Massachusetts State Hazard Mitigation and Climate Adaptation Plan

Chapter 2: Planning Context

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Acronyms and Abbreviations

°F	Degrees Fahrenheit
BIA	U.S. Bureau of Indian Affairs
CZM	Office of Coastal Zone Management
DEP	Department of Environmental Protection
DPA	Designated Port Areas
EJ	Environmental Justice
EOEEA	Executive Office of Energy and Environmental Affairs
EOPSS	Executive Office of Public Safety and Security
GHG	Greenhouse Gas
GIS	Geographic Information System
GWSA	Global Warming Solutions Act of 2008
MAPC	Metropolitan Area Planning Council
MassDOT	Massachusetts Department of Transportation
MEMA	Massachusetts Emergency Management Agency
MBTA	Massachusetts Bay Transportation Authority
MVP	Municipal Vulnerability Preparedness
RTA(s)	Regional Transit Authority (Authorities)
SHMCAP	State Hazard Mitigation and Climate Adaptation Plan
STIP	State Transportation Improvement Plan
TDI	Transformative Development Initiative

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2. Planning Context

This chapter provides an overview of key considerations for hazard mitigation and climate adaptation planning in the Commonwealth, including the organization of government in Massachusetts and introduction of the Commonwealth's Climate Change Strategy. Table 2-1 identifies the Commonwealth's Executive Offices and agencies that are primarily responsible for hazard mitigation and climate adaptation planning in the state. Sections on recent and projected development trends and climate change projections are also included to provide a summary of changes that have occurred or are projected to occur in Massachusetts that may affect risk and vulnerability, as determined in the risk assessment that was conducted for this integrated State Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

Table 2-1: Commonwealth Government Roles for Hazard Mitigation and Climate Adaptation Planning

Executive Office / Agency	Role
Massachusetts Emergency Management Agency (MEMA)	MEMA ensures the state is prepared to withstand, respond to, and recover from all types of emergencies and disasters, and is responsible for maintaining the Commonwealth's State Hazard Mitigation Plan.
Executive Office of Energy and Environmental Affairs (EOEEA) and the Executive Office of Public Safety and Security (EOPSS)	Per Governor Baker's *Executive Order 569, Establishing an Integrated Climate Change Strategy for the Commonwealth*, EOEEA and EOPSS are responsible for maintaining a statewide climate adaptation plan.

2.1 Organization of State Government

Massachusetts was designated a commonwealth in 1780 when the Massachusetts constitution was ratified. The term is used to describe a body of people constituting a nation or state.

Massachusetts has three branches of government—the Executive, Legislative, and Judicial Branches—as well as constitutional officers and independent agencies and commissioners, which are part of the Executive Branch, but not subject to its oversight or control. The Commonwealth elects six constitutional officers every 4 years (see Table 2-2).

Table 2-2: Constitutional Officers as of September 2018

Title	Name
Governor	Charlie Baker
Lieutenant Governor	Karyn Polito
Secretary of the Commonwealth	William Francis Galvin
Treasurer and Receiver General	Deborah Goldberg
Attorney General	Maura Healey
Auditor	Suzanne Bump

The General Court, which consists of a 40-member Senate and a 160-member House of Representatives, is the legislative body of Massachusetts. Senators and Representatives are elected every 2 years. The Legislative Branch creates State laws and makes changes to existing laws. The Judicial Branch consists of the Supreme Judicial Court, Appeals Court, Executive Office of the Trial Court, seven Trial Court departments, Massachusetts Probation Services, and the Office of Jury Commissioner. The Supreme Judicial Court consists of Chief Justice Ralph D. Gants and six associate justices. The Governor, with the advice and consent of an executive council, appoints all justices. The Executive Branch of the state government oversees the programs and services offered by the State. Table 2-3 lists the Executive Offices and their functions.

The State House in Boston is the primary seat of Massachusetts government. The State Legislature and offices of the Governor are located at the State House.

Table 2-3: Executive Offices of Massachusetts

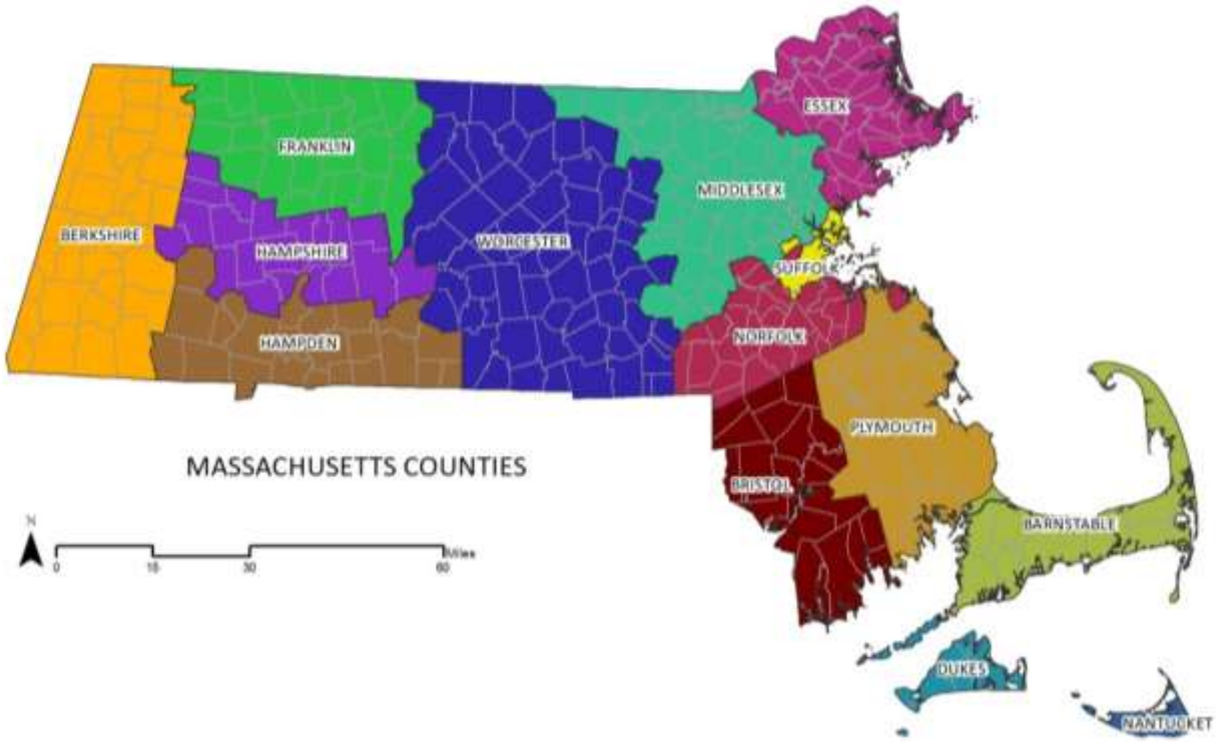
Executive Office	Function
Executive Office of Administration and Finance	Oversees the financial and administrative aspects of State government.
Executive Office of Education	Manages and sets the standards for State-backed education, and provides support for administrators, teachers, parents, and students.
Executive Office of Energy and Environmental Affairs	Manages and preserves the Commonwealth’s open spaces, enforces pollution laws, ensures new development projects do not harm the environment, and promotes eco-friendly energy production and conservation.
Executive Office of Health and Human Services	Oversees health and general support services to help people meet basic needs.
Executive Office of Housing and Economic Development	Supports job creation and economic development by fostering an environment conducive to business creation and expansion, and helps to drive housing construction that addresses the needs of residents.
Executive Office of Labor and Workforce Development	Manages the Commonwealth’s workforce and labor departments to ensure that employers, workers, and the unemployed have the tools and training needed to succeed in the Massachusetts economy.
Executive Office of Public Safety and Security	Keeps the people of Massachusetts informed about public safety issues, and provides services to protect residents from natural and man-made threats.
Massachusetts Department of Transportation	Oversees roads, public transit, aeronautics, and transportation licensing and registration across the state.
Executive Office of Technology Services and Security	Provides secure and quality digital information, services, and tools to customers and constituents when and where they need them.

Source: Mass.gov, 2018

2.1.1 Counties

There are 14 counties in Massachusetts (see Figure 2-1). Many counties’ governments are no longer in existence. However, county government continues to exist in Barnstable, Bristol, Dukes, Nantucket, Norfolk, and Plymouth Counties. In all counties, regardless of where there is a county government, there is a sheriff elected by the voters of the county.

Figure 2-1: Map of Counties in Massachusetts



Source: MassGIS, 2018

Home rule legislation allows officials or voters in a county to establish a regional charter commission to study its government. The commission can submit one of three model charters for voter approval in that county at a statewide election, or it can submit a special charter, which must first be approved by the State Legislature. Cities and towns may choose a regional council or government charter, which is binding on cities or towns where a majority of voters approve it. The regional council of governments can provide services to cities and towns, such as planning, public safety, engineering, water, and waste disposal. The participating communities pay assessments based on local property valuations. The legislature approved special charters to allow several counties to become regional councils of government (SEC, 2016).

2.1.2 Municipalities

Municipalities are the unit of government primarily responsible for providing local services. There are 351 cities and towns in Massachusetts, each with its own governing body. Typically, elected mayors govern Massachusetts' cities, and elected officials called selectmen govern the towns; however, there are exceptions, including town managers and city councils. A board of selectmen is usually elected for terms ranging from 1 to 3 years, and citizens participate in an annual town meeting. The open town meeting is the active legislature in a town. Some communities have a representative open town meeting, while others have a true "open" town meeting (SEC, 2016).

2.1.3 Indian Tribal Governments

The Commonwealth of Massachusetts has two federally recognized Indian Tribes within its boundary: the Mashpee Wampanoag Tribe, and the Wampanoag Tribe of Gay Head (Aquinnah). Federally recognized tribes are those recognized by the U.S. Bureau of Indian Affairs (BIA) for certain Federal government purposes. Federal tribal recognition grants to tribes the right to self-government, as well as certain benefits that include funding and services from the BIA and other federal agencies, either directly or through contracts, grants, or compacts.

2.1.4 Planning Regions

Chapter 40B of the Massachusetts General Laws established 13 planning regions throughout the Commonwealth in 1963 (see Figure 2-2). The Regional Planning Agency for each planning region works in concert with partnering jurisdictions and organizations to complete planning tasks, such as development of regional mitigation plans, transportation planning, economic growth studies, land use and energy planning, historic preservation, open space and natural resources, water and coastal resources, and mapping/geographic information system (GIS). These planning regions also support the Commonwealth's District Local Technical Assistance Program to pursue a variety of municipal shared service initiatives and planning projects through a region-wide solicitation process. Regional Planning Agencies are established as commissions or councils, and serve an advisory role. Each commission or council is composed of a representative from each member community.

Figure 2-2: Map of Planning Regions in Massachusetts

Source: MassGIS, 2018

2.1.5 The Commonwealth's Climate Change Strategy

The Commonwealth's Global Warming Solutions Act (GWSA) of 2008 created a framework for reducing greenhouse gas (GHG) emissions. The GWSA requires a 25 percent reduction in GHGs from all sectors of the economy below the 1990 baseline emission level in 2020, and at least an 80 percent reduction in 2050, with the goal of helping to avoid the worst impacts of climate change.

In September 2011, the Executive Office of Energy and Environmental Affairs (EOEEA) released the first Climate Adaptation Report for Massachusetts, fulfilling an important mandate of the GWSA. The report was developed by a Climate Change Advisory Committee that included a broad array of practitioners, scientists, non-governmental organizations, and Federal, State, and local governments. Findings from the report made clear that while the Commonwealth does its part to reduce and stabilize GHG emissions, it must also think seriously about how Massachusetts as a state will be impacted by climate change, the causes of which are global, and how it will prepare for and respond to local impacts.

In September 2016, Massachusetts Governor Charlie Baker signed Executive Order 569, which established an integrated climate change strategy for the Commonwealth. This executive order expands on the objectives of the GWSA to reduce GHG emissions, and directs the EOEEA to continue and accelerate efforts to mitigate and reduce GHG emissions. This includes establishing statewide GHG emissions limits for 2030 and 2040, and to promulgate regulations to ensure compliance with the 2020 emissions limit. Section 3 of the Executive Order directs the EOEEA to coordinate efforts across the Commonwealth to strengthen the resilience of communities, prepare for the impacts of climate change, and prepare for and mitigate damage from extreme weather events. This integrated hazard mitigation plan and climate adaptation plan has been developed in response to this recognition of the need and benefits of addressing climate change through an integrated strategy across sectors that brings together all parts of State and local government, and capitalizes on the expertise and institutional knowledge of the Executive Office of Public Safety and Security and the Massachusetts Emergency Management Agency. This plan satisfies the Executive Order 569 directive to publish a statewide climate adaptation plan.

Executive Order 569 also directs GHG emissions reductions and natural hazard resilience planning to wherever possible employ strategies that conserve and sustainably employ the natural resources of the Commonwealth to enhance climate adaptation, build resilience, and mitigate climate change. Natural resources, open spaces, and nature-based solutions provide multiple services that include resilience benefits, public health services, and contribute to environmental and restoration economies.

2.2 Recent and Projected Development Trends

2.2.1 Population and Population Trends

Massachusetts is a small, densely populated and growing state. Between 2000 and 2010, the population of Massachusetts increased by 3.1 percent, or nearly 200,000 people (U.S. Census 2000, 2010). Although in recent years it has been the fastest growing state in the Northeast (UMDI, 2015), the state has a relatively slow growth rate compared to the national growth rate of 9.7 percent between 2000 and 2010. According to the most recent American Community Survey 5-Year Estimates, the population of the state was 6,742,143 (ACS, 2012-2016). Middlesex County is the most populous county in the state, accounting for approximately 23 percent of the estimated population in 2016, while Dukes and Nantucket Counties comprise less than 1 percent of the population. The statewide density is approximately 864 people per square mile, and ranges from 101 people per square mile in Franklin County to 13,180 people per square mile in Suffolk County (see Table 2-4).

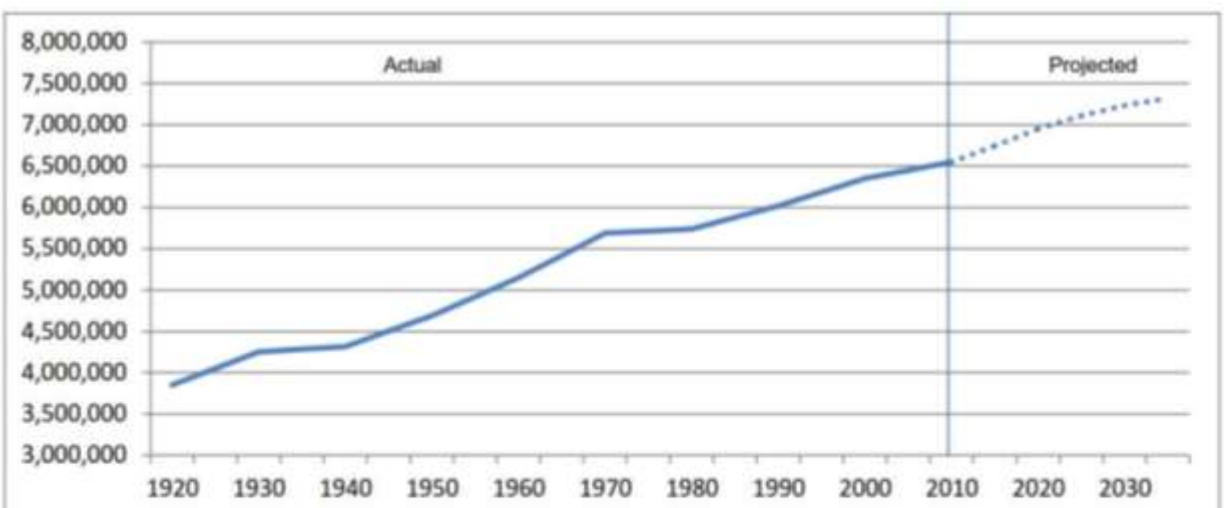
Local, regional, and statewide populations in Massachusetts were prepared by the University of Massachusetts Donahue Institute in 2015. The projected statewide population from 2015 through 2035 is displayed on Figure 2-3. According to these projections, the state's population is

Table 2-4: Population and Population Density by County

County	Population			Land Area (Square Miles)	Population Density in 2016 (People/Square Mile) [3,4]
	2000[1]	2010[2]	2016[3]		
Barnstable	222,230	215,888	214,703	394	545
Berkshire	134,953	131,219	128,563	927	139
Bristol	534,678	548,285	554,868	553	1,003
Dukes	14,987	16,535	17,137	103	166
Essex	723,419	743,159	769,362	492	1,562
Franklin	71,535	71,372	70,916	699	101
Hampden	456,228	463,490	468,072	617	759
Hampshire	152,251	158,080	161,035	527	305
Middlesex	1,465,396	1,503,085	1,567,610	818	1,917
Nantucket	9,520	10,172	10,694	46	232
Norfolk	650,308	670,850	691,218	396	1,745
Plymouth	472,822	494,919	506,657	659	769
Suffolk	689,807	722,023	767,719	58	13,180
Worcester	750,963	798,552	813,589	1,511	539
State	6,349,097	6,547,629	6,742,143	7,801	864

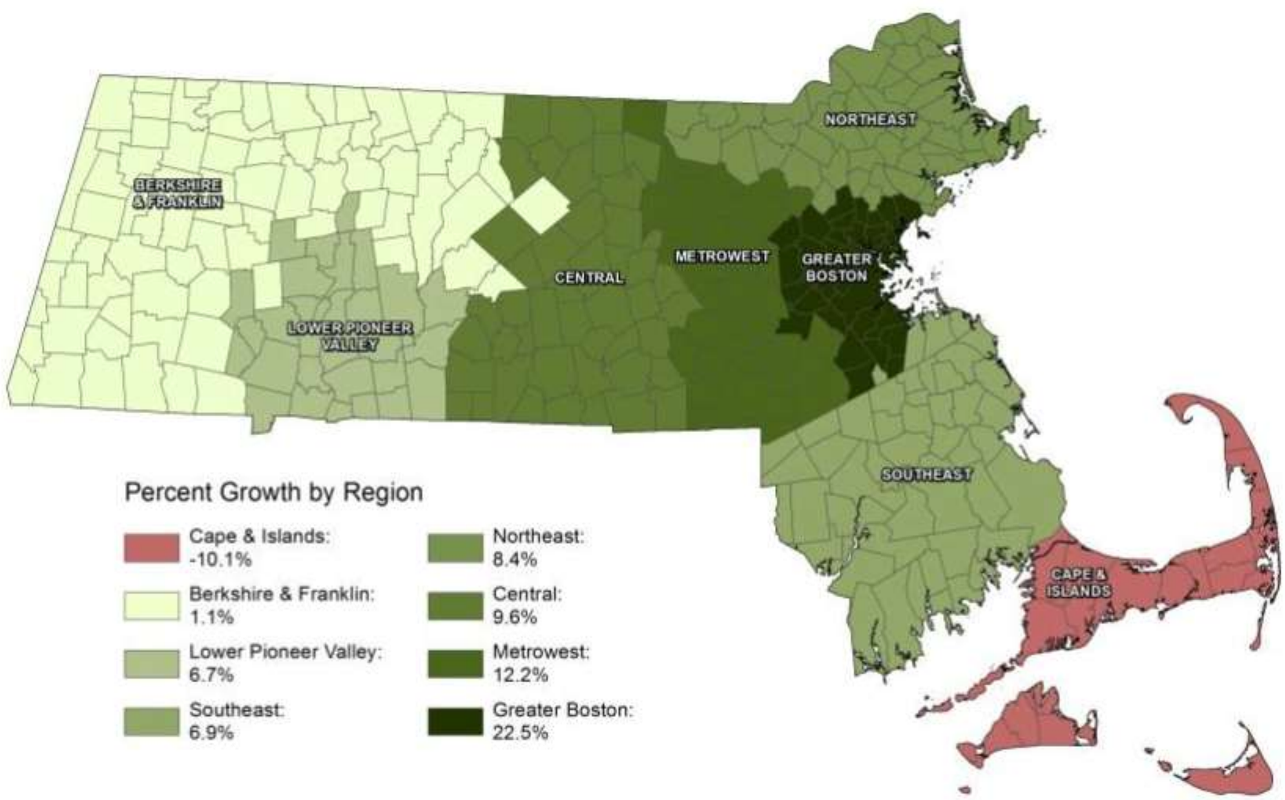
Source: [1]2000 Census; [2]2010 Census; [3]American Community Survey 2012-2016 5-Year Estimates; [4]U.S. Census TIGERweb

Figure 2-3: Past and Projected Population



Source: U.S. Census; UMass Donahue Institute, 2015 projected to increase by 11.8 percent between 2010 and 2035, exceeding 7.3 million in 2035. Factors that affect growth rates include natural increase associated with a greater number of births than deaths; and a net positive immigration, attributable to positive international immigrations into the state, in spite of the domestic out-migration to other areas of the U.S. Figure 2-4 shows the projected growth by region through 2035. The population of the Greater Boston area is projected to increase by 22.5 percent during this time period, while the population of the Cape and Islands is projected to decrease by 10 percent (UMDI, 2015). Projected growth and development in the Greater Boston area may result in increased vulnerability in this region of the state due to the increased population and infrastructure exposed to a hazard or climate change impact. Additionally, increases in development that lead to an increased area of impervious surfaces may exacerbate the impacts of hazards, such as flooding and extreme heat. Development in areas that are currently affected by natural hazards, or are projected to be subject to those hazards in the future, can drastically increase the risk posed by those hazards, and can increase the vulnerability of populations in those hazard-prone areas.

Figure 2-4: Projected Percent Growth by Region 2010-2035



Source: UMass Donahue Institute, 2015

A gradual slow-down in growth is projected in the 2020s and 2030s due to the state's aging population, which impacts both birth and death rates. The effect of aging will be more pronounced in Massachusetts because the state already has an older population than the national average. (UMDI, 2015). By 2035, the percentage of the population aged 65 and over is projected to account for 23.0 percent of the state's population, compared to 13.8 percent in 2010. Because the population aged 65 and over is considered to be more vulnerable to natural hazards and the secondary impacts of natural hazards, an increase in this population has implications for hazard mitigation ranging from evaluation management and assistance to the availability of cooling centers. This will likely increase the burden on emergency responders, hospitals, and communities assisting this population.

VULNERABLE POPULATIONS

Figure 2-5 illustrates how exposure, sensitivity, and adaptive capacity determine the vulnerability of populations to natural hazards and climate change. A range of factors can result in the increased vulnerability of certain populations. For example, individuals who have less physical and socioeconomic resiliency due to factors such as age, mobility, access to transportation, income level, race, or health status are more vulnerable to the impacts of natural hazards and climate change. Table 2-5 provides a snapshot of vulnerable populations by county across the Commonwealth. This table provides a comparison of the percentages of the population of each county that are potentially vulnerable due to a range of factors. The counties with a greater percentage of vulnerable populations compared to the statewide percentage are shaded blue. Counties with a greater percentage of vulnerable populations than the average across counties are underlined. This analysis reveals that Suffolk County has a greater percentage of vulnerable individuals compared to the overall state percentage in all indicators except the percentage of the population age 65 and older. For example, information from the U.S. Census that reported 9.5 percent of the Spanish-speaking population in Suffolk County speaks English at a level that is less than "very well" must be considered when developing hazard mitigation and climate adaptation plans and outreach programs. Refer to *Chapter 4: Risk Assessment* for specific analysis of the populations vulnerable to each natural hazard and its related climate change impacts.

Figure 2-5: Assessment of Climate Change Vulnerability

Table 2-5: Vulnerable Populations by County

County	Percent of the Total Population Under Age 5	Percent of the Total Population Age 65+	Percent of the Population for Whom Poverty Status is Determined that are Living Below the Poverty Level	Percent of the Civilian, Non-institutionalized Population with a Disability	Percent of the Spanish Speaking Population Over Age 5 that Speaks English Less Than "Very Well"	Percent of the Total Population that is Non-White or White and Another Race	Percent of Occupied Housing Units that are Occupied by Renters	Percent of Total Households With No computer	Percent of Occupied Housing Units With No Vehicle Available
Barnstable	3.8	27.8	8.2	13.8	0.6	7.6	20.8	7.6	5.6
Berkshire	4.4	20.9	12.4	15.2	1.2	8.5	31.6	11.0	9.8
Bristol	5.3	15.7	12.5	14.2	2.1	13.6	37.9	12.5	11.3
Dukes	4.0	20.4	9.1	8.4	0.2	11.9	23.5	n.d.	2.4
Essex	5.7	15.6	11.3	12.1	7.0	20.0	36.8	9.1	11.0
Franklin	4.5	18.2	11.3	14.0	0.5	6.3	31.4	13.8	6.7
Hampden	5.8	15.3	17.6	15.7	6.0	20.2	38.4	13.9	13.6
Hampshire	3.6	14.8	14.7	10.9	0.6	11.5	33.8	7.9	8.0
Middlesex	5.6	14.0	8.2	9.1	2.2	21.6	37.6	7.6	10.6
Nantucket	5.1	14.0	10.3	8.1	4.2	14.7	36.1	n.d.	8.2
Norfolk	5.4	15.7	6.7	9.7	0.7	20.0	31.5	7.3	9.3
Plymouth	5.3	16.2	8.0	11.3	0.8	15.4	24.1	7.8	6.2
Suffolk	5.5	11.0	20.1	12.4	9.5	44.6	64.2	9.8	33.0
Worcester	5.5	14.1	11.4	11.9	3.1	15.3	35.3	10.0	8.9
Average	**5.0**	**16.7**	**11.6**	**11.9**	**2.8**	**16.5**	**34.5**	**9.9**	**10.3**
Massachusetts	**5.4**	**15.1**	**11.4**	**11.6**	**3.5**	**20.7**	**37.9**	**9.3**	**12.5**

Blue-shaded box denotes percentages that are higher than the overall percentage statewide. Underline denotes higher than the average of all counties.
Source: American Community Survey 2012-2016 5-Year Estimates

Vulnerable populations include Environmental Justice (EJ) populations. In Massachusetts, EJ populations are determined by identifying all block groups from the 2010 Census that meet any of the following criteria:

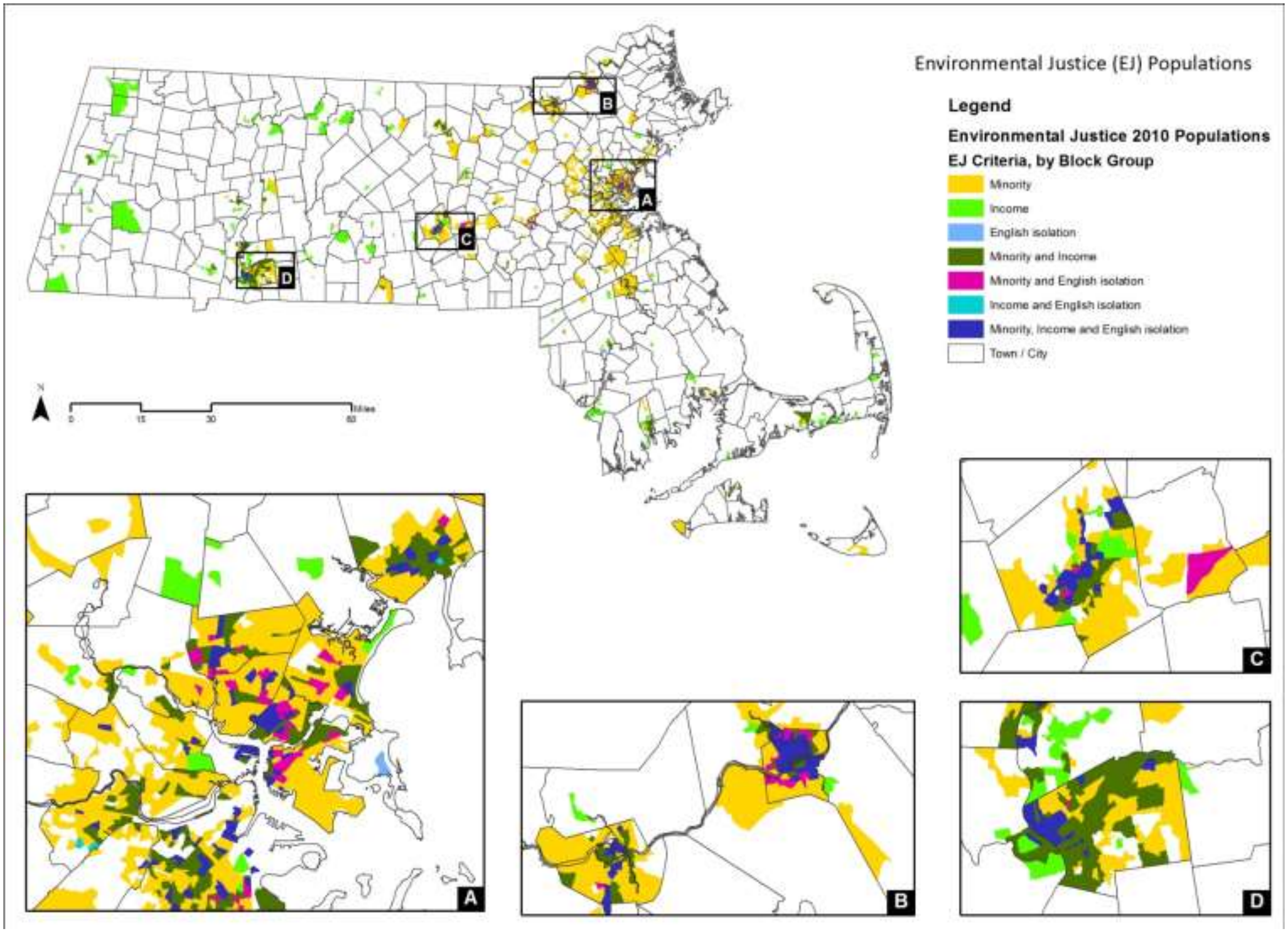
- Annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010); or
- 25 percent or more of the residents identify as a race other than white; or
- 25 percent or more of households have no one over the age of 14 who speaks English only, or very well (EOEEA, 2018).

EJ communities are vulnerable to hazards due to a range of factors, which may include lack of personal transportation or access to resources, preexisting health conditions, or difficulty translating and understanding emergency alerts or procedures.

There is a total of 1,838 EJ block groups in 138 municipalities in Massachusetts. The population in these block groups accounts for nearly half of the population in these municipalities. In Aquinnah, Chelsea, Everett, Lawrence, and Randolph, 100 percent of the block groups are EJ communities. Many EJ block groups meet more than one EJ criteria, and 38 EJ communities meet all three (income, minority population, English isolation). Figure 2-6 displays EJ communities (EOEEA, 2018).

Refer to Chapter 4 for a discussion of the populations vulnerable to each hazard and its related climate change impacts.

Figure 2-6: Environmental Justice Communities (2010 Census Block Groups)



Source: EOEEA, 2018

2.2.2 Housing and Development Highlights

HOUSING

Between 2000 and 2010, the total number of housing units in the state increased by 186,265 units: from 2,621,989 to 2,808,254 units. The average annual increase in housing units during this time was 0.71 percent. The American Community Survey 2012-2016 5-Year Estimates reports that the state has an estimated 2,836,658 units, an increase of approximately 28,400 units from 2010 at a rate of 0.1 percent per year (U.S. Census, 2000; 2010).

Nearly 10 percent of housing units in the state are vacant (see Table 2-6). The high vacancy rates for Barnstable, Dukes, and Nantucket Counties shown in Table 2-6 may reflect the high seasonal populations. Owner-occupancy rates range from a low of 35.8 percent in Suffolk County to a high of 79.2 percent in Barnstable County. Conversely, Suffolk County has the highest percentage of renter-occupied housing units in the state (see Table 2-6).

Table 2-6: Housing Characteristics by County

County	Total Housing Units	Percent of Housing Units that are Vacant	Total Occupied Housing Units	Percent of Housing Units that are Owner Occupied	Percent of Housing Units that are Renter Occupied
Barnstable	161,632	41.6	94,351	79.2	20.8
Berkshire	68,391	19.8	54,854	68.4	31.6
Bristol	231,247	7.9	212,933	62.1	37.9
Dukes	17,536	65.0	6,134	76.5	23.5
Essex	308,459	6.5	288,291	63.2	36.8
Franklin	33,684	9.8	30,389	68.6	31.4
Hampden	192,032	7.7	177,153	61.6	38.4
Hampshire	62,915	7.1	58,448	66.2	33.8
Middlesex	619,399	5.1	587,735	62.4	37.6
Nantucket	11,844	67.6	3,836	63.9	36.1
Norfolk	273,280	4.8	260,061	68.5	31.5
Plymouth	202,564	10.0	182,252	75.9	24.1
Suffolk	324,390	7.6	299,658	35.8	64.2
Worcester	329,285	8.0	302,794	64.7	35.3
Massachusetts	2,836,658	9.8	2,558,889	60.9	37.9

Source: American Community Survey 2012-2016 5-Year Estimates

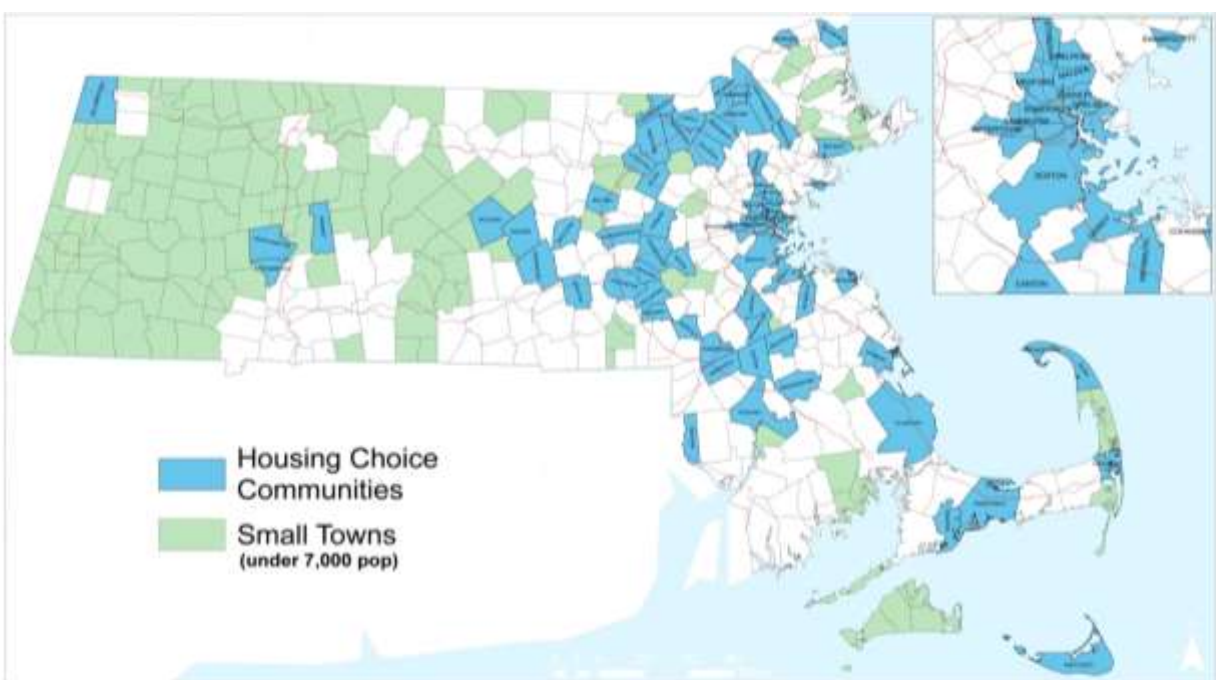
STATEWIDE INITIATIVES, ACCOMPLISHMENTS, AND TRENDS THAT SHAPE THE COMMONWEALTH'S LANDSCAPE

Policies, initiatives, and programs influence development trends and patterns. Targeted economic development, housing programs, transportation improvements, coastal land use planning, and numerous other planning efforts shape the physical landscape of the Commonwealth and influence residential settlement. Examples of statewide initiatives and accomplishments are briefly described in this section. This section is not intended to serve as a comprehensive review of all development initiatives, but to highlight trends and initiatives that have the potential to influence the vulnerability of people, the built environment, and the natural environment to hazards discussed in this SHMCAP.

Housing Choice Initiatives

As part of the Baker-Polito Administration's Housing Choice Initiative, 67 communities have been designated as Housing Choice Communities. This designation is part of a comprehensive effort to create 135,000 new housing units by 2025, while promoting sustainable development that reduces land, energy, and natural resource consumption. Small towns with a population under 7,000 are also eligible for additional funding through the Small Town Housing Choice capital grant program. Figure 2-7 displays Housing Choice Communities and small towns eligible for additional funding (HCI, 2018).

Figure 2-7: Housing Choice Communities and Small Towns



Source: Mass.gov, 2018

Transformative Development Initiative Districts

In 2014, the Commonwealth's economic development and finance authority, MassDevelopment, launched the Transformative Development Initiative (TDI), a place-based development program for Gateway Cities designed to be a tool for economic development. Ten cities were selected for a 3-year TDI pilot program in 2014. Since MassDevelopment initiated a TDI Fellow program in 2015, 11 fellows have been placed in communities to provide assistance. In May of 2018, additional TDI Districts were announced, including Chelsea, Fitchburg, Lawrence, and Worcester; and existing TDI districts in Brockton, Holyoke, Lynn, New Bedford, Pittsfield, and Springfield were extended (MassDevelopment, 2018).

Shoreline Change Project

The coast of Massachusetts continues to be subject to intense development. To assist coastal managers, shorefront landowners, and potential property owners with making informed decisions about coastal land use and development, the Office of Coastal Zone Management (CZM) initiated the Shoreline Change Project in 1989. CZM delineated and mapped shoreline trends from the mid-1800s to 2009, and released updated shoreline data in 2013. This shoreline analysis found that the highest statistically significant long-term (mid-1900s to the early 2000s) rates of erosion occurred on Nantucket, Outer Cape Cod, and Martha's Vineyard. The highest statistically significant rates of erosion over the short term (between 1970 and 1982 to the early 2000s) occurred on the North Shore, Outer Cape Cod, and Nantucket. The Shoreline Change Project presents shoreline change rates at 50-meter intervals along ocean-facing sections of the coast (USGS, 2013). Updated rates of change will be released in 2018, and this information can be used to understand historical and recent migration of shorelines, hot spots of erosion, and the influence of coastal structures (e.g., seawalls and revetments), and to guide smart development (CZM, 2018a).

Port and Harbor Planning Program

As part of the CZM Port and Harbor Planning Program, Massachusetts has 10 Designated Port Areas (DPAs): Gloucester Inner Harbor, Salem Harbor, Lynn, Mystic River, Chelsea Creek, East Boston, South Boston, Weymouth Fore River, New Bedford-Fairhaven, and Mount Hope Bay. DPAs have been designated to promote and protect water-dependent industrial uses. CZM works with municipalities to take a comprehensive approach to planning for DPAs through a DPA Master Plan, which is one component of a Municipal Harbor Plan. The primary goals of Port and Harbor Planning are to help ensure that waterfront areas in the Commonwealth grow in a safe, environmentally sound, and economically prosperous manner; and to balance potentially competing uses in a port or harbor (CZM, 2018b).

Land Conservation Trends

As of May 2018, almost 26 percent of the Commonwealth's 5 million acres of land were protected as conservation or parkland. Between 2007 and 2018, more than 162,479 acres (254 square miles) of land were permanently conserved. For a sense of scale, Suffolk County is 58 square miles.

Community Compact Initiative

In 2015, Governor Baker established the Community Compact Initiative to give cities and towns the chance to make needed improvements in a range of areas through collaboration with and support from the Commonwealth. Communities that participate choose one or more best practices, which include energy and environment, housing and economic development, transportation and citizens' safety, and regionalization/shared services.

Massachusetts Downtown Initiative

The Department of Housing and Community Development provides a range of services and assistance to communities seeking help on how to revitalize their downtowns through the Massachusetts Downtown Initiative. In 2016, 13 communities were awarded technical assistance grants for engaging in revitalization in areas that included design, business improvement district management, economics of downtown, parking, small business support, and wayfinding. The 2016 grantees were: Auburn, Holliston, Hudson, Middleborough, Saugus, Stoughton, Beverly, Essex, Sturbridge, Stoneham, Agawam, Wellesley, and Woburn.

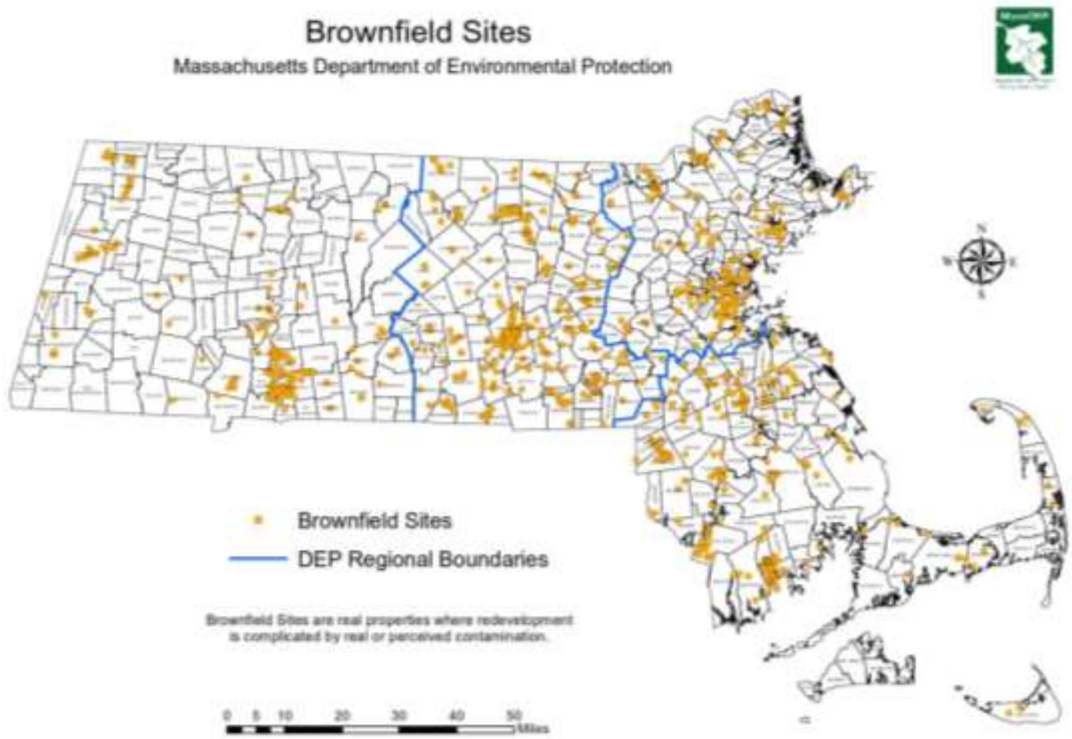
Last Mile Infrastructure Grant Program

The Last Mile Infrastructure Grant Program, administered by the Executive Office of Housing and Economic Development, aims to increase access to broadband in communities that are unserved or underserved. The program has provided grants since its inception in 2015. These grants have resulted in increased access to the internet and to information about hazards and emergency response (EOHED, 2018).

Brownfields Cleanup and Redevelopment

Since 1993, more than 35,000 brownfields sites have been cleaned up in Massachusetts. As of January 2017, the Department of Environmental Protection (DEP) brownfields list identifies more than 1,000 sites across the state (displayed on Figure 2-8). The presence of contamination on these sites may exacerbate the impacts of natural hazards.

Figure 2-8: Known Brownfields Sites in Massachusetts



Source: DEP, 2018

Transportation Trends

Sustainable Development

The Massachusetts Department of Transportation (MassDOT) supports climate resilience through investments that improve system reliability and modernize the Commonwealth's transportation infrastructure. Approximately 79 percent of MassDOT's proposed $17.3 billion in capital spending over the next 5 years is targeted at these two priorities. This includes improving interstate highway and airport pavement conditions, bridge reconstruction and replacement, new and rehabilitated revenue vehicles for the Massachusetts Bay Transit Authority (MBTA) and Regional Transit Authorities (RTAs), and upgrades to track and signal and power systems across the commuter rail and transit system. MassDOT continues to conduct climate vulnerability assessments that will help target future expenditure on assets that are most at risk from a changing climate.

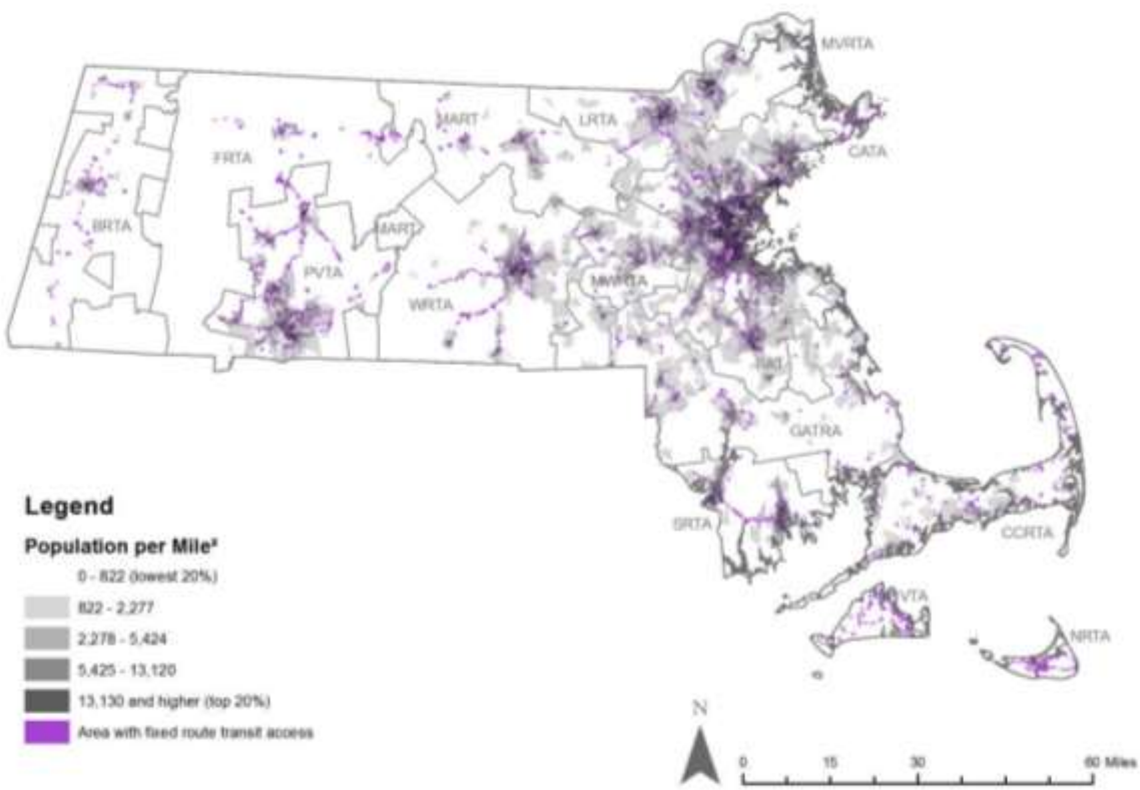
MassDOT's investments in infrastructure can also have a measured impact on GHG emissions. By improving walking and cycling facilities, MassDOT makes short trips by these zero carbon modes a safer, more realistic option for Massachusetts residents and communities. To this end, MassDOT has programmed $240 million dollars for bicycle and pedestrian infrastructure over the next 5 years. In addition, by expanding transit in places where transit use is financially sustainable and where transit-oriented development will be encouraged, MassDOT can support land use change that makes driving less necessary.

Access to Transit

According to the MassDOT Annual Performance Tracker, residents' access to transit (fixed-route bus service) increased 1.4 percent from 2016 to 2017. Figure 2-9 displays statewide access to transit. More than 52.8 percent of residents have access to transit (MassDOT, 2018), and proximity to transit is increasingly desired by residents (MAPC, 2016). As of 2017, MBTA operated 175 bus routes. However, annual ridership on fixed-route buses decreased for 8 out of the 15 RTAs from 2012 to 2016. Similarly, MBTA ridership decreased by 1 percent from 2016 to 398 million in 2017 (MassDOT, 2018). The 2017-2021 State Transportation Improvement Plan (STIP) includes $2.3 billion for transit systems statewide (MassDOT, 2016).

Between 2010 and 2016, there was a 17.5 percent increase in Amtrak ridership at 14 stations in the state. Priority projects for the future include establishing more frequent rail service from New Haven into Springfield, and extending passenger rail service from Springfield to Greenfield (MassDOT, 2018).

Figure 2-9: Population Density and Access to Fixed-Route Transit



Source: MassDOT, 2018

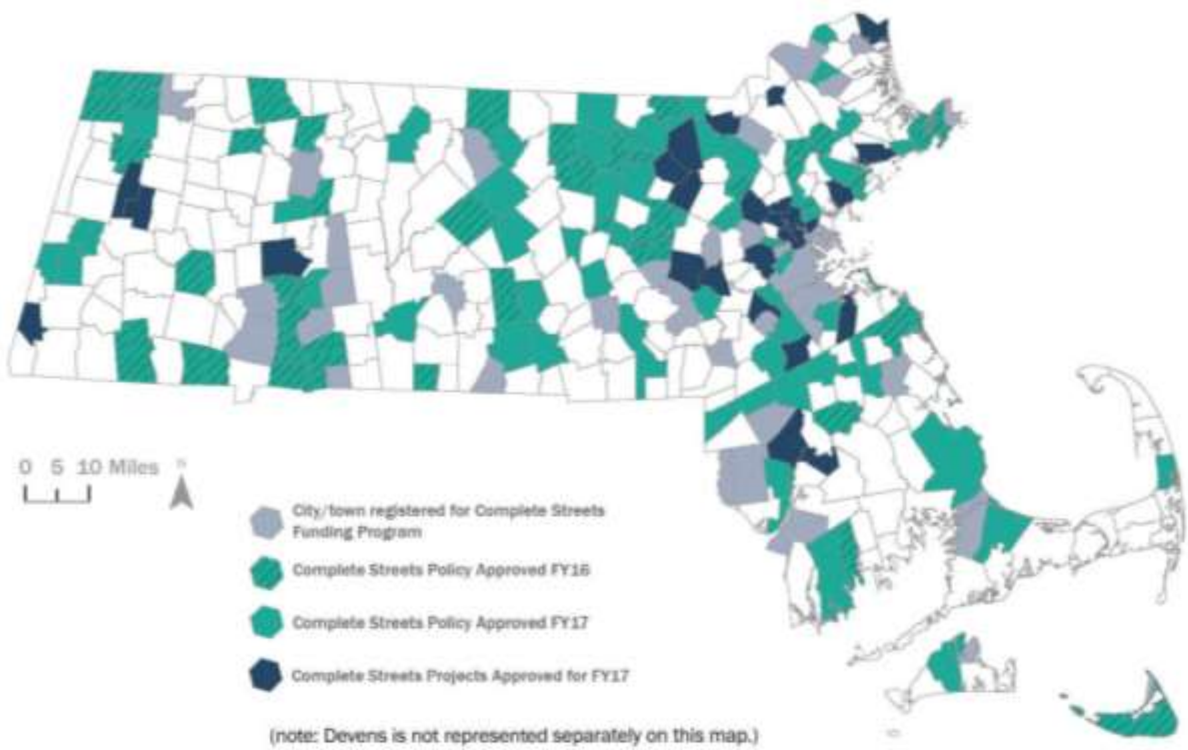
Bridge Improvements

Nearly 9 percent of Massachusetts bridges (more than 400) are considered structurally deficient (MAPC, 2018). A total of $760 million has been allocated for improvements to bridge health in the STIP (MassDOT, 2016). MassDOT owns 3,491 bridges in the state (MassDOT, 2018).

Complete Streets

A component of a sustainable community, Complete Streets is a program to provide safe access for all users. Figure 2-10 displays communities with Complete Streets policies and projects.

Figure 2-10: Communities with Complete Streets Policies and Projects



Source: MassDOT, 2018

Building Resilience at the Local and Regional Level

Communities and regional planning agencies are increasingly placing emphasis on the need for resiliency planning. For example, the City of Boston made climate adaptation a key theme in its recently adopted citywide plan, and continues to invest heavily in its Climate Ready Boston initiative to help Boston prepare for the future impacts of climate change. Similarly, the Metropolitan Area Planning Council's (MAPC's) goal is that municipalities will take a long-term perspective on growth that considers climate change when making development and policy decisions. In its Regional Indicators report, MAPC highlights the need for a collaborative approach to prevent damage from future disasters, and to build resilience. Further, MAPC aims to mitigate hazards by having no structurally deficient dams and limited new growth in floodplains (MAPC, 2008).

The Commonwealth provides technical assistance and funding to municipalities for resiliency planning through various programs, including the CZM Coastal Resilience Grant Program and the Municipal Vulnerability Preparedness (MVP) Program. The CZM Coastal Resilience Grant Program provides the 78 coastal communities with funding to advance local efforts to address coastal flooding, erosion, and sea level rise through the StormSmart Coasts Program. As of June 2018, there are 156 communities participating in the MVP Program that have completed or are in the process of completing climate change vulnerability assessments. Refer to *Chapter: 10 Coordination of Local Hazard Mitigation and Climate Adaptation Planning* for additional information about this program.

2.3 Climate Change Projections

2.3.1 Resilient MA Climate Change Clearinghouse for the Commonwealth

In 2017, the Commonwealth launched the Massachusetts Climate Change Clearinghouse (resilient MA), an online gateway for policymakers, local planners, and the public to identify and access climate data, maps, websites, tools, and documents on climate change adaptation and mitigation. The goal of resilient MA is to support scientifically sound and cost-effective decision-making, and to enable users to plan and prepare for climate change impacts.

The resilient MA site provides access to resources relevant to adaptation and building resiliency for climate change in Massachusetts. This includes information about GHG emissions and atmospheric concentrations, projected temperature and precipitation changes, climate change impacts such as sea level rise and extreme weather events, and other changes. It also catalogs specific vulnerabilities, risks, and strategies for and across industry sectors (including agriculture, forestry, local government, education, energy, recreation, and transportation) and for local governance priorities, including public health, public safety/emergency management, infrastructure, coastal zones, natural resources/habitats, and water resources.

The website's target audiences are local planners, decision makers, and state agency staff. It is intended to help decision makers identify vulnerable infrastructure, residential areas, and ecosystems; evaluate the risks posed by climate change; and develop strategies and implementation plans for their community. It is also a resource for policymakers, analysts, scientists, planners, businesses, and the general public.

2.3.2 Massachusetts Climate Projections

Changes in precipitation, temperature, sea level rise, and storm surge due to climate change are summarized in this section. Climate projections are derived from emerging research conducted by the Northeast Climate Adaptation Science Center at the University of Massachusetts, Amherst. The data used in downscaled projections for Massachusetts are based on simulations from the latest generation of climate models included in the Coupled Model Intercomparison Project Phase 5, which form the basis of projections summarized in the Intergovernmental Panel on Climate Change Fifth Assessment Report (2013). The projections available through resilient MA and summarized in this SHMCAP represent the best estimates for a range of scenarios for how GHG emissions may change over time, based on human decision-making. Additional information about the data and climate models is available on the resilient MA website.

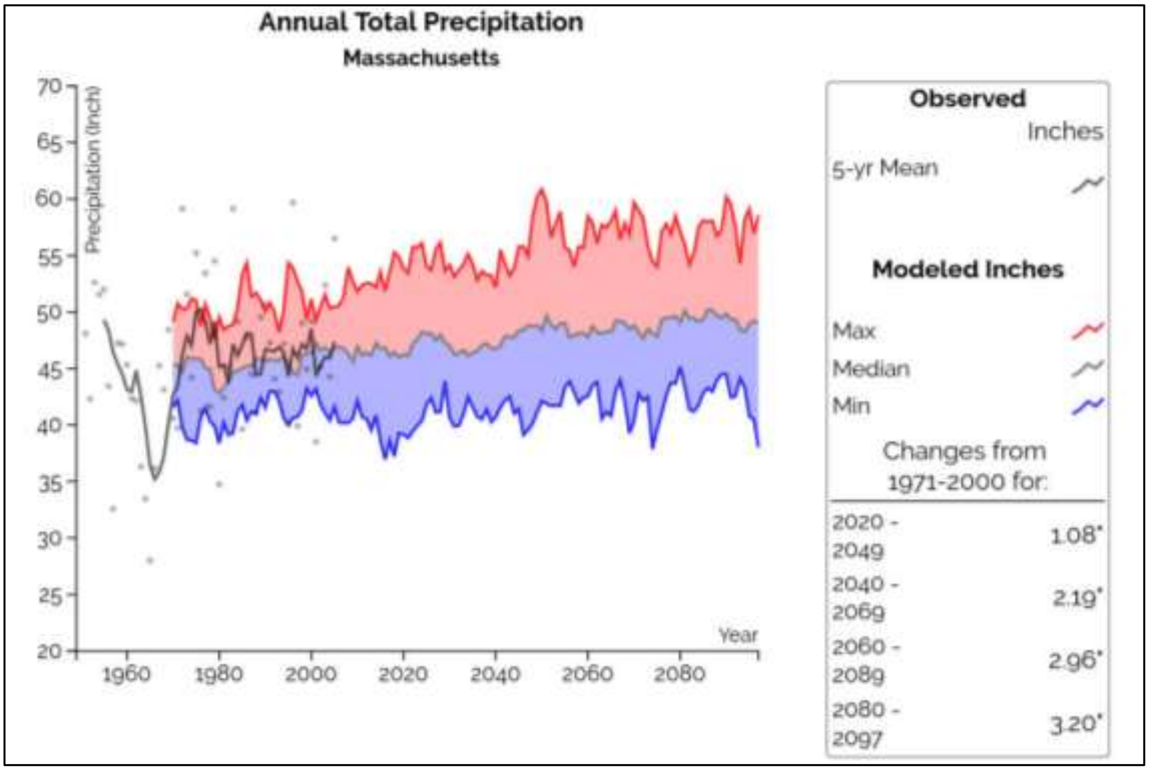
PRECIPITATION

Precipitation is expected to increase over this century. Total annual precipitation is projected to increase by 1 to 6 inches by mid-century, and by 1.2 to 7.3 inches by the end of this century (see Figure 2-11). This will result in up to 54.3 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 47 inches per year in Massachusetts. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century.

By mid-century, the state can expect to receive greater than 1 inch of rain on an average of up to 10 days per year. The number of days with rainfall accumulation over 1 inch may reach 11 days by the end of this century, which represents an increase of 4 days from the observed average between 1971 and 2000.

The number of continuous dry days is projected to increase to nearly 20 days per year at the end of this century, compared to the observed average of 16.64 days per year from 1971 to 2001. Under a lower emissions scenario, however, little change in the average time between rain events is expected over this century (see Table 2-7). The eastern half of the state is expected to experience a greater number of consecutive dry days than the western side of the state.

Figure 2-11: Annual Total Precipitation



Source: resilient MA, 2018

Table 2-7: Continuous Dry Days by Planning Year

Planning Year	2030s	2050s	2070s	2090s
Projected Range of Consecutive Dry Days	16.44-17.94	16.34-18.64	15.94-18.94	16.34-19.64

Source: resilient MA, 2018

TEMPERATURE

The average, maximum, and minimum temperatures in Massachusetts are likely to increase significantly over the next century (resilient MA, 2018). Table 2-8 displays the projected increase in annual and seasonal temperature by mid-century and the end of this century, compared to the baseline average temperature from 1971-2000. The average annual temperature is projected to increase from 47.6 degrees Fahrenheit (°F) to 50.4 to 53.8°F (2.8 to 6.2°F change) by mid-century, and to 51.4 to 58.4°F (3.8 to 10.8°F change) by the end of this century. This trend is shown on Figure 2-12. Winter temperatures are projected to increase at a greater rate than spring, summer, or fall. By the end of this century, the long-term average minimum winter temperature of 17.1°F is projected to increase by 4.6 to 11.4°F (up to a 66 percent increase),

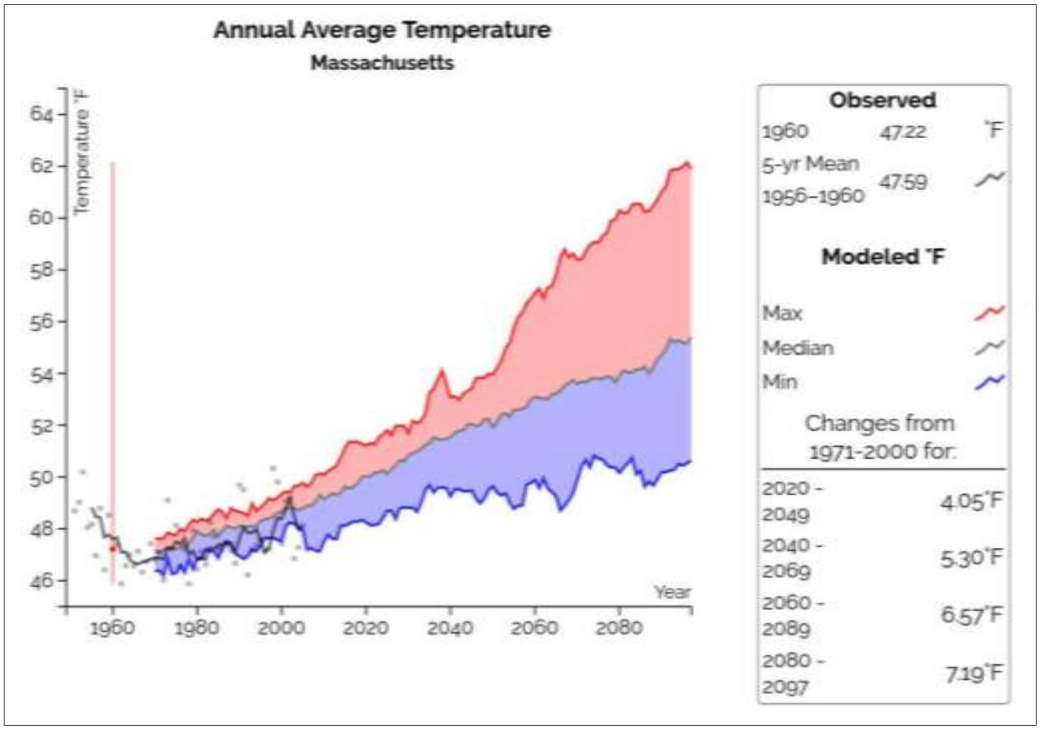
Table 2-8: Maximum Daily Projected Temperature Changes through 2100

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected and Percent Change in 2050s (2040-2069)	End of Century Projected and Percent Change in 2090s (2080-2099)*
Average Temperature	Annual	47.6 °F	Increase by 2.8 to 6.2 °F Increase by 6 to 13 %	Increase by 3.8 to 10.8 °F Increase by 8 to 23 %
	Winter	26.6 °F	Increase by 2.9 to 7.4 °F Increase by 11 to 28 %	Increase by 4.1 to 10.6 °F Increase by 15 to 40 %
	Spring	45.4 °F	Increase by 2.5 to 5.5 °F Increase by 6 to 12 %	Increase by 3.2 to 9.3 °F Increase by 7 to 20 %
	Summer	67.9 °F	Increase by 2.8 to 6.7 °F Increase by 4 to 10 %	Increase by 3.7 to 12.2 °F Increase by 6 to 18 %
	Fall	50 °F	Increase by 3.6 to 6.6 °F Increase by 7 to 13 %	Increase by 3.9 to 11.5 °F Increase by 8 to 23 %
Maximum Temperature	Annual	58.0 °F	Increase by 2.6 to 6.1 °F Increase by 4 to 11 %	Increase by 3.4 to 10.7 °F Increase by 6 to 18 %
	Winter	36.2 °F	Increase by 2.5 to 6.8 °F Increase by 7 to 19 %	Increase by 3.5 to 9.6 °F Increase by 10 to 27 %
	Spring	56.1 °F	Increase by 2.3 to 5.4 °F Increase by 4 to 10 %	Increase by 3.1 to 9.4 °F Increase by 6 to 17 %
	Summer	78.9 °F	Increase by 2.6 to 6.7 °F Increase by 3 to 8 %	Increase by 3.6 to 12.5 °F Increase by 4 to 16 %
	Fall	60.6 °F	Increase by 3.4 to 6.8 °F Increase by 6 to 11 %	Increase by 3.8 to 11.9 °F Increase by 6 to 20 %
Minimum Temperature	Annual	37.1 °F	Increase 3.2 to 6.4 °F Increase by 9 to 17 %	Increase by 4.1 to 10.9°F Increase by 11 to 29 %
	Winter	17.1 °F	Increase by 3.3 to 8.0 °F Increase by 19 to 47 %	Increase by 4.6 to 11.4 °F Increase by 27 to 66 %
	Spring	34.6 °F	Increase by 2.6 to 5.9 °F Increase by 8 to 17 %	Increase by 3.3 to 9.2 °F Increase by 9 to 26 %
	Summer	56.8 °F	Increase by 3 to 6.9 °F Increase by 5 to 12 %	Increase by 3.9 to 12 °F Increase by 7 to 21 %
	Fall	39.4 °F	Increase by 3.5 to 6.5 °F Increase by 9 to 16 %	Increase by 4.0 to 11.4 °F Increase by 10 to 29 %

* A 20-yr mean is used for the 2090s because the climate models end at 2100.

Source: resilient MA, 2018

Figure 2-12: Projected Annual Average Temperature



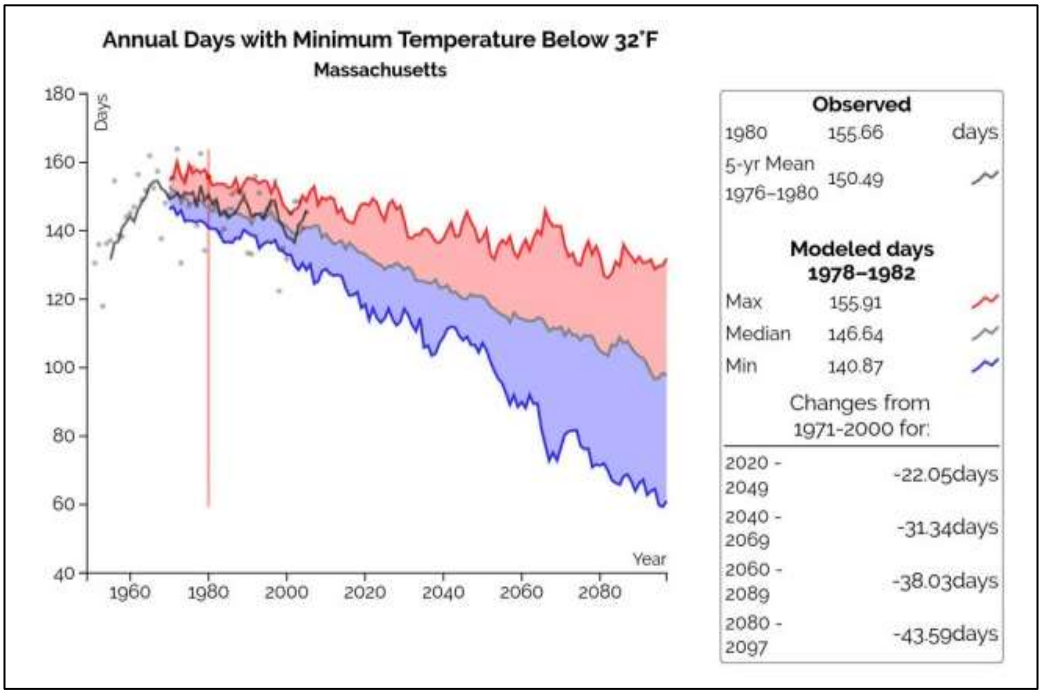
Source: resilient MA, 2018

resulting in a minimum winter temperature of between 21.7°F and 28.5°F. The number of days per year with daily minimum temperatures below freezing (32°F) is projected to decrease by 19 to 40 days (down to 106 days total) by the 2050s, and 24 to 62 days (down to 84 days total) by the 2090s, from the average observed range from 1971 to 2000. Figure 2-13 displays this trend of fewer days below freezing.

Although minimum temperatures are projected to increase at a greater rate than maximum temperatures in all seasons, significant increases in maximum temperatures are anticipated. Summer highs are projected to reach 85.6°F by mid-century, and 91.4°F by the end of this century, compared to the historical average of 78.9°F. Figure 2-14 displays the projected increase in number of days per year over 90°F. The number of days per year with daily maximum temperatures over 90°F is projected to increase by 7 to 26 days (up to 31 days total) by the 2050s, and by 11 to 64 days (up to 69 days total) by the 2090s, compared to the average observed range from 1971 to 2000 of 5 days per year. Maximum temperatures in winter are projected to increase by 9.6°F by the end of this century.

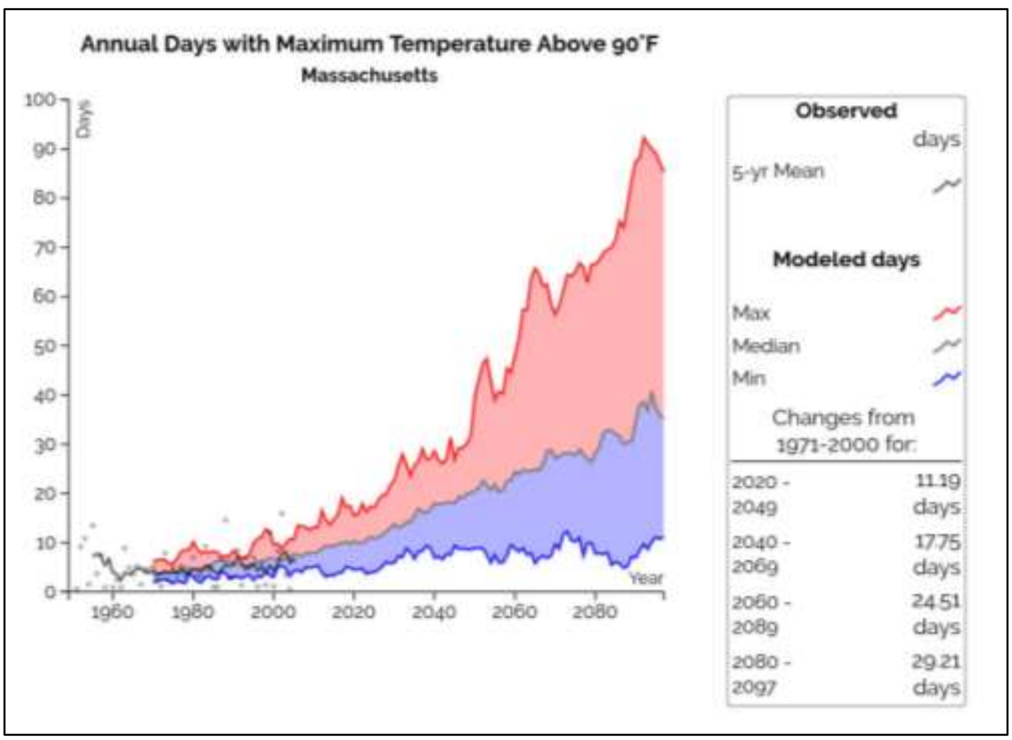
As temperatures increase, the growing season will expand. The number of growing degree days is projected to be 23 to 52 percent higher at the end of this century relative to the 1971-2000 average, as shown on Figure 2-15.

Figure 2-13: Projected Annual Days with Temperature Below 32°F



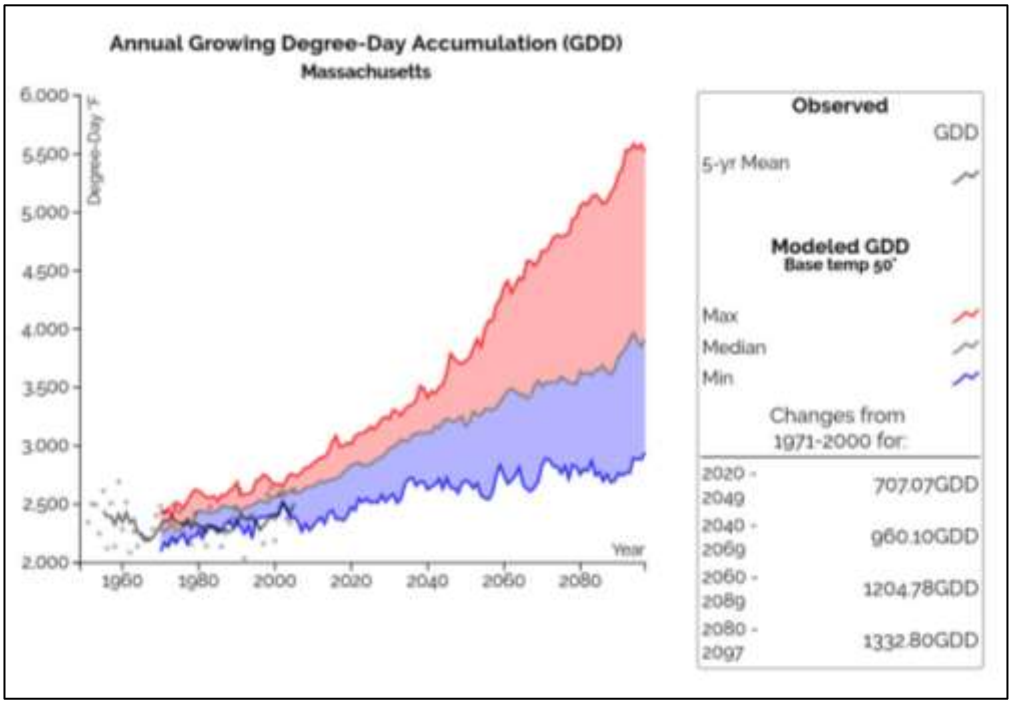
Source: resilient MA, 2018

Figure 2-14: Projected Annual Days with Temperature Above 90°F



Source: resilient MA, 2018

Figure 2-15: Projected Annual Growing Degree-Day Accumulation



Source: resilient MA, 2018

SEA LEVEL RISE

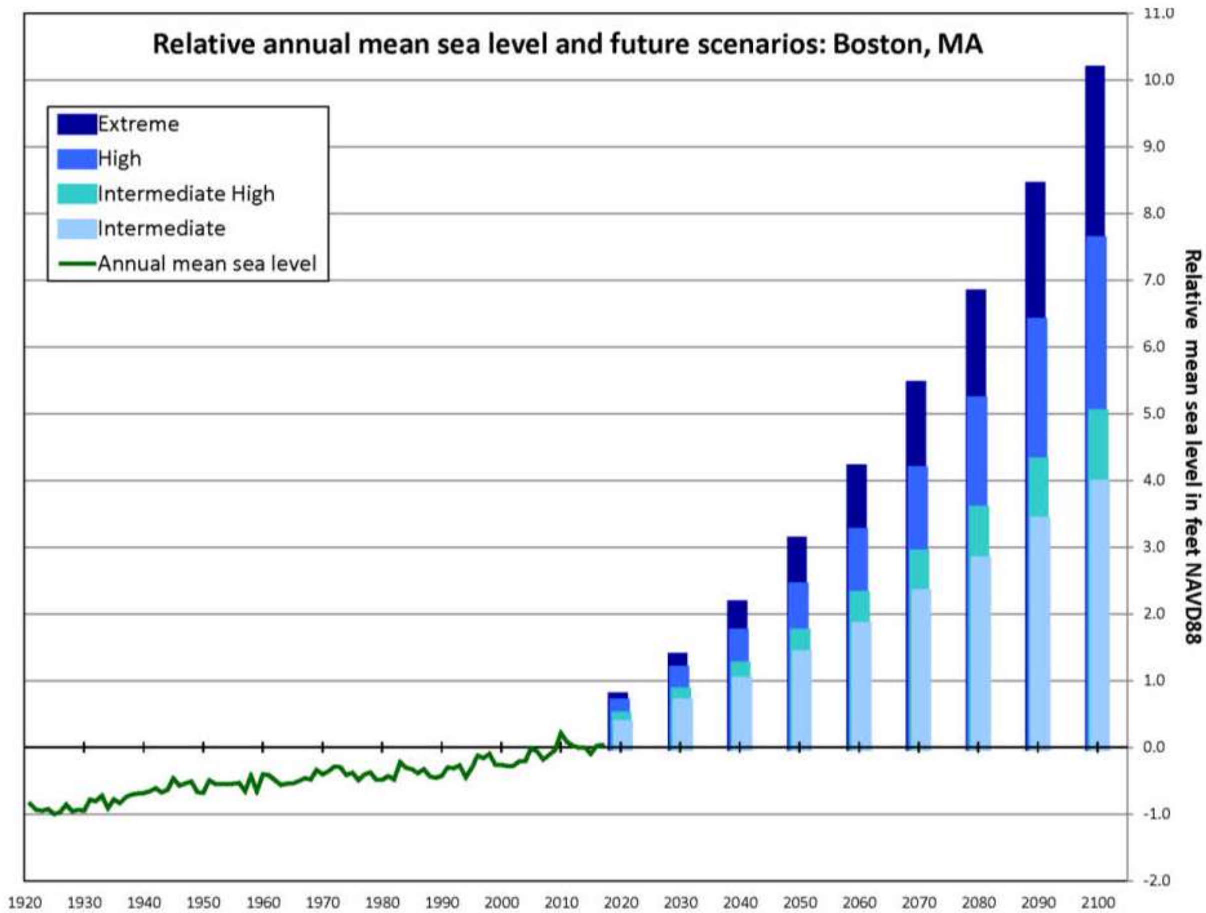
The rate of sea level rise is projected to increase with climate change. Along the Boston coast, sea level rise is expected to reach 2.4 feet by 2050 and 7.6 feet by 2100 under a high scenario (see Table 2-9). Figures 2-16 through 2-18 display similar relative mean sea level and future scenarios at three tide stations in the state: Boston, Woods Hole, and Nantucket. Refer to the Massachusetts Climate Change Projections - Statewide and for Major Drainage Basins for additional details.

Table 2-9: Northeast Climate Adaptation Science Center Relative Mean Sea Level Projections for Boston, MA, Tide Station

Boston Relative Mean Sea Level (feet NAVD88)									
Scenario	**Summary**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Intermediate	Intermediate scenario primarily based on medium and high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4.0
Intermediate-High	Intermediate-high scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise	0.8	1.2	1.7	2.3	2.9	3.6	4.3	5.0
High	High scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise	1.2	1.7	2.4	3.2	4.2	5.2	6.4	7.6
Extreme (Maximum physically plausible)	Highest scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise and consistent with estimates of physically possible "worst case"	1.4	2.2	3.1	4.2	5.4	6.8	8.4	10.2

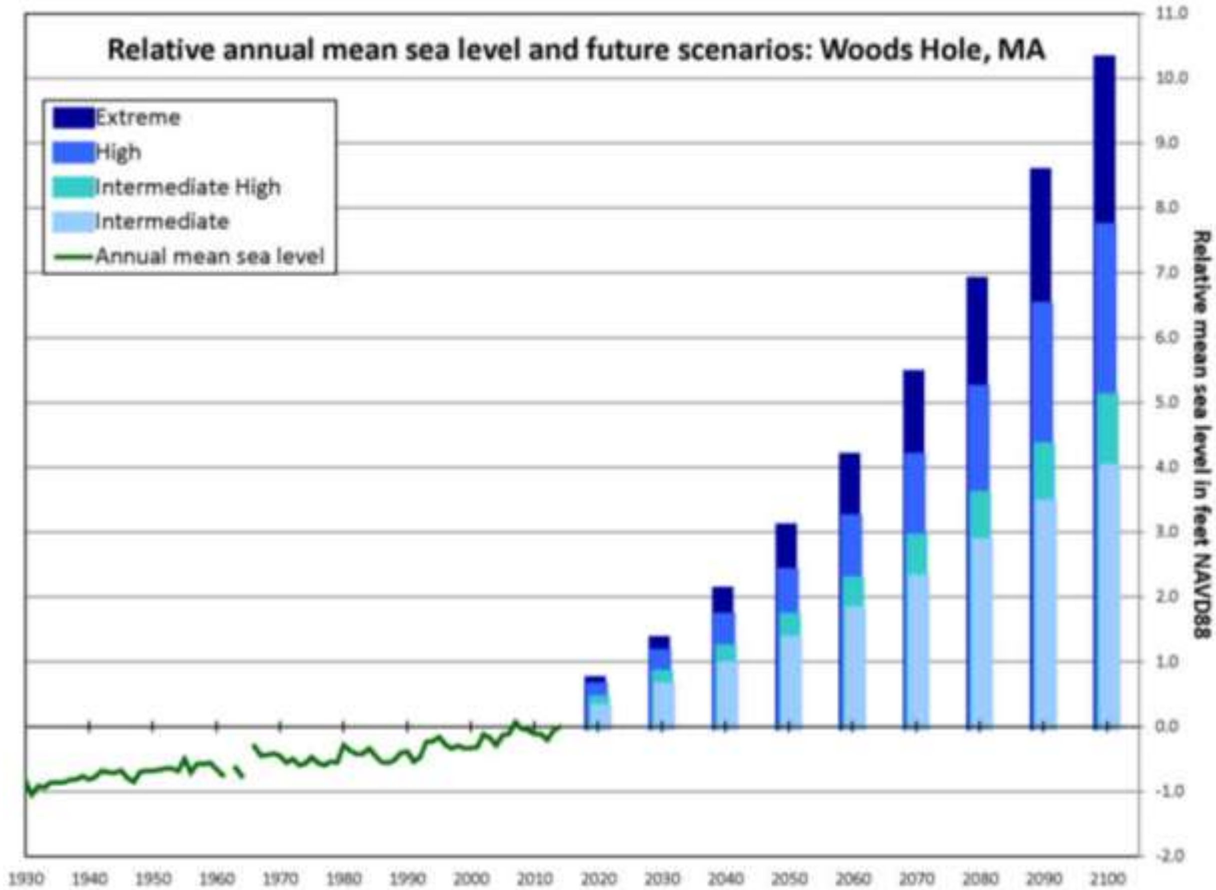
Source: resilient MA, 2018

Figure 2-16: Relative Mean Sea Level and Future Scenarios for Boston, MA



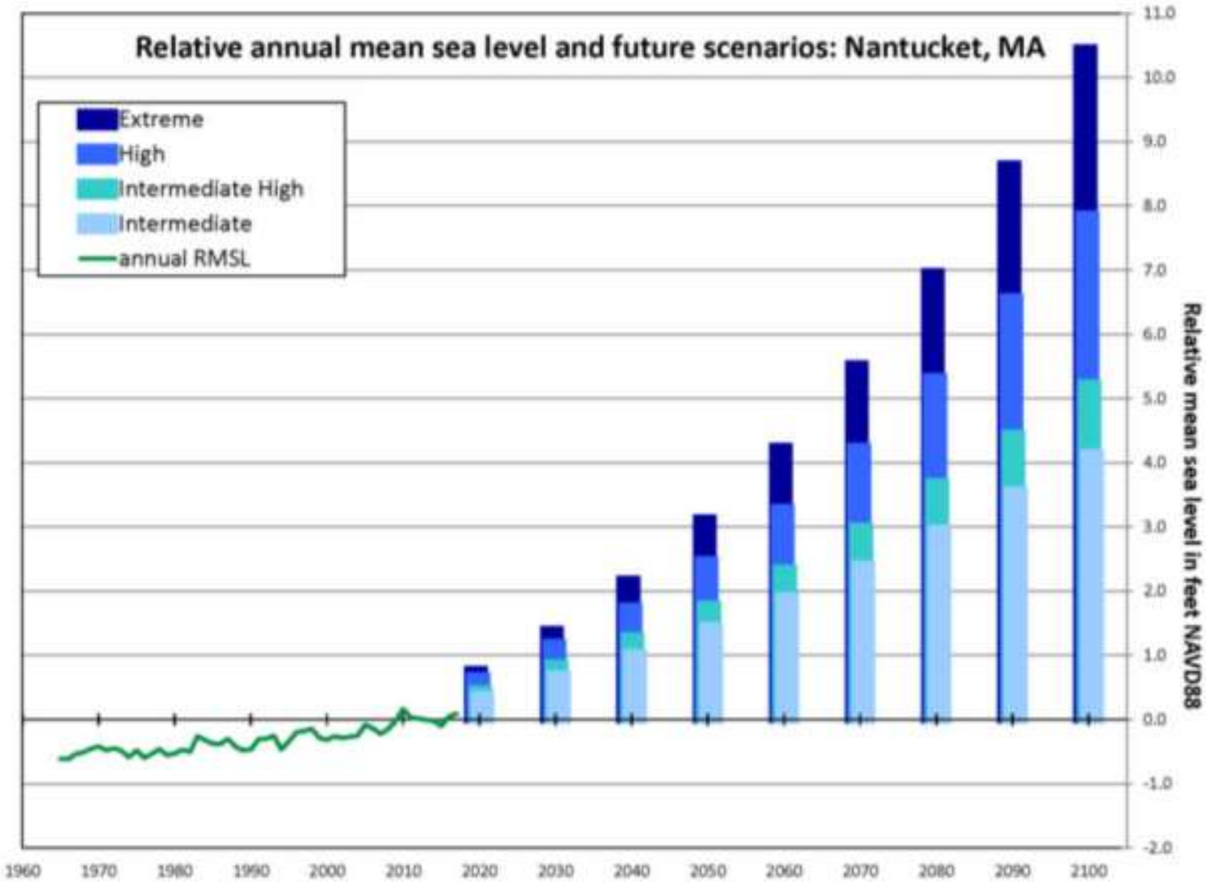
Source: resilient MA, 2018

Figure 2-17: Relative Mean Sea Level and Future Scenarios for Woods Hole, MA



Source: resilient MA, 2018

Figure 2-18: Relative Mean Sea Level and Future Scenarios for Nantucket, MA



Source: resilient MA, 2018

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