



## Key Message 1

Bartram Bridge in Pennsylvania

### Changing Seasons Affect Rural Ecosystems, Environments, and Economies

The seasonality of the Northeast is central to the region's sense of place and is an important driver of rural economies. Less distinct seasons with milder winter and earlier spring conditions are already altering ecosystems and environments in ways that adversely impact tourism, farming, and forestry. The region's rural industries and livelihoods are at risk from further changes to forests, wildlife, snowpack, and streamflow.

## Key Message 2

### Changing Coastal and Ocean Habitats, Ecosystems Services, and Livelihoods

The Northeast's coast and ocean support commerce, tourism, and recreation that are important to the region's economy and way of life. Warmer ocean temperatures, sea level rise, and ocean acidification threaten these services. The adaptive capacity of marine ecosystems and coastal communities will influence ecological and socioeconomic outcomes as climate risks increase.

## Key Message 3

### Maintaining Urban Areas and Communities and Their Interconnectedness

The Northeast's urban centers and their interconnections are regional and national hubs for cultural and economic activity. Major negative impacts on critical infrastructure, urban economies, and nationally significant historic sites are already occurring and will become more common with a changing climate.

## Key Message 4

### Threats to Human Health

Changing climate threatens the health and well-being of people in the Northeast through more extreme weather, warmer temperatures, degradation of air and water quality, and sea level rise. These environmental changes are expected to lead to health-related impacts and costs, including additional deaths, emergency room visits and hospitalizations, and a lower quality of life. Health impacts are expected to vary by location, age, current health, and other characteristics of individuals and communities.

## Key Message 5

### Adaptation to Climate Change Is Underway

Communities in the Northeast are proactively planning and implementing actions to reduce risks posed by climate change. Using decision support tools to develop and apply adaptation strategies informs both the value of adopting solutions and the remaining challenges. Experience since the last assessment provides a foundation to advance future adaptation efforts.

## Executive Summary



The distinct seasonality of the Northeast's climate supports a diverse natural landscape adapted to the extremes of cold, snowy winters and warm to hot, humid summers. This natural landscape provides the economic and cultural foundation for many

rural communities, which are largely supported by a diverse range of agricultural, tourism, and natural resource-dependent industries (see Ch. 10: Ag & Rural, Key Message 4).<sup>1</sup> The recent dominant trend in precipitation throughout the Northeast has been towards increases in rainfall intensity,<sup>2</sup> with increases in intensity exceeding those in other regions of the contiguous United States. Further increases in rainfall intensity are expected,<sup>3</sup> with increases in total precipitation expected during the winter and spring but with little change in the summer.<sup>4</sup> Monthly

precipitation in the Northeast is projected to be about 1 inch greater for December through April by end of century (2070–2100) under the higher scenario (RCP8.5).<sup>4</sup>

Ocean and coastal ecosystems are being affected by large changes in a variety of climate-related environmental conditions. These ecosystems support fishing and aquaculture,<sup>5</sup> tourism and recreation, and coastal communities.<sup>6</sup> Observed and projected increases in temperature, acidification, storm frequency and intensity, and sea levels are of particular concern for coastal and ocean ecosystems, as well as local communities and their interconnected social and economic systems. Increasing temperatures and changing seasonality on the Northeast Continental Shelf have affected marine organisms and the ecosystem in various ways. The warming trend experienced in the Northeast Continental Shelf has been associated with many fish and invertebrate species moving northward and to greater depths.<sup>7,8,9,10,11</sup> Because of the diversity of the Northeast's coastal landscape, the impacts

from storms and sea level rise will vary at different locations along the coast.<sup>12,13</sup>

Northeastern cities, with their abundance of concrete and asphalt and relative lack of vegetation, tend to have higher temperatures than surrounding regions due to the urban heat island effect. During extreme heat events, nighttime temperatures in the region's big cities are generally several degrees higher than surrounding regions, leading to higher risk of heat-related death. Urban areas are at risk for large numbers of evacuated and displaced populations and damaged infrastructure due to both extreme precipitation events and recurrent flooding, potentially requiring significant emergency response efforts and consideration of a long-term commitment to rebuilding and adaptation, and/or support for relocation where needed. Much of the infrastructure in the Northeast, including drainage and sewer systems, flood and storm protection assets, transportation systems, and power supply, is nearing the end of its planned life expectancy. Climate-related disruptions will only exacerbate existing issues with aging infrastructure. Sea level rise has amplified storm impacts in the Northeast (Key Message 2), contributing to higher surges that extend farther inland, as demonstrated in New York City in the aftermath of Superstorm Sandy in 2012.<sup>14,15,16</sup> Service and resource supply infrastructure in the Northeast is at increasing risk of disruption, resulting in lower quality of life, economic declines, and increased social inequality.<sup>17</sup> Loss of public services affects the capacity of communities to function as administrative and economic centers and triggers disruptions of interconnected supply chains (Ch. 16: International, Key Message 1).

Increases in annual average temperatures across the Northeast range from less than 1°F (0.6°C) in West Virginia to about 3°F (1.7°C) or more in New England since 1901.<sup>18,19</sup> Although the relative risk of death on very hot days is lower today than it was a few decades ago, heat-related illness and

death remain significant public health problems in the Northeast.<sup>20,21,22,23</sup> For example, a study in New York City estimated that in 2013 there were 133 excess deaths due to extreme heat.<sup>24</sup> These projected increases in temperature are expected to lead to substantially more premature deaths, hospital admissions, and emergency department visits across the Northeast.<sup>23,25,26,27,28,29</sup> For example, in the Northeast we can expect approximately 650 additional premature deaths per year from extreme heat by the year 2050 under either a lower (RCP4.5) or higher (RCP8.5) scenario and from 960 (under RCP4.5) to 2,300 (under RCP8.5) more premature deaths per year by 2090.<sup>29</sup>

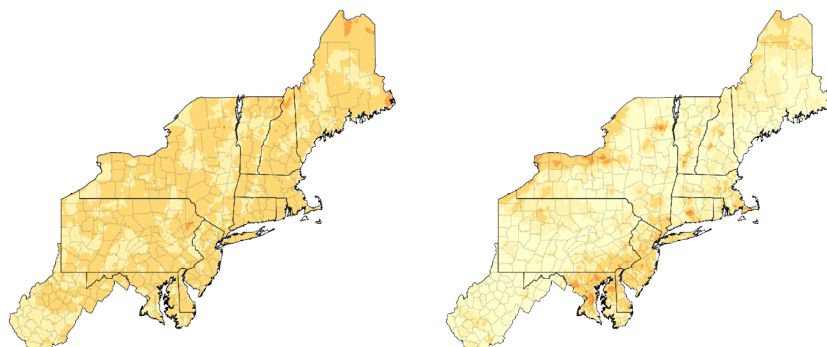
Communities, towns, cities, counties, states, and tribes across the Northeast are engaged in efforts to build resilience to environmental challenges and adapt to a changing climate. Developing and implementing climate adaptation strategies in daily practice often occur in collaboration with state and federal agencies (e.g., New Jersey Climate Adaptation Alliance 2017, New York Climate Clearinghouse 2017, Rhode Island STORMTOOLS 2017, EPA 2017, CDC 2015<sup>30,31,32,33,34</sup>). Advances in rural towns, cities, and suburban areas include low-cost adjustments of existing building codes and standards. In coastal areas, partnerships among local communities and federal and state agencies leverage federal adaptation tools and decision support frameworks (for example, NOAA's Digital Coast, USGS's Coastal Change Hazards Portal, and New Jersey's Getting to Resilience). Increasingly, cities and towns across the Northeast are developing or implementing plans for adaptation and resilience in the face of changing climate (e.g., EPA 2017<sup>33</sup>). The approaches are designed to maintain and enhance the everyday lives of residents and promote economic development. In some cities, adaptation planning has been used to respond to present and future challenges in the built environment. Regional efforts have recommended changes in design standards when building, replacing, or retrofitting infrastructure to account for a changing climate.

## Lengthening of the Freeze-Free Period

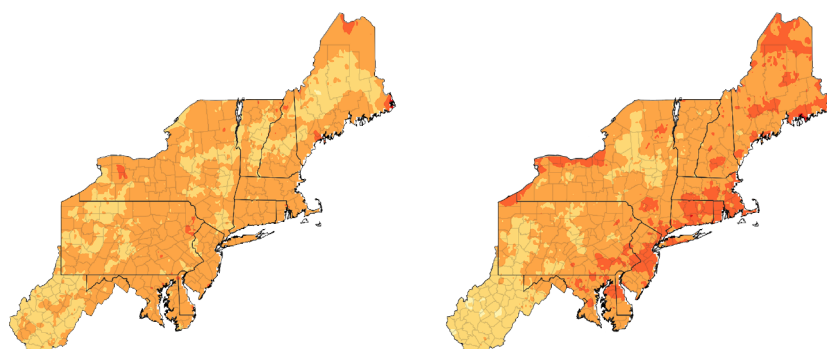
Last Spring Freeze

First Fall Freeze

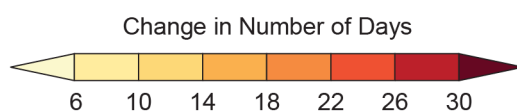
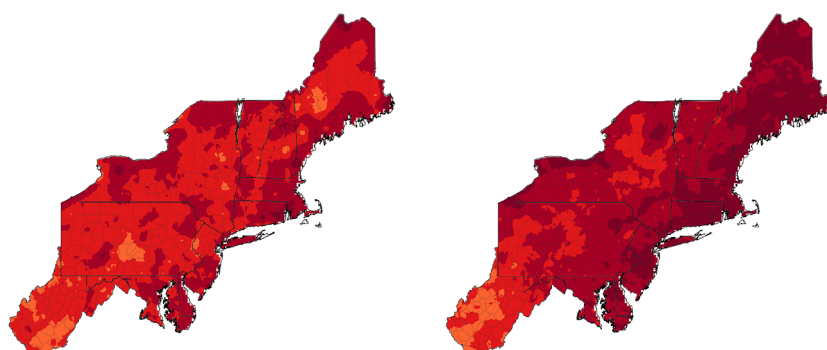
2040–2069, Lower Scenario (RCP4.5)



2040–2069, Higher Scenario (RCP8.5)



2070–2099, Higher Scenario (RCP8.5)

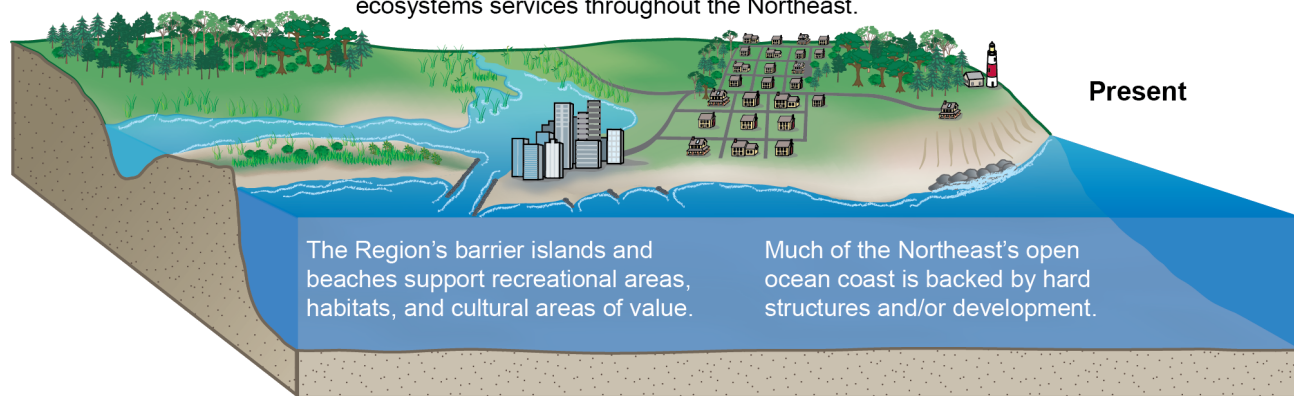


These maps show projected shifts in the date of the last spring freeze (left column) and the date of the first fall freeze (right column) for the middle of the century (as compared to 1979–2008) under the lower scenario (RCP4.5; top row) and the higher scenario (RCP8.5; middle row). The bottom row shows the shift in these dates for the end of the century under the higher scenario. By the middle of the century, the freeze-free period across much of the Northeast is expected to lengthen by as much as two weeks under the lower scenario and by two to three weeks under the higher scenario. By the end of the century, the freeze-free period is expected to increase by at least three weeks over most of the region. *From Figure 18.3 (Source: adapted from Wolfe et al. 2018<sup>35</sup>).*



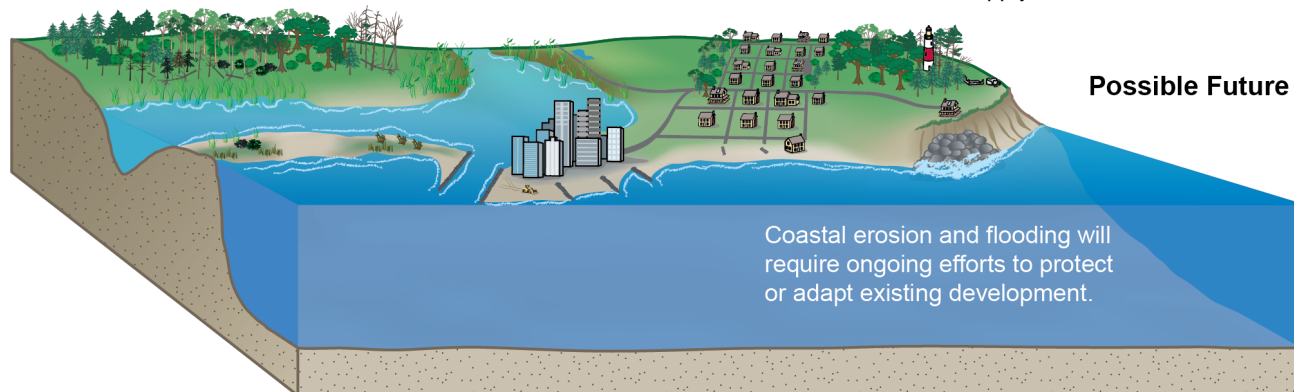
## Coastal Impacts of Climate Change

Coastal marshes, uplands, forests, and estuaries provide critical habitat and ecosystems services throughout the Northeast.



Forests, uplands, and marshes will either adapt to changing conditions by migrating landward or will become submerged.

Bluffs will erode, and barrier islands and beaches will migrate landward, erode, or narrow, particularly where sediment supply is limited.



(top) The northeastern coastal landscape is composed of uplands and forested areas, wetlands and estuarine systems, mainland and barrier beaches, bluffs, headlands, and rocky shores, as well as developed areas, all of which provide a variety of important services to people and species. (bottom) Future impacts from intense storm activity and sea level rise will vary across the landscape, requiring a variety of adaptation strategies if people, habitats, traditions, and livelihoods are to be protected. *From Figure 18.7 (Source: U.S. Geological Survey).*