated Geological Survey

Since 2020, the Maine Drought Task Force has collected data about wells that run dry due to drought (Table 10). 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 Biddeford who rely on groundwater wells as their water source.

Table 10. Number of dry wells in York County in 2020, 2021, and 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 11.

Table 11. 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.[43] 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 12).[44]

Table 12. Number of wildfires statewide in 2020, 2021, and 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 Biddeford specifically, increased wildfire frequency and severity was associated with the 2002 and 2020 droughts. There were two large wildfires during the summer of 2002 which destroyed about 10 acres.[45] More recently, in April 2020 a large wildfire burned about 20 acres of wooded area and took 3 hours to get under control.[46] Over the last several decades, Biddeford has been a hotspot for wildfire occurrences compared to the rest of the county (Figure 27).[47] In the future, more frequent, prolonged, or intense droughts have the potential to increase the risk of wildfires, posing a threat to Biddeford's natural environment and public safety.

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

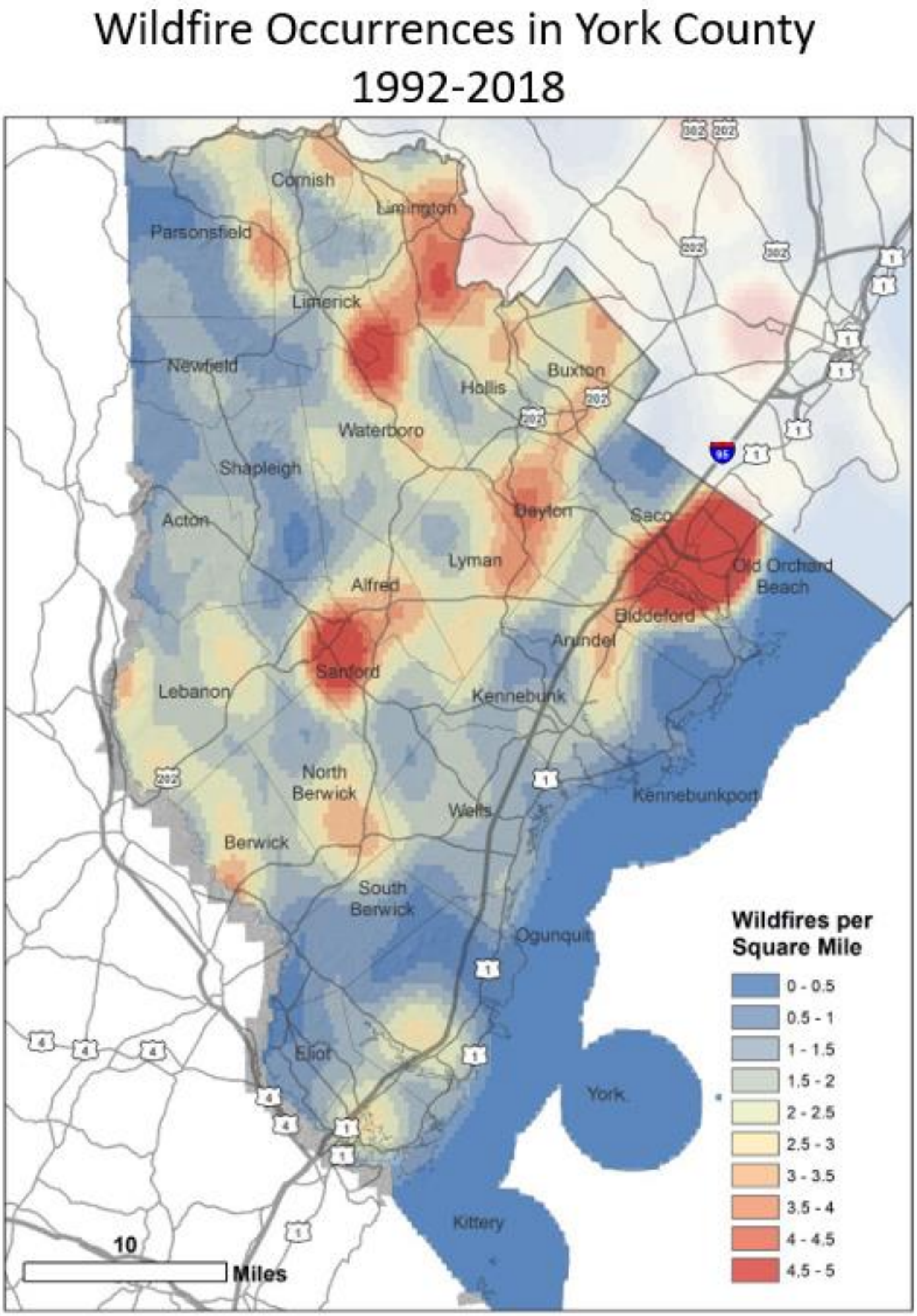

Figure 27. Wildfire occurrence in York County per square mile, 1992-2018. Data source: York County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.yorkcountymaine.gov/emergency-management

There are several pockets of conserved land in Biddeford (Figure 28). These conserved areas are managed by the City, Saco Valley Land Trust, Maine Coast Heritage Trust, Blandings Park Wildlife Sanctuary, and the USFWS Racheal Carson National Wildlife Refuge. The richest habitat areas are in the forested Blandings Park Wildlife Sanctuary near Tattle Corner, and the marsh habitats near Hills Beach and Fortunes Rocks that are part of the National Wildlife Refuge. In the future, more frequent, prolonged, or intense droughts have the potential to damage these critical habitat areas.

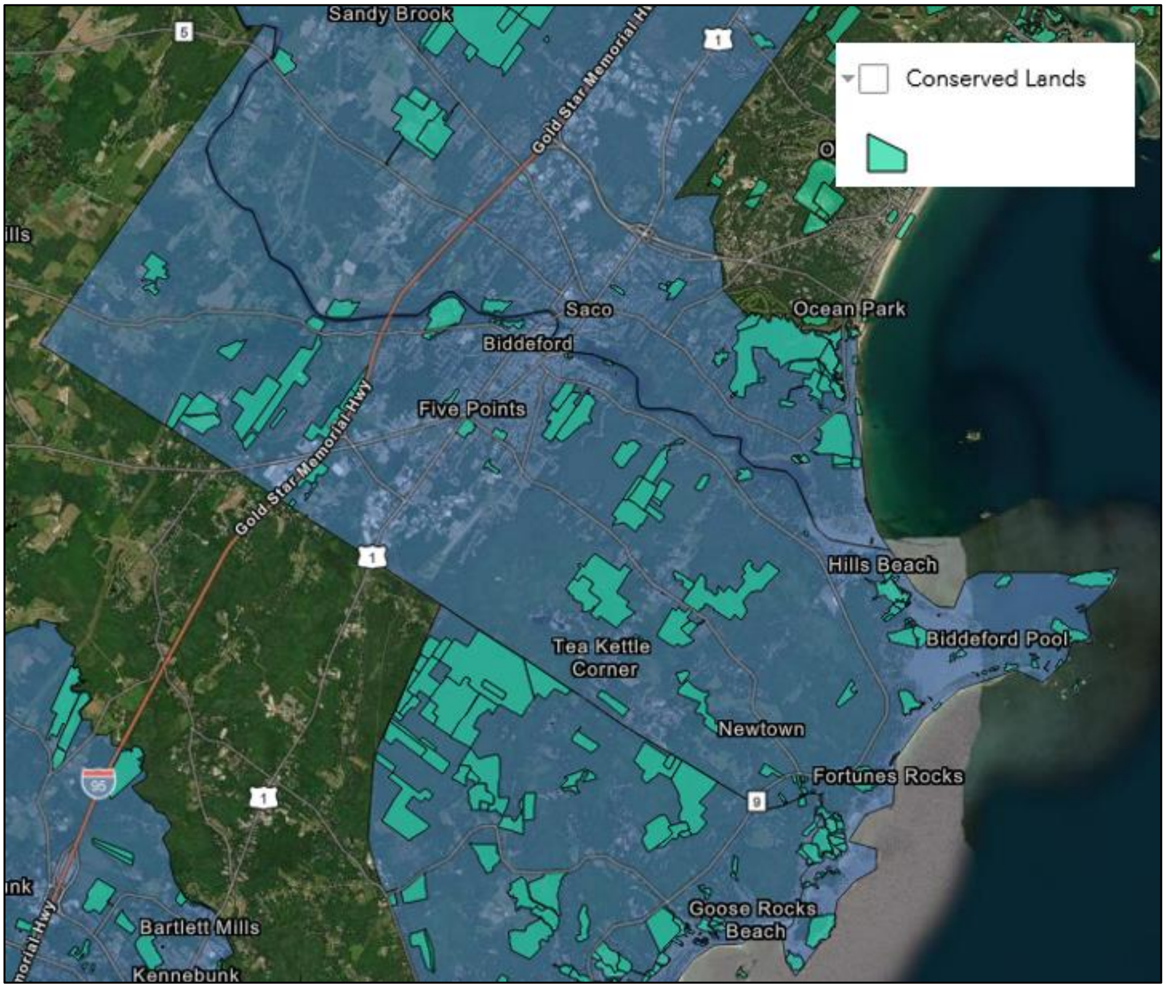

Figure 28. Conserved lands in Biddeford are indicated by the green polygons. Data source: Maine Natural Areas Program. Map source: Climate Ready Coast Southern Maine

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.[48] In both 2020 and 2022, the Farm Services Administration issued emergency declarations for York County as a result of prolonged, severe drought conditions.[49] Even if farmers have irrigation systems, water supply can still be

[48] ME Drought Task Force Report, 8/4/2022: https://www.maine.gov/mema/hazards/drought-task-force
[49] Cumberland County Emergency Management Agency, Hazard Mitigation Plan, 2022: https://www.cumberlandcounty.org/231/Hazard-Mitigation

an issue. The Maine Department of Environmental Protection restricts irrigation withdrawals when stream and river levels fall below a certain threshold.[50]

Biddeford is known for its vibrant downtown and historic textile industry, but the City has a strong agricultural heritage as well. At least half of Biddeford is zoned for rural farm use (see zoning map) and a number of operating farms grow vegetables and raise animals like alpacas and goats. In 2018, Engine, a local community development organization, launched a local foods initiative to create opportunities for local farms and increase access to healthy, local foods for disadvantaged groups. In the future, more frequent, prolonged, or intense droughts have the potential to reduce local farmers' production, increase their costs, and disrupt the local food system and economy.

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. Maines marine ecosystem will resemble present day conditions in southern New England.
    - There is limited commercial fishing and aquaculture activity in Biddeford, however the individuals who rely on these industries 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 improved in the Biddeford Pool and Woods Island Harbor between 1997 and 2010, potentially because of better stormwater 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 due to rising air temperatures and shifting ocean currents caused by climate change.[51] 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

[50] Maine DEP Press Release: https://www.maine.gov/dep/news/news.html?id=8535391

[51] https://www.gmri.org/stories/gulf-of-maine-warming-update-summer-2021/

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.[52]

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.[53]

It is also 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 functions 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.[54]

DMR surveyed eelgrass distribution in Biddeford in 1997 and again in 2010 (Figure 29). The greatest distribution and highest density eelgrass habitat was located at the mouth of the Biddeford Pool in Woods Island Harbor, with sparser patches at the mouth of the Saco River. Between 1997 and 2010, eelgrass habitat disappeared at the mouth of the Saco River, while the distribution in Woods Island Harbor remained largely unchanged and density increased. These changes suggest that water quality in the Saco River declined over this time period and improved in the Biddeford Pool potentially as a result of changing stormwater and 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

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

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

[54] Piscataqua Region Estuaries Partnership: https://prepestuaries.org/eelgrass/

increase in the green crab population.[55] Biddeford may have experienced similar losses, but there is not 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.

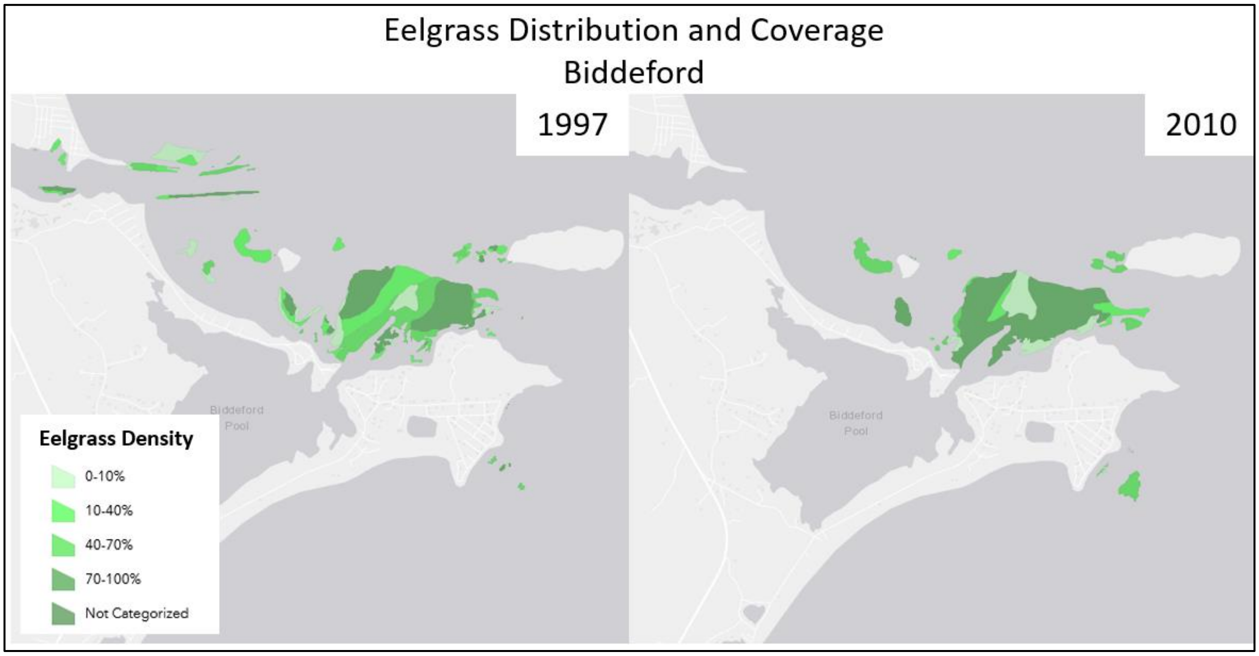

Figure 29. Distribution and coverage of eelgrass habitat in Biddeford in 1997 and 2010 based on the Department of Marine Resources eelgrass survey. Exact distribution ranges may have shifted in the last decade, but these data indicate the presence of historic eelgrass habitat and potential carbon sinks.

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, potentially threatening the health of Biddeford's eelgrass beds. The Biddeford Pool also has a high degree of impervious surfaces (see Extreme Storms & Precipitation), which increases runoff during heavy rainfall events further stressing eelgrass habitat. Additionally, warming ocean temperatures favor green crab population growth which may contribute to future eelgrass habitat loss.[56]

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 against intense coastal storms. For these reasons, eelgrass habitat is not only important for the role it plays in ecosystem functions, but also for the climate mitigation and resilience benefits it provides. These important ecosystem services emphasize the importance of protecting this vulnerable habitat.[57]

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[55] 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

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

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

Economic Impacts

There are a total of 36 commercial fishing licenses held in Biddeford and 74 non-commercial licenses (Table 13). 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. Non-commercial license holders' recreational fishing opportunities may also be impacted, representing a significant cultural loss for the community's identity.

Table 13. Commercial and non-commercial fishing licenses in Biddeford from the Maine Department of Marine Resources.

Commercial and Non-Commercial Fishing Licenses	
Commercial	**Number of Licenses**
Lobster/crab	13
Fishing	12
Shellfish	6
Green crab	3
Elver	1
Scallop dragger	1
Total	*36*
Non-Commercial	
Saltwater fishing	43
Lobster/crab	30
Menhaden	1
Total	*74*

In 2010, the Maine Department of Marine Resources (DMR) conducted a survey of shellfish habitat across the state. Based on that survey, there are several pockets of softshell clams, blue mussels, and surf clams in Biddeford (Figure 30). However, shellfish harvesting is prohibited along much of Biddeford's coastline because of poor water quality. Fortunes Rocks Beach is open for harvesting and the Pool is conditionally approved, which means DMR will allow harvesting under certain conditions. As a result, wild shellfish harvesting is limited in Biddeford and there are only a handful of commercial license holders. The community is therefore less economically vulnerable to the impacts of climate change on shellfish species. However, warmer waters and ocean acidification have the potential to impact these species which are a critical part of the marine ecosystem.

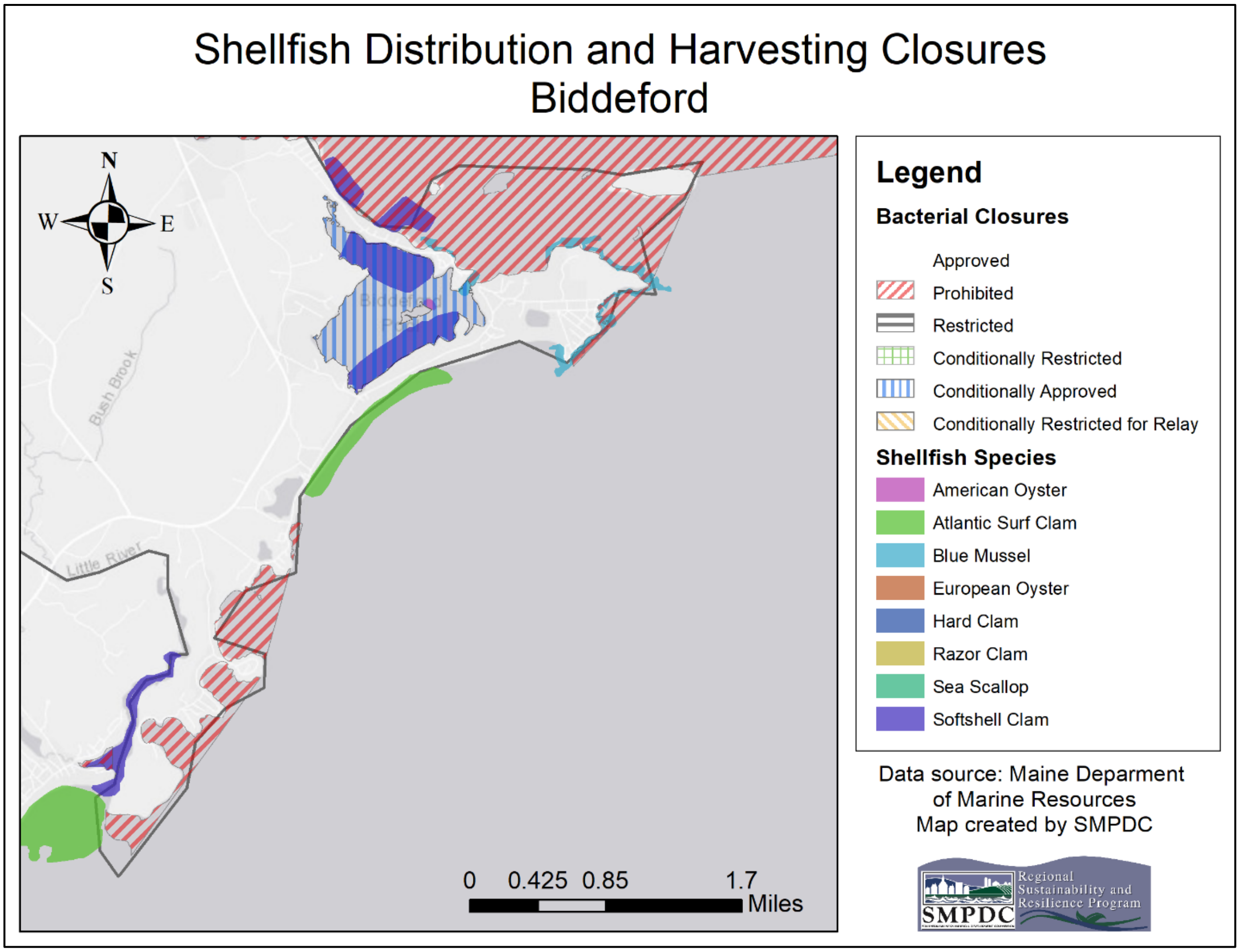

Figure 30. Distribution of shellfish species based survey conducted by the Maine Department of Marine Resources in 2010. Areas that are prohibited or restricted for shellfish harvesting based on poor water quality from bacterial contamination are also indicated. Data from the Maine Department of Marine 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 more climate resilient alternative to wild harvest fisheries like lobster. Currently, aquaculture activity is sparse in Biddeford, with only one Limited Purpose Application License for growing kelp off of Woods Island. Shellfish aquaculture is likely limited by the harvesting closures in many of the community's more protected areas. Two of the state's few farmed seaweed processors are based in Biddeford; their operations could be impacted by shifting marine conditions across Maine, not just those in Biddeford.