



Climate Change Impacts in southern Maine: A Regional Summary

May 2023

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Key Takeaways

This report summarizes the anticipated climate change impacts on southern Maine communities. It is intended to help local communities develop their Climate Action Plans and inform the public about the possible effects of climate change in the region. **Through local actions and solutions, we will build stronger communities and protect all Maine community members from climate change impacts.**

Overall, southern Maine is undergoing changes driven by rising temperatures, altering precipitation patterns, rising sea levels, and shifting ecosystems. Communities are experiencing these climate change impacts across the region, which will have far-reaching effects on the people, places, and culture of southern Maine.



Southern Maine's natural environment – the ecosystems, plants, and animals that make this region special – are already being stressed by climate change.



Southern Maine's roads, bridges, and critical infrastructure are at greater risk of damage due to sea level rise and increasing storm severity and frequency.



Large sectors of southern Maine's economy including tourism, fishing, recreation, and agriculture will need to adjust to climate change impacts.



The essential public services that southern Maine municipalities provide will be greatly strained by climate change impacts.

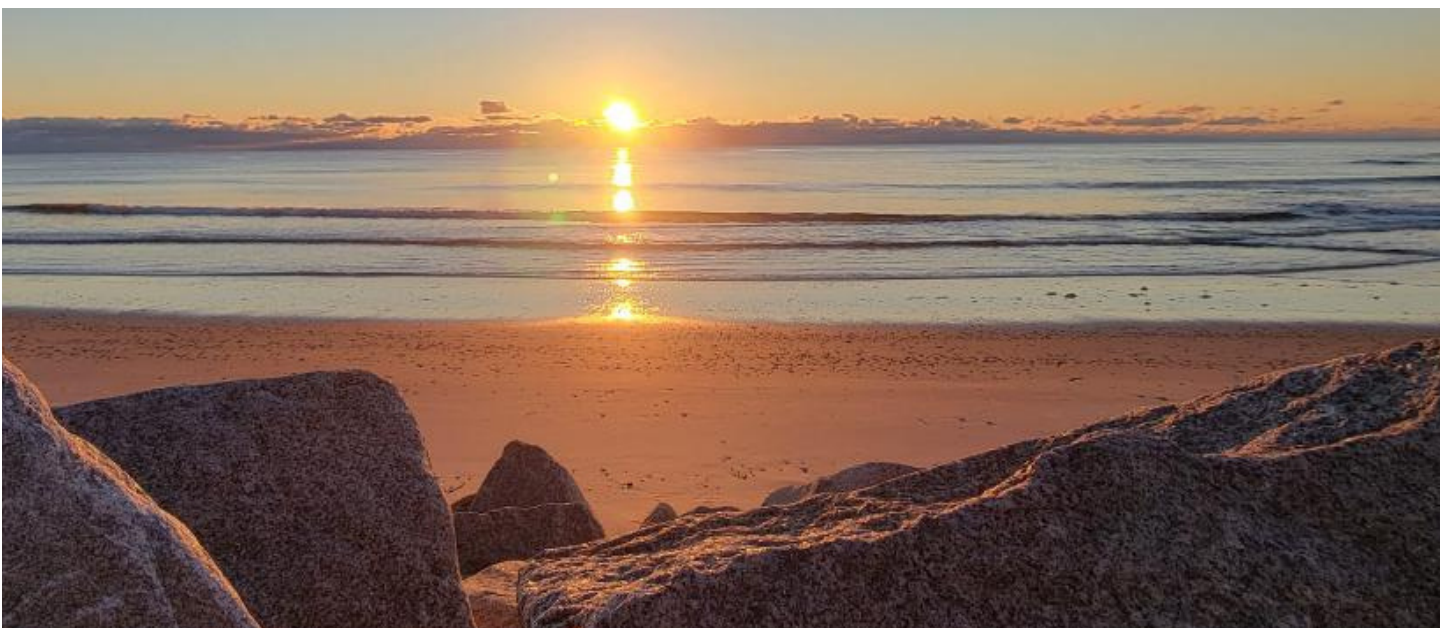


Climate change is altering the availability of recreation activities traditional to southern Maine.



Climate change impacts are negatively affecting the health of southern Maine community members.

To learn more about how southern Maine communities are preparing for climate change impacts, please visit www.somainecapcohort.com.



Climate Change Drivers

Climate change is the long-term shifting of temperatures and weather patterns driven by increased carbon dioxide (CO₂) and other greenhouse gases (GHGs) in the atmosphere.

Types of Greenhouse Gases

Carbon Dioxide (CO₂)

Carbon dioxide is the main byproduct of fossil fuel combustion, such as burning gasoline, oil, coal, or other fuels for energy.

Methane (CH₄)

Methane is primarily emitted through agricultural activities, waste management, and natural gas combustion. Pound for pound, the comparative impact of methane is 25 times greater than carbon dioxide over a 100-year period.

Nitrous Oxide (NO₂)

Nitrous oxide is primarily emitted through agricultural soil management and fertilizer use. Fertilizer production and domestic wastewater management are also sources.

Fluorinated Gases

Synthetic gases that are emitted from a variety of household and commercial applications such as refrigerants, aerosol propellants, foam blowing agents, solvents, and fire retardants. Although they are emitted at far lower quantities, they are particularly potent and trap substantially more heat than carbon dioxide.

Sources of Emissions

In Maine, 91% of GHG emissions come from energy consumption. Fossil fuel GHG emissions come from:

Transportation

Emissions from the burning of fossil fuels for cars, trucks, ships, trains, and planes.

Electricity Production

Emissions from fossil fuels like coal and natural gas that are burned in electricity generation plants.

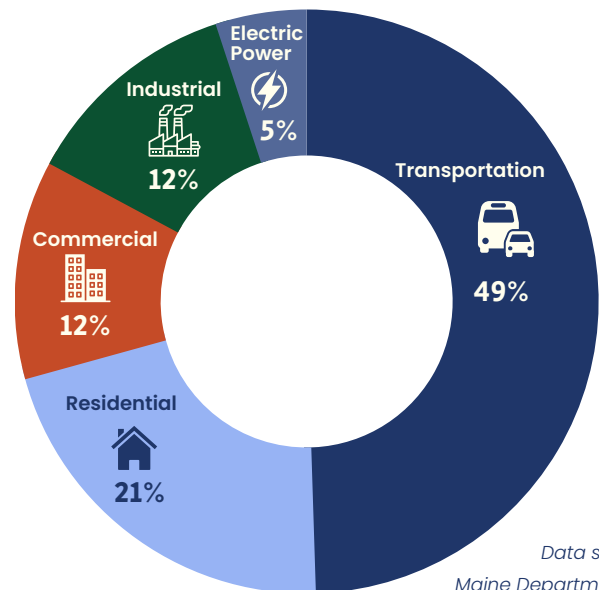
Industry

Emissions from burning fossil fuels and electricity used for energy in industrial facilities.

Commercial & Residential

Emissions from homes and businesses are primarily from burning fossil fuels for heating buildings, the use of certain GHG emitting products and waste management.

Maine Carbon Dioxide Emissions from Fossil Fuel Combustion by Sector (2019)



Data source:
Maine Department of
Environmental Protection

Other types of GHG emissions include those from agriculture (livestock, manure management, and cultivation practices), industrial processes (non-combustion activities that create emissions, such as cement production and semiconductor manufacturing) and waste (solid waste disposal and wastewater treatment).

Southern Maine's Changing Climate



We face major threats to the future of our communities and the places we love. But we have it within our power to take action on local solutions that will make a difference. Increasing temperatures, changing precipitation, sea level rise, and shifting ecosystems are driving changes across southern Maine.

Increasing Temperatures

Due to the Greenhouse Effect, **average air temperatures around the world are increasing over time. Maine's statewide annual temperature has increased by 3.2 °F (≈1.8 °C) since 1895.**

(Maine Climate Council, Scientific Assessment of Climate Change and its Effects in Maine)

Impacts of Increasing air temperatures:

- **Increased frequency of extreme temperature days (over 90°F):** Extreme heat days are expected to be 2 - 4 times more frequent in Maine by 2050, increasing the likelihood of heatwaves.
- **Increased average air temperatures:** Resulting in more frost-free days, shifting ecosystems, and increases in average water temperatures in lakes and rivers.
- **Shorter and warmer winters:** Warming has shortened Maine's winters and lengthened the summers by two weeks on average over the last century. This has led to reduced snowpack, changing snowmelt patterns, and earlier river and lake ice-out dates.
- **Increased risk of algal blooms:** Recurring blooms of harmful blue-green algae in freshwater are expected to become frequent as temperatures warm, potentially impacting human, animal, and ecosystem health.



Freshwater blue green algae bloom. Photo source: Lake Stewards of Maine.



What is the Greenhouse Effect?

The release of greenhouse gases (GHGs) into the atmosphere creates a layer of gas that acts like a blanket, trapping heat released from the surface of the Earth.

Changing Precipitation

In Maine precipitation has become both heavier and more frequent; **Maine's annual precipitation (rain and snowfall) has increased more than 6 inches since 1895, and extreme precipitation events (1+ inches over 24 hours) are becoming more frequent.**

(Maine Climate Council, Scientific Assessment of Climate Change and its Effects in Maine)

Impacts of changing precipitation:

- **Less precipitation is falling as snow due to increased temperatures.** This results in changes in seasonal water-flow patterns.
- **Extreme weather events are becoming more likely:** More frequent nor'easters, coastal storms, and hurricanes can cause flooding and damage to infrastructure and buildings.
- **More extensive flooding in coastal areas:** Stormwater runoff from intense rainfall events combined with storm surge and future sea level rise will lead to more extensive flooding in coastal areas. That threat is further exacerbated by development pressure in southern Maine that is increasing the number of roads, buildings, and parking lots that limit the natural infiltration of water into the soil.



Wiggins Pond in the Hope Woods., Kennebunk, ME. Photo Credit: Lisa Pratt.



What Causes Increased Precipitation?

Increased temperatures cause the evaporation of surface waters to intensify. This leads to more water in the atmosphere, resulting in unpredictable and intensified precipitation events.

Changing Drought

Despite increasing annual precipitation across the state, **York County has experienced three severe droughts in the last five years, which lasted between two to eight months.**

(Maine Climate Council, Scientific Assessment of Climate Change and its Effects in Maine)

Impacts of changing drought:

- **Decreased resilience of drinking water sources:** Reduced water supply and degraded quality can affect public and private drinking water sources, agricultural operations, and ecosystem health.
- **Increased risk of wildfires:** Wildfire frequency, particularly in the spring, is increasing in Maine due to drought, decreased snowpack, and windier conditions.



In April 2020, high winds and dry conditions led to more than a dozen wildfires in Maine. A wildfire in Biddeford burned about 20 acres of forest.

What Causes Droughts?

Warmer air temperatures and changing precipitation patterns have caused water tables to fall during the summer months and increased the severity of droughts.



Sea Level Rise

Globally, the mean sea level has risen about 8 to 9 inches since 1880, with roughly one third of that occurring in just the last two and a half decades. In the Gulf of Maine, sea level rise has mirrored the global trend. Data from the Portland tide gauge show that local sea level has increased 7.5 inches since 1912, when the gauge first began collecting data. Nearly half of the documented sea level rise that has occurred over the past century in Maine has occurred since 1993, representing a rapid increase in the rate of change.

By 2050, Maine will likely experience between 1.1 – 1.8 feet of sea level rise, and between 3.0 –4.6 feet of sea level rise by 2100, with higher amounts possible.

(Maine Climate Council, Scientific Assessment of Climate Change and its Effects in Maine)

Impacts of sea level rise:

- **Increase in average sea level:** The increase in the normal tidal extent of the sea level will decrease the width of dry beach and will inundate both natural and built environments.
- **Increase in the likelihood of nuisance flooding during high tide:** southern Maine has seen 4 times as many nuisance flooding events over the last decade compared with the average of the past 100 years. One foot of sea level rise will increase the frequency of nuisance flooding in southern Maine by 15-fold.
- **Saltwater Intrusion:** As average sea level rises, coastal waters seep further inland and underground, pushing groundwater levels up and shifting the interface of fresh groundwater and saltwater. Saltwater can intrude into groundwater, contaminating drinking water resources, cause flooding from higher coastal water tables, result in premature septic system failure, mobilize hazardous waste, and damage subsurface infrastructure and pavement from underground.
- **Increased severity of coastal flooding and storm surge:** With a higher normal high tide, storm surge from coastal storms will extend further into natural and built environments, causing flooding and damage to roads, homes, and bridges. Intense wave action and surge can bring with it dangerous debris like rocks, sand, and seaweed. While future sea level rise will occur gradually over time, extreme storm events can cause damaging flooding episodically in the short-term.
- **Loss of coastal habitat:** As sea level rises, coastal beaches, dunes, salt marshes, and bluffs are likely to experience increased erosion and land loss. Landward migration of coastal habitats like salt marshes can occur, but only if the habitat is healthy, can keep pace with the rate of sea level rise, and is unobstructed by landward barriers.



What Causes Sea Level Rise?

Warming temperatures cause rapid melting of glaciers as well as the expansion of water molecules in the oceans. Both effects are increasing the total volume of water in the earth's oceans. This causes the average sea level to increase over time, with water encroaching on beaches and coastal communities.



King Tide, Kittery, ME. Photo Credit: Robert McDonough.



Changing Terrestrial and Marine Ecosystems

Of the State's **378 most at-risk fish and wildlife species, nearly one-third are predicted to be negatively affected by climate-change related threats**, including habitat shifts and alterations, droughts, temperature extremes, and storms and flooding

(Maine Climate Council, Scientific Assessment of Climate Change and its Effects in Maine)

Impacts of changing ecosystems:

- **Ocean Acidification:** As the concentration of carbon dioxide increases in the atmosphere, carbon dioxide is absorbed into the ocean. This changes the chemistry of ocean waters, increasing the overall acidity of the water. Acidification is exacerbated by river discharge which carries excess nutrients from stormwater runoff. Increased ocean acidity limits marine life that produce calcium carbonate to build shells, such as oysters, scallops, clams, mussels, and sea urchins.
- **Ocean Warming:** The Gulf of Maine is warming faster than 99% of the world's oceans. This warming has harmful effects on the Gulf of Maine's subarctic ecosystem, including iconic North Atlantic species such as cod, whales, and puffins, as well as species like plankton that serve as the base of the food web.
- **Decreased biodiversity:** Maine is an ecological transition area, meaning both the temperate climate of southern New England and colder boreal forests of Canada overlap. The many compounding impacts of climate change have changed this environment over time, and a smaller number of species will be able to survive and thrive as many go extinct or migrate elsewhere.
- **Increased Potential for Invasive Species:** Invasive species, such as the Emerald ash borer, Asiatic bittersweet, and European green crab, are those that have a competitive advantage in our environment because they are not native to the area. In many cases, they are adapted for higher temperatures or wetter environments, making them better at surviving in a changing Maine climate. Invasive species can overgrow and outpace native Maine plants and wildlife, making it extremely difficult for native species to survive.



An invasive green crab. Photo Credit: USFWS 2019.

What Impacts Ecosystems?

Warming temperatures, changing precipitation, and a general shifting climate stress Maine's natural ecosystems and resources. These can have detrimental effects on Maine wildlife and people.



What Climate Change Means For Southern Maine

Climate change and its impacts will affect all the people, places, and culture of southern Maine.

Infrastructure

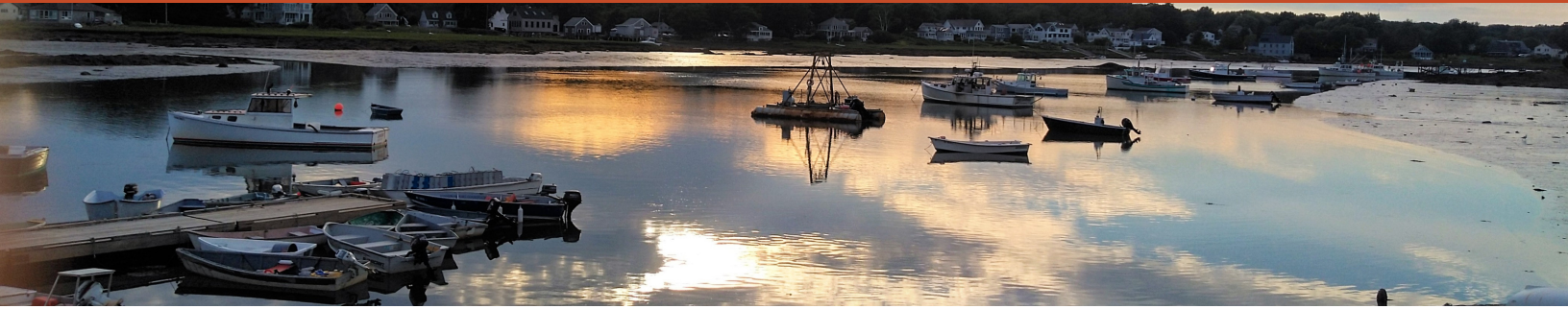
Southern Maine's roads, bridges, and critical infrastructure are at greater risk of damage due to increasing storm severity and frequency.

- **Sea level rise, storm surge, and extreme precipitation put coastal infrastructure at very high risk.**
 - Several coastal southern Maine towns' critical drinking and wastewater treatment facilities are in areas of high flood risk. Repairing and replacing these facilities will cost millions of dollars.
- **Southern Maine's electricity infrastructure is particularly vulnerable to increases in storm frequency and intensity.**
 - Maine has some of the worst power outages in the country. From 2015–2019, the state had the highest average annual frequency of power outages per customer of any state (3.9 outages per customer per year). These power outages jeopardize essential public safety services.
- **Inland infrastructure is at risk from extreme weather events, and particularly extreme precipitation.**
 - When a large amount of rain falls in a short amount of time, small watersheds can flood suddenly, damaging culverts, roads and bridges. Hundreds of statewide culverts are not designed for expected future precipitation. In 2021, an intense downpour washed out a large portion of an embankment along the Saco River in Biddeford, with repair costs estimated over \$2 Million.
- **Drought and decreases in summertime precipitation are negatively impacting drinking water supply for both private wells and public water systems.**
 - In the summer of 2022, drought led to water restrictions in some southern Maine communities. In addition to increased concerns about water supply, drought can lead to decreased water quality and greater health risks due to algal blooms and trace mineral concentrations.



Flooding in Kittery, ME. Photo Credit: Cross Currents Communications

What Climate Change Means For Southern Maine



Economy

Large sectors of southern Maine's economy including tourism, fishing, recreation, and agriculture will need to adjust to climate change impacts.

- **With 1.6 feet of sea level rise projected by 2050, Maine can expect \$17.5 billion in coastal damage and 21,000 coastal jobs lost.**
 - Additionally, this could result in 1.1 million fewer visitors in the southern Maine beach region and a \$136 million loss in tourism spending annually.
- **Southern Maine outdoor recreation industries account for 12% of all outdoor recreation value produced in the state.**
 - Fast-warming future temperatures, especially in winter, and declines in regional snowpack and ice cover will negatively impact winter recreation industries and the industries that support them. Alternatively, longer summer and shoulder seasons will be an opportunity for expanding summer recreation activities like boating and RVing.
- **Maine's farms will experience benefits from warming temperatures such as longer growing seasons and lower heating costs, but also costs such as heat stress to workers, crops and livestock and higher cooling costs.**
 - Increased frosts/freezes and unpredictable precipitation are expected to grow. Plant hardiness zones will shift northward with future warming, making Maine's climate more suitable for some kinds of crops (e.g. corn and soybeans) and potentially more challenging for others (e.g. wheat, Christmas trees, and wild blueberries).
- **Ocean warming and acidification are already affecting coastal fisheries including shrimp, clams, oysters, scallops, and groundfish.**
 - Lobsters, Maine's largest and most valuable fishery, are becoming more susceptible to shell disease and predatory fish, and are beginning to migrate north and farther offshore to colder waters.



Recreation

Climate change is altering the availability of recreation activities traditional to southern Maine.

- **Winter recreation opportunities are changing as less snowpack and more winter rain caused by warmer winter temperatures are making snowmobiling, skiing and ice fishing seasons shorter and more challenging.** River and lake ice is also thinner, making ice fishing and other activities more dangerous.
- **Earlier thaws and warmer waters lower important fish species' survival,** decreasing population health and impacting fishing opportunities.
- **Some natural and recreational services enjoyed at coastal beaches and waterways will disappear as sea level rise erodes beaches and damages sand-dune systems.** Coastal access points could even be lost as sea level rises.



Public Services

The essential public services that southern Maine municipalities provide will be greatly strained by climate change impacts.

- **More frequent flooding and extreme weather events will lead to higher costs and will stress municipal capacity** to respond to and repair after storm events.
- **Southern Maine municipal budgets are highly dependent on revenue from local property taxes, and in particular coastal development.**
 - Municipal fiscal health could be affected if coastal properties, which generate a large portion of local tax revenue and sustain community operations, services, and programs, are exposed to flooding and if development in flood prone areas continues.
- **Climate change is likely to lead to in-migration into areas like southern Maine that are perceived to be comparatively healthier and safer than areas considered to be at greater risk of climate impacts.**
 - Rapid increases in population could stress southern Maine's relatively small cities and towns. While climate migration presents an opportunity for the regional economy, fast population increases can cause new cultural conflicts, stress housing markets, put additional demand on limited municipal resources, and overwhelm recreational facilities.
- **Higher sea levels and flooding may cut off emergency routes and access to neighborhoods during storm events, obstructing emergency services and disrupting local travel.**
 - During the December 23, 2022 storm event, roads and bridges throughout coastal York County were flooded by a 13.7 feet-high tide, the fourth highest on record. Road closures, power outages, and frigid temperatures compounded, increasing the need for emergency services as well as the difficulty in providing them.



Public Health

Climate change impacts are negatively affecting the health of southern Maine community members.

- **Warmer, shorter winters are contributing to increased tick-borne illnesses, such as Lyme disease.** Tick abundance and disease risk are expected to increase with warming temperatures.
- **Increasing temperatures and more high-heat days are putting people at risk,** especially those who are elderly, have health issues, or have limited access to home air conditioning.
- **Extreme weather may cause injuries and deaths, outbreaks of waterborne diseases, and food-borne illnesses following power outages, as well as mental health stress.**
- **Plant-based allergens have longer to affect Mainers during the year due to longer summers and shorter winters.** The length of the pollen season and the amount of pollen produced will likely increase with rising temperatures and carbon dioxide concentrations. Asthma and hay fever are also likely to increase with climate change.