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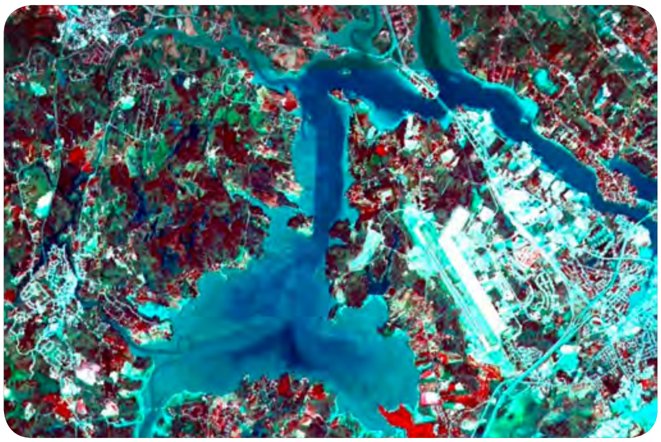
University of New Hampshire

Carbon Solutions New England

Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future

The full Piscataqua/Great Bay Report and additional New England climate change information are available online at CarbonSolutionsNE.org



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Executive Summary

EARTH'S CLIMATE CHANGES. It always has and always will. However, an overwhelming body of scientific evidence indicates that human activities – including the burning of fossil fuel for energy, clearing of forested lands for agriculture, and raising livestock – are now a significant and growing force driving change in the Earth's climate system. This report describes how the climate of the Piscataqua/Great Bay region has changed over the past century and how the future climate of the region will be affected by human activities that are warming the planet.

Overall, the region has been getting warmer and wetter over the last century, and the rate of change has increased over the last four decades. Detailed analysis of data collected at four meteorological stations (Durham and Concord NH; Lawrence, MA; and Portland, ME) in and around the Piscataqua/Great Bay region show that since 1970, mean annual temperatures have warmed 1.3 to 1.7 ºF, with the greatest warming occurring in winter (2.7 to 4.2 ºF). Average minimum and maximum temperatures have also increased over the same time period, with minimum temperatures warming faster than mean temperatures. Both the coldest winter nights and the warmest summer nights are warming as well. Over the past four decades, annual precipitation has increased 5 to 20%, and extreme precipitation events (more than one inch of precipitation in 24 hours and more than four inches of precipitation in 48 hours) have increased across the region. While the amount of snowfall and the number of snow-covered days does vary on decadal time scales over the past six decades, there are no significant trends. Annual discharge has increased in the Lamprey and Oyster rivers, due primarily to increases in flow during the fall. More than a century of observations shows that lake ice-out dates on Lake Winnipesaukee and Sebago Lake are occurring earlier today than in the past. Data collected from ships, buoys, and other observational platforms show that the rate of warming of sea surface temperatures in the Gulf of Maine has quadrupled over the last four decades.

To generate future climate projections for Durham, Concord, Lawrence, and Portland, simulated temperature and precipitation from four atmosphere-ocean general circulation models were fitted to local, long-term weather observations. Unknowns regarding future fossil fuel consumption were accounted for by using two future emissions scenarios, each of which paints a very different picture of the future. In the "lower emissions" scenario, improvements in energy efficiency combined with the development of renewable energy reduce our emissions below those of today by 2100. In the "higher emissions" scenario, fossil fuels are assumed to remain a primary energy resource, and our emissions grow to three times those of today by 2100. The scenarios describe climate in terms of temperature and precipitation for three future periods: the near-term (2010-2039), mid-century (2040-2069), and end-of-century (2070-2099). All changes are relative to a historical baseline, 1970-1999.

As greenhouse gases continue to accumulate in the atmosphere, seasonal and annual temperatures will rise in the Piscataqua/Great Bay region. Depending on the scenario, mid-century temperatures increase by 3 to 6ºF, and end-of-century temperatures increase as much as 4ºF to 9ºF. Summer temperatures experience the most dramatic change, up to 11ºF warmer under the higher emissions scenario. Extreme heat days are projected to occur more often, and to be hotter. At end-of-century, under a lower emissions scenario, days where temperatures rise above 90ºF increase to more than 20 per year from their current average of 9 per year. Under a higher emissions scenario, these hot days increase to more than 60 days each year in Durham, Concord, and Lawrence, raising concerns regarding the impact of extreme, sustained heat on human health, infrastructure, and the electricity grid. These concerns are further exacerbated by projections of increases in very hot days, where temperatures climb above 95ºF. Under higher emissions, these may increase to more than 30 days per year from their current average of just one day each year.

Extreme cold temperatures are projected to occur less often, and cold days will be warmer than in the past. By the end of the century, under lower emissions, Durham could experience 25 fewer days with minimum temperatures below 32ºF (a 15% decline), or under the higher emissions scenario 50 fewer days with minimum temperatures below 32ºF (a 30% decline). Very cold days, where minimum temperature falls below 0ºF, are projected to drop from their current average of 12 days per year in Durham, to 4 days per year under lower emissions and less than one day per year on average under higher emissions before the end of the century. Coldest temperatures of the year are also expected to warm. As an example, by the end of the century, the lowest temperatures on the coldest day of the year in Durham under the lower emissions scenario will on average be 8 to 9ºF warmer and under the high emissions scenario will be 19 to 20ºF warmer. These changes will reduce winter heating bills and the risk of cold-related accidents and injury. However, they may also lift the cold temperature constraints currently limiting some pest and invasive species to more southern states, and simultaneously reduce the number of chilling hours experienced each year required for iconic crops such as berries and fruit.

Annual average precipitation is projected to increase 12 to 17% by end-of-century. Larger increases are expected for winter and spring, exacerbating concerns regarding rapid snowmelt, high peak stream flows, and flood risk. In addition, the Piscataqua/Great Bay region can expect to see more extreme precipitation events in the future, and more extreme precipitation events under the higher emissions scenario relative to the lower emissions scenario. Frequency of drought, a precipitation deficit more than 20% below long-term historical averages for a month, is projected to remain the same in Durham and Lawrence under the higher emissions scenario, while Portland can expect the number of months in drought conditions to double by 2070-2099. Under the lower emissions scenario, all three stations are projected to experience a slight decrease in the number of months in drought.

Tidal gauge data indicates relative sea level at Portsmouth is rising at about 0.7 inches per decade over the past eight decades. To generate future projections of coastal flooding on the New Hampshire seacoast, projected increases in global and regional sea level were combined with current 100-year flood elevations, also using two future emissions scenarios. Coastal flooding projections, not including wave effects, were generated for 2050 and 2100, relative to 1990. Flood maps showing the spatial extent of these estimates of future coastal flooding elevations for the New Hampshire seacoast will be developed once the new digital elevation model has been generated from the recently acquired LiDAR (Light Detection And Ranging) data. A review of the most recent analyses suggests that global sea level rise by 2100 will range from 1.7 to 6.3 feet, not including wave effects. Our analysis shows that this results in 100-year flood stillwater elevations at Fort Point (at the mouth of the Piscataqua River) will range from 9.4 to 12.9 feet by 2050 and 10.9 to 17.5 feet by 2100. These estimated stillwater elevations do not include wave effects, which can be significant.

The changes in climate over the past several decades are already having a significant impact on New Hampshire's coastal watershed. The projected changes in the climate of the Piscataqua/Great Bay region over the next century will continue to impact ecosystems and society in a range of ways. Because some future changes are inevitable, smart choices must be made to ensure our society and our environment will be able to adapt. But with prompt action that improves the efficiency with which we use energy and significantly enhances sources of renewable energy, many of the most extreme consequences of climate change can be avoided and their worst impacts reduced. Our hope is that the focused information presented in this report provides local and regional stakeholders with decision relevant information and serves as a foundation for the development of local climate change adaptation plans.