Town of Swansea
Open Space and Recreation Plan
2023 - 2030

Appendix C:

Climate Change Regional Overview

Planning for Climate Change in Swansea, Massachusetts

Introduction

Our modern human civilization developed during a time of relative stability in earth's geological history. This stability enabled us to design buildings, communities, infrastructure – all the cornerstones of modern life – with confidence that in planning these structures, we knew what to expect for the course of their lifetimes. The ability to draw on prior conditions to inform our predictions for what we can expect the future to hold is referred to as "stationarity." For example, engineers could design a road to withstand a weather event called a "hundred-year storm," which represented the intense weather conditions that would be expected to occur just once in a one-hundred-year period. Stationarity allowed us to prepare for the future with the knowledge of prior conditions.

According to past trends, Swansea is considered to have a temperate humid continental climate. The Town's average annual temperature is 31.6 degrees F*ahrenheit* in the winter and 69.5 degrees F*ahrenheit* in the summer. Temperatures and weather are moderated by the Town's proximity to the coast and the Atlantic Gulf Stream. The growing season – the number of days between the last killing frost in the spring (early April) and the first killing frost in late summer or fall (mid-October) – has a historical average range of 160 to 180 days. Swansea's average annual precipitation is, historically, 44.1 inches.

Climate change, however, is shifting what is typical of our region's temperature and precipitation beyond the boundaries of this predictability we have grown to expect. Presently occurring climate shifts and the anticipated new conditions toward which we are moving with additional greenhouse gas emissions will continue to move the needle, representing a paradigm shift into 'non-stationarity;' a condition in which we can no longer rely on historical records to precisely predict future outcomes. We are planning for our communities today against a future that is a moving target. What was previously classified as the 100-year storm event may become a more likely and frequent occurrence; it may become the twenty- or ten-year storm event. Everything from emergency response plans, to siting community facilities, to designing roadways to determining flood insurance rates may have to continually evolve on much quicker timelines going forward in this new reality.

Climate Change Overview

Climate Change refers to a change in a region's climate conditions – particularly its temperature and precipitation levels – over a period of time. Climate change shifts have occurred naturally throughout earth's existence. Key elements of the climate change threat are communicated by the "**3S's**" of climate change:

Q1: How do we know climate change is occurring?
Answer: It's **simple**.

Our human actions are forcing the earth's system to retain more heat. When thermal energy in the form of sunlight reaches earth, two things can happen to it; either it is absorbed into the Earth's atmospheric system, or it is reflected and able to emit back into space and dissipate. We can conceive of these phenomena as Earth's "energy budget." If the energy that is reflected and emitted back to space equals the energy that is absorbed into the Earth's system, the energy budget is in balance. If more energy is emitted than absorbed, the Earth's system cools. If more energy is absorbed than emitted, the Earth's system warms. Certain gases, known as Green House Gases (Carbon Dioxide/CO_2, methane, and others) naturally increase the trapping capacity of the atmosphere, causing thermal energy to remain in the system, which causes the world to warm. The changing concentrations of these gases are measurable over time, and climatologists worldwide examining all available data have concluded that the rate of warming we are experiencing today cannot be explained solely by natural causes – it is a human-made phenomenon.

In previous eons, warming and cooling cycles have occurred in periods of roughly 100,000 years due to shifts in the planet's tilt, rotation and shape of its orbit. However, since 1900 there has been a massive increase in the global concentrations of atmospheric carbon dioxide (CO_2), started by the Industrial Revolution and the burning of fossil fuels such as coal, oil, and gasoline. The global release of CO_2 is occurring at rates nearly **nine times greater** than in the hottest period of the past 800,000 years and has created an environment fruitful for trapping thermal energy from sunlight within the earth's atmospheric system.

Q2: What harm will climate change cause?
Answer: It's **serious**.

Since 1895, the global temperature has increased 1.8 degrees Fahrenheit. Due to global differences in topography, wind patterns, and ocean circulation, this temperature increase is not felt evenly; in Massachusetts, the temperature increase has been even greater and since 1895 has increased 2.9 degrees Fahrenheit. There is also a large difference between the warming felt on land and in water. In fact, an astounding 90% of the excess thermal energy that has entered the Earth's system has sunk into the deep ocean. While this has kept us cooler on land, it is extremely problematic for the ocean – higher sea surface temperatures mixed with excess carbon dioxide entering the water causes acidification, all with serious implications for aquatic species.

As temperature and precipitation change in the future, so too will the features of our natural and built environment that rely on them, such as forests and open space, agriculture, and disease/tick seasons, among others. In the northeastern United States, the increase in temperature will lead to less distinct seasons, with winter warming three times faster than summer, and earlier spring conditions. This change in turn will lead to a longer freeze-free period, and earlier leaf-out and bloom. Without a longer frost period to kill them off, more pests will survive season to season, and they will emerge earlier in the season as well. Changing temperatures will likely shift the habitable zone for plant, insect, and animal species, prompting their migration. Iconic trees such as Red Maple and Oak have started to migrate north and west, seeking more suitable climates.

A secondary impact of increased temperatures is the melting of ice sheets and glaciers throughout the world. Melting, in conjunction with thermal expansion of the ocean whereby hotter water takes up a greater volume, is causing sea levels to rise. Sea level rise along coastal Massachusetts could reach 2.4 feet by 2050 under the high emissions scenario (RCP 8.5). Preparing for sea level rise requires re-evaluating the costs of developing parcels located in the floodplain or along coastal regions and the siting of community infrastructure.

Climate change is bringing about an era of extremes. Rain falls more intensely in fewer rain events. Droughts are longer. More extreme precipitation events combined with overall conditions will increase the likelihood and risk of erosive flooding. Extreme precipitation can contribute to soil and riverbank degradation as quick-moving waters strip sediment away, and the loss of topsoil and riverbanks can impact agricultural and riverine uses. Precipitation will also increase pre-existing issues with flooding and contribute to an overall environment where it is difficult and dangerous to move around Swansea during storm conditions. Increased rainfall also leads to increased stormwater runoff, which can be a serious issue for contaminated surfaces, or further contribute to the pollution of important waterbodies.

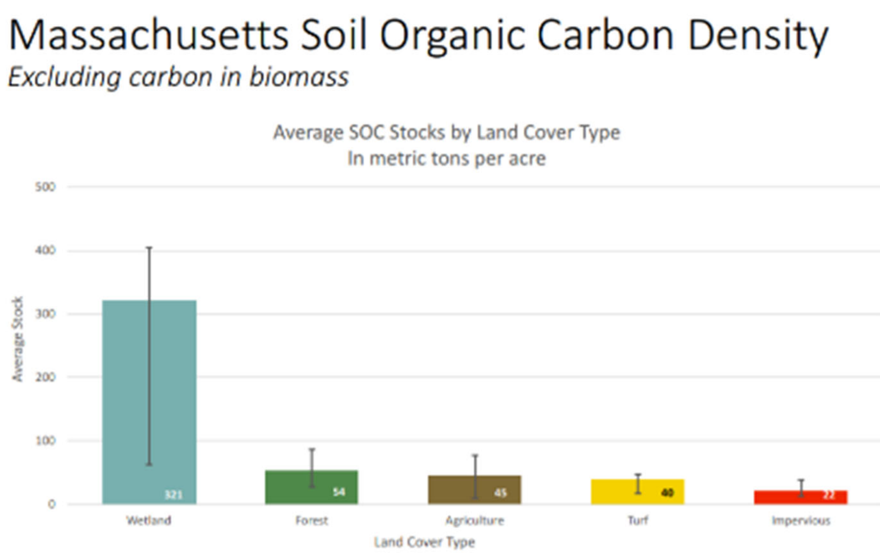
Q3: What can we do?
Answer: It's **solvable**.

We are looking at an extremely different world by the end of this century if our high rate of CO_2 emissions continues unabated. However, there is some possibility for humans to change this harsh trajectory. Future emissions upon which various climate change scenarios are based have not yet occurred and are not set in stone. Climate scientists use a range of greenhouse gas emissions scenarios - called Representative Concentration Pathways (or RCP's) - as a basis to predict how temperature and precipitation might change in the future based on different levels of CO2 emissions. Under lower emissions scenarios called RCP 2.6 and RCP 4.5, humans would decrease our overall emissions to limit global temperature increases between 2 – 6 degrees Fahrenheit. This shift to meeting lower emissions scenarios, however, will take material changes to the way that we live, plan our communities, and consume. Under the medium emissions scenario (RCP 4.5) greenhouse gas emissions are assumed to peak by mid-century. Under the high scenario (RCP 8.5) emissions continue to rise based on the current trajectory.

Each scenario offers a range of potential future outcomes (predictions for the region are detailed further below). As such, the uncertainty associated with climate change means that communities must take the long view and build some of this uncertainty into their decision-making structures with strategies that are flexible and nimble, that can **adapt** to and **mitigate** the effects of climate change. **Mitigation** refers to reducing the overall amount of climate change caused by human released greenhouse gases (requiring a reduction in the amount of greenhouse gases an individual, city, or country emits in the first place, or the establishment of ways to draw carbon and other gases out of the atmosphere). By mitigating carbon emissions, we can help slow down the rates of human-caused climate change, lengthen stationarity, and reduce the uncertainty caused by climate change. **Adaptation** refers to implementing changes in our built or natural environment to reduce our societal and individual vulnerability to the negative impacts of climate change. Adaptation strategies can cut across all sectors of our life, including our behaviors, building techniques, and where we live.

At our current moment in earth's history, proactive open space planning and land preservation is tied to climate change mitigation and adaptation. Preserving open space tracts in particular locations or with specific features in Swansea is one action that the community can take as a means of local response to this global crisis. Mitigation, for example, in an open space planning context can refer to preserving open spaces, trees, and wetlands as these can absorb carbon dioxide. In fact, according to the Massachusetts Healthy Soils Action Plan, wetlands are actually even more productive carbon sinks than forests (Figure 1).

Figure 1: Average amount of Carbon stored in the soil below various land cover types



Examples of adaptation can include protecting critical areas like floodplains and aquifers as open space, so that they are able to absorb rainfall and storm water runoff, thereby minimizing the impact of extreme storm events on our downtowns and built environment. Adaptation could also refer to planting more trees so that they cool down neighborhoods and protect people from rising temperatures. We can expand our traditional definition of open space, to also include smaller but key patches of green space that perform critical functions, such as roadside bioswales that collect stormwater runoff. We can expand recreation offerings to activities that provide educational programming on household resilience and connect residents with the landscape to further a community stewardship ethic. Adaptation efforts are flexible and can incorporate changes in both our environment and our behavior. Using conservation- or open space-minded subdivisions in combination with planned migration away from shorelines provides the dual benefits of protecting open space while minimizing people's vulnerabilities to extreme storms.

Protecting our open space now allows us to hedge against an uncertain future and tap into the multitude of benefits of adaptation and mitigation, while proving immediate improvements to local community wellbeing. Taking proactive adaptation and mitigation action now makes our communities more resilient. **Resilience** is commonly defined as the ability of social, environmental, and economic systems to return to their original form and integrity after enduring stress or disruption. Communities that exhibit high resilience will be able to withstand many impacts of climate change and return to their regular operations after a hazardous event (e.g., intense storm) or prolonged disruption (e.g., drought). Resilience could look like the ability to return people to work after a pandemic, the reconstruction of a flood-prone roadway to withstand more intense storms, or the preservation of environmental features that perform essential functions like absorbing and infiltrating floodwaters.

Regional Climate Change Projections

Massachusetts climate scientists have projected future climate conditions under various Representative Concentration Pathway (RCP) scenarios at the watershed level, the most localized predictive scale possible under current models, to predict some of the anticipated impacts[1]. Swansea lies entirely within the Narragansett Bay Watershed. Modeled projections under a relatively high emissions scenario (RCP 8.5) in 2050 in the Narragansett Bay Watershed show average annual temperature increasing in the range of 3.6 to 7.2 degrees Fahrenheit (Table 1). The expected number of days above 90 degrees Fahrenheit (generally days similar to a heat wave) is expected to be between 11 to 31days per year in 2050 (Table 2).

Precipitation patterns in the Narragansett Watershed are also expected to change drastically. Under a high CO_2 emissions scenario (RCP 8.5), by 2050, the watershed will see an 8.5% increase in total annual precipitation, and by 2090 a 12.6% increase in total annual precipitation (Table 3).

These ranges show us the importance of making choices to pursue climate change mitigation and adaptation now at the local level. The combination of increasing temperature, changing seasonal precipitation amounts, and increasing prevalence of heavy precipitation will likely increase drought impacts and increase flood risk, particularly in areas with impervious surfaces that are conducive to flash floods.

[1] Led by the Executive Office of Energy and Environmental Affairs (EEA), the Massachusetts Climate and Hydrologic Risk Project (Phase 1) has developed new climate change projections for the Commonwealth. These new temperature and precipitation projections are downscaled for Massachusetts at the HUC8 watershed scale using Global Climate Models and a Stochastic Weather Generator and reflect a warming scenario linked to the Representation Concentration Pathway (RCP) 8.5, a comparatively high greenhouse gas emissions scenario. https://eeaonline.eea.state.ma.us/ResilientMAMapViewer/

Table 1: Projected Changes, in Degrees Fahrenheit, to Average Annual and Seasonal Temperature (in Degrees Fahrenheit) for the Narragansett Bay Watershed

Season	Baseline	2030	2050	2070	2090
ANNUAL	50.8	3.6 (1.8-5.4)	5.4 (3.6-7.2)	8.1 (5.4-9.9)	9.9 (7.2-12.6)
SPRING	47.6	2.7 (1.8-5.4)	5.4 (2.7-8.1)	7.2 (4.5-10.8)	9.0 (6.3-11.7)
SUMMER	69.5	3.6 (1.8-4.5)	5.4 (3.6-7.2)	8.1 (5.4-9.9)	9.9 (7.2-12.6)
FALL	54.0	3.6 (2.7-5.4)	5.4 (3.6-7.2)	8.1 (6.3-9.9)	9.9 (7.2-NaN)
WINTER	31.6	3.6 (2.7-5.4)	5.4 (4.5-8.1)	8.1 (5.4-10.8)	9.9 (7.2-12.6)

Table shows the median (50th percentile) value by future target decade and season as compared to baseline values. Lower and upper bounds (the 10th-90th percentile range) is presented in parenthesis. Projected decreases are denoted by a minus (-) sign. The value highlighted in dark green is the value corresponding to the season and decade currently selected within the legend controls. Values are presented as absolute change.

Figure 2: Projected Changes, in Degrees Fahrenheit, to Average Annual Temperature in 2050, by Watershed

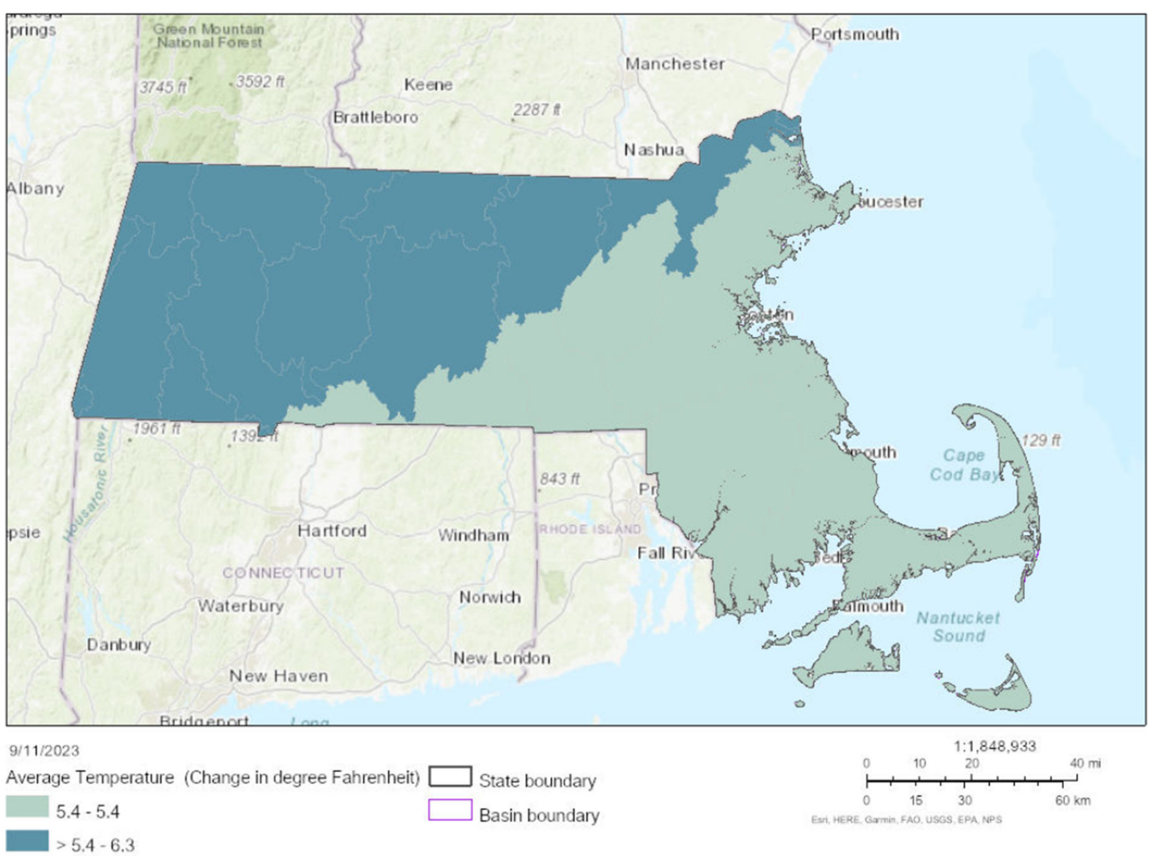


Table 2: Expected Number of Days Above 90 Degrees in the Narragansett Bay Watershed

Season	Baseline	2030	2050	2070	2090
ANNUAL	5	11 (4-20)	20 (11-31)	38 (20-52)	52 (31-75)
SPRING	0	0 (0-1)	1 (0-2)	2 (1-4)	3 (1-5)
SUMMER	5	9 (4-12)	17 (9-26)	31 (17-41)	41 (26-56)
FALL	0	1 (1-2)	2 (1-3)	5 (3-7)	7 (3-13)
WINTER	0	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)

Table shows the median (50th percentile) value by future target decade and season as compared to baseline values. Lower and upper bounds (the 10th-90th percentile range) is presented in parenthesis. Projected decreases are denoted by a minus (-) sign. The value highlighted in dark green is the value corresponding to the season and decade currently selected within the legend controls. Values are presented as absolute change.

Figure 3: Projected Number of Days Above 90 Degrees Fahrenheit in 2050, by Watershed

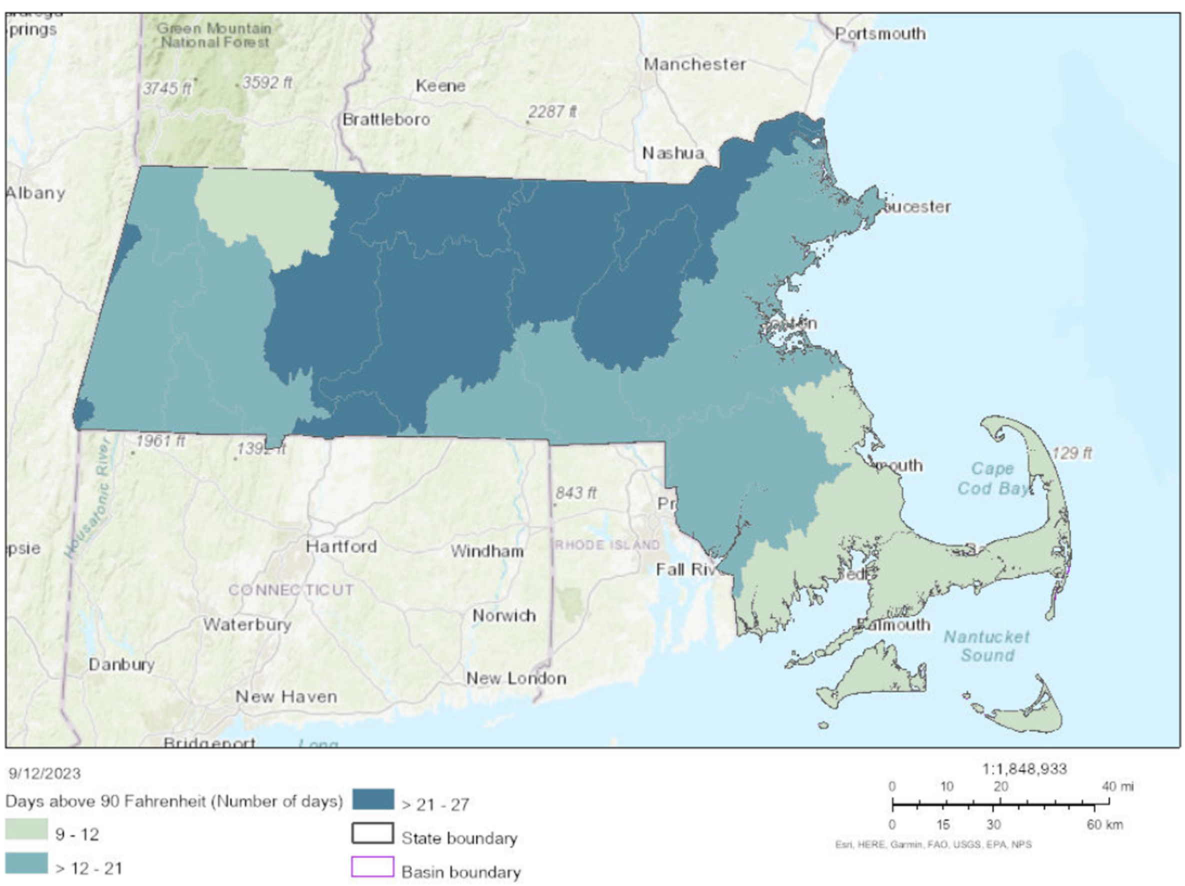


Table 3: Projected Percent Change to Total Annual and Seasonal Precipitation in the Narragansett Bay Watershed

Season	Baseline	2030	2050	2070	2090
ANNUAL	44.1	6.3 (-5.3-18.1)	8.5 (-4.3-21.5)	10.2 (-4.9-25.0)	12.6 (-3.2-29.4)
SPRING	11.4	8.7 (-1.0-17.4)	9.3 (-1.5-19.2)	13.8 (0.6-25.0)	15.5 (-0.1-26.5)
SUMMER	9.6	9.1 (-7.5-25.9)	6.8 (-8.7-24.4)	6.8 (-12.1-26.6)	8.5 (-10.1-29.1)
FALL	11.4	0.8 (-9.9-13.5)	4.8 (-9.8-17.7)	3.8 (-12.9-17.3)	4.8 (-9.3-20.9)
WINTER	11.7	7.1 (-3.1-16.8)	12.5 (2.0-25.1)	15.5 (3.3-31.2)	20.6 (5.3-40.6)

Table shows the median (50th percentile) value by future target decade and season as compared to baseline values. Lower and upper bounds (the 10th-90th percentile range) is presented in parenthesis. Projected decreases are denoted by a minus (-) sign. The value highlighted in dark green is the value corresponding to the season and decade currently selected within the legend controls. Values are presented as percent (%) change.

Figure 4: Projected Percent Change to Total Annual Precipitation in 2050, by Watershed