Northeast

The Northeast has significant geographic and climatic diversity within its relatively small area. The character and economy of the Northeast have been shaped by many aspects of its climate including its snowy winters, colorful autumns, and variety of extreme events such as nor'easters, ice storms, and heat waves. This familiar climate has already begun changing in noticeable ways. Since 1970, the annual average temperature in the Northeast has increased by 2°F, with winter temperatures rising twice this much[1]. This warming has resulted in many other climate-related changes, including:

- More frequent days with temperatures above 90°F
- A longer growing season
- Less winter precipitation falling as snow and more as rain
- Reduced snowpack and increased snow density
- Earlier breakup of winter ice on lakes and rivers
- Earlier spring snowmelt resulting in earlier peak river flows
- Rising sea-surface temperatures and sea levels

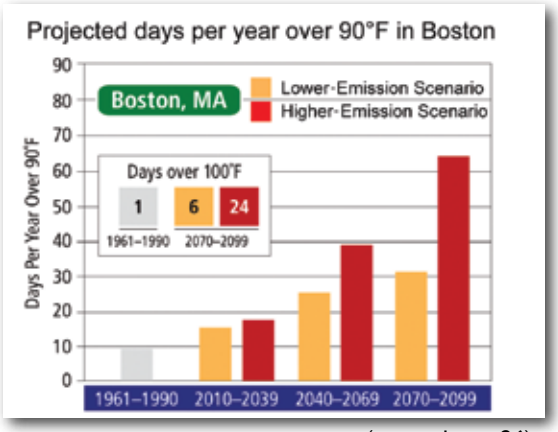
All of these observed regional changes are consistent with ones expected to result from global warming. The Northeast is projected to face continued warming and more extensive climate-related changes, some of which could dramatically alter the region's economy, landscape, character, and quality of life.

Over the next several decades, temperatures are projected to rise an additional 2.5 to 4°F in winter and 1.5 to 3.5°F in summer. By mid-century and beyond, however, today's emissions choices generate starkly different climate futures, with a lower emissions scenario resulting in much smaller climatic changes and resulting impacts[2,3]. By late this century, under a higher-emissions scenario:

- Winters in the Northeast are projected to warm by 8 to 12°F and summers by 6 to 14°F.
- The length of the winter snow season would be cut in half across northern New York, Vermont, New Hampshire, and Maine, and reduced to a week or two in southern parts of the region.
- Cities that today experience few days above 100°F each summer would average 20 such days per summer, while certain cities, such as Hartford and Philadelphia, would average nearly 30 days over 100°F.
- Short-term (one- to three-month) droughts are projected to occur as frequently as once each summer in the Catskill and Adirondack Mountains, and across the New England states.
- Hot summer conditions would arrive three weeks earlier and last three weeks longer into the fall.
- Global average sea level is conservatively projected to rise one to two feet, with the potential for much larger rises.

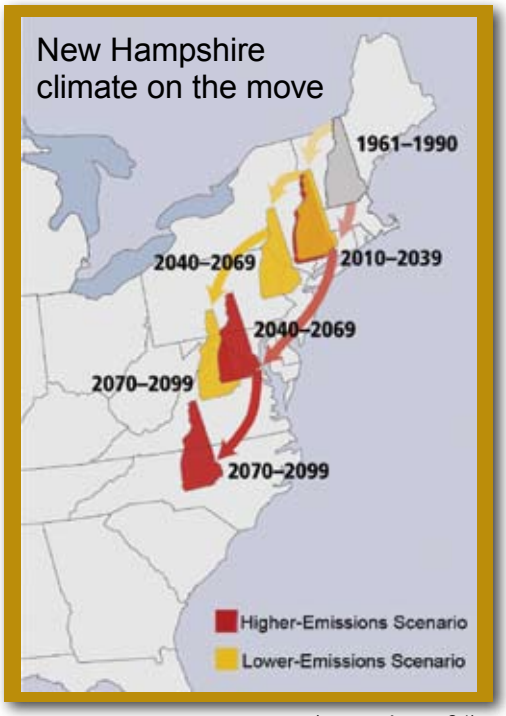
Extreme heat and declining air quality are projected to pose increasing problems for human health, especially in urban areas.

Heat waves, which are currently rare in the region, are projected to become much more commonplace in a warmer future, with major implications for human health (see *Human Health* sector). Future impacts in the Northeast are evident in the projections of the number of summer days with temperatures over 90°F and over 100°F, illustrated for the city of Boston[4].



(see endnote 26)

In addition to the physiological stresses associated with hotter days and nights[5], for cities that now experience ozone pollution problems, the number of days that fail to meet federal air-quality standards is projected to increase with rising temperatures[6] (see *Human Health* sector).



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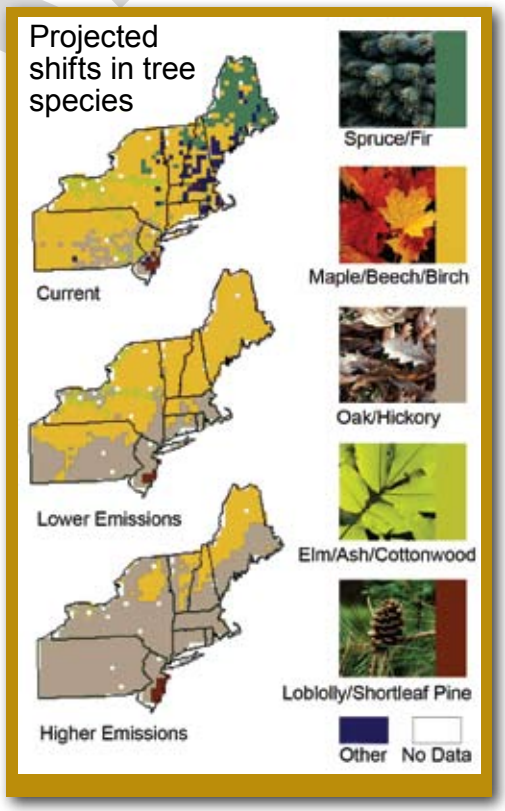
Projected changes in the summer heat index provide a graphic sense of how different the climate of the Northeast is projected to be under low *versus* high emissions scenarios. Yellow arrows track what summers are projected to feel like under a lower emissions scenario, while red arrows track projections for a higher emissions scenario. For example, under the higher emission scenario, by late in this century residents of New Hampshire would experience summer climate more like what occurs today in North Carolina. The effects of this kind of change will be particularly problematic in this region, since air conditioning is considerably less prevalent in New England homes, with some form of air conditioning being present in only about 58 percent of homes in this region, compared to the national average of 77 percent[7].

Agricultural production, including dairy, fruit, and maple syrup, will be increasingly affected as favorable climates shift.

Large portions of the Northeast are likely to become unsuitable for growing popular varieties of apples, blueberries, and cranberries under a higher-emissions scenario[8,9]. Climate conditions suitable for maple/beech/birch forests are projected to shift dramatically northward, eventually leaving only a small portion of the Northeast with a maple sugar business[10].

The dairy industry is the most important agricultural sector in this region, with annual production worth $3.6 billion[11]. Heat stress in dairy cows depresses both milk production and birth rates for periods of weeks to months[12]. By late this century, all but the northern parts of Maine, New Hampshire, New York, and Vermont are projected to suffer declines in July milk production under the higher-emissions scenario. In parts of Connecticut, Massachusetts, New Jersey, New York, and Pennsylvania, a ten to 20 percent or greater decline in milk production is projected. Under the lower-emissions scenario, however, reductions in milk production of up to ten percent remain confined primarily to New Jersey and small areas of Pennsylvania[13]. This analysis used average monthly temperature and humidity data that do not capture daily variations in heat stress and projected increases in extreme heat. Nor did the analysis directly consider farmer responses, such as installation of potentially costly cooling systems. On balance, these projections are likely to underestimate impacts on the dairy industry.



(see endnote 26)

Severe floods due to sea-level rise and heavy downpours are projected to occur more frequently.

Many current sea-level projections do not fully account for changes in ice flow dynamics such as those recently observed on the world's major ice sheets, and thus are likely to be underestimated[14]. However, even under these projections, the densely populated coasts of the Northeast face substantial increases in the extent and frequency of coastal flooding, erosion, property damage, and loss of wetlands. New York State alone has more than $1.9 trillion in insured coastal property[15]. Much of this coastline is exceptionally vulnerable to sea-level rise and related impacts. Some major insurers have withdrawn coverage from thousands of homeowners in coastal areas of the Northeast, including New York City.

Increased flood risk in New York City

The light blue area in these maps depicts today's FEMA 100-year flood zone for New York City (*i.e.*, the area of the city that is expected to be flooded once every 100 years). With additional sea-level rise by 2100 under the higher-emissions scenario, this area is projected to have a ten percent chance of flooding in any given year; under the lower-emissions scenario, a five percent chance. Critical transportation infrastructure located in the Battery area could be flooded far more frequently unless protected. The 100-year flood at the end of the century (not mapped here) is projected to inundate a far larger area of New York City, especially under the higher-emissions scenario[26].

Rising sea levels are projected to increase the frequency and severity of damaging storm surges and flooding. Under a higher-emissions scenario, what is now considered a once-in-a-century coastal flood in New York City is projected to occur at least twice as often by mid-century, and ten times as often, or once per decade on average, by late-century. With lower emissions, today's 100-year flood is projected to occur once every 22 years on average by late century[16].

The projected reduction in snow cover will affect winter recreation and the industries that rely upon it.

Winter snow and ice sports, which are worth some $7.6 billion annually to the regional economy, will be particularly affected by warming[17]. Of this total, alpine skiing and other snow sports (not including snowmobiling) account for $4.6 billion annually. Snowmobiling, which now rivals skiing as the largest winter recreation industry in the nation, accounts for the remaining $3 billion[18]. Other winter traditions, ranging from skating and ice fishing on frozen ponds and lakes, to cross-country (Nordic) skiing, snowshoeing, and dogsledding, are integral to the character of the Northeast, and for many residents and visitors, its desirable quality of life.

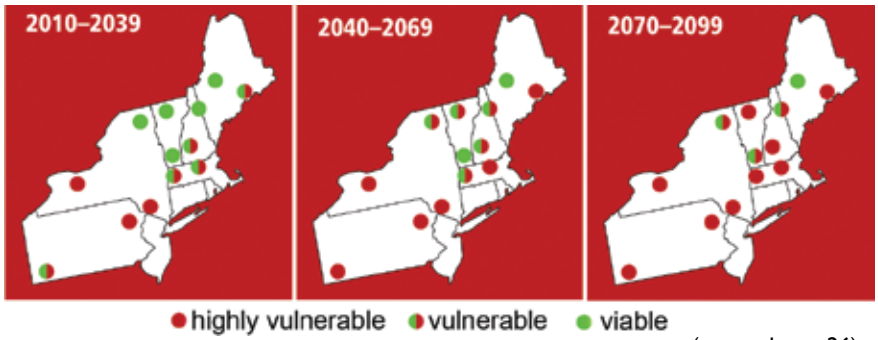
Warmer winters will shorten the average ski and snowboard seasons, increase artificial snowmaking requirements, and drive up operating costs. While snowmaking can enhance the prospects for ski resort success, it requires a great deal of water and energy, as well as very cold nights, which are becoming less frequent. Analyses of projected changes in ski-season length, the probability of being open during the Christmas to New Year holiday, and snowmaking

Adaptation: Raising a Sewage Treatment Plant in Boston

Boston's Deer Island sewage treatment plant was designed and built taking future sea-level rise into consideration. Because the level of the plant relative to the level of the water at the outfall is critical to the amount of rainwater and sewage that can be treated, the plant was built 1.9 feet higher than it would otherwise have been to accommodate the amount of sea-level rise projected to occur by 2050, the planned life of the facility.

The planners recognized that the future would be different than the past and they decided to plan for the future based on the best available information. They assessed what could be easily and inexpensively changed at a later date *versus* those things that would be more difficult and expensive to change later. For example, increasing the plant's height would be less costly to incorporate in the original design, while armoring the island could be added at a later date as needed at a relatively small cost.

Ski areas at risk under higher emissions scenario



(see endnote 26)

requirements suggest that most ski areas in the Northeast will have a projected average season of less than 100 days and a less-than-75-percent probability of operating during the lucrative holiday period, making them highly vulnerable to climate change. Only one area in the region is projected to support viable ski resorts by the end of this century under a higher-emissions scenario[19]. Without the opportunity to benefit from snowmaking, the prospects for the snowmobiling industry are even worse. Most of the region is likely to have a marginal or non-existent snowmobile season by mid-century.

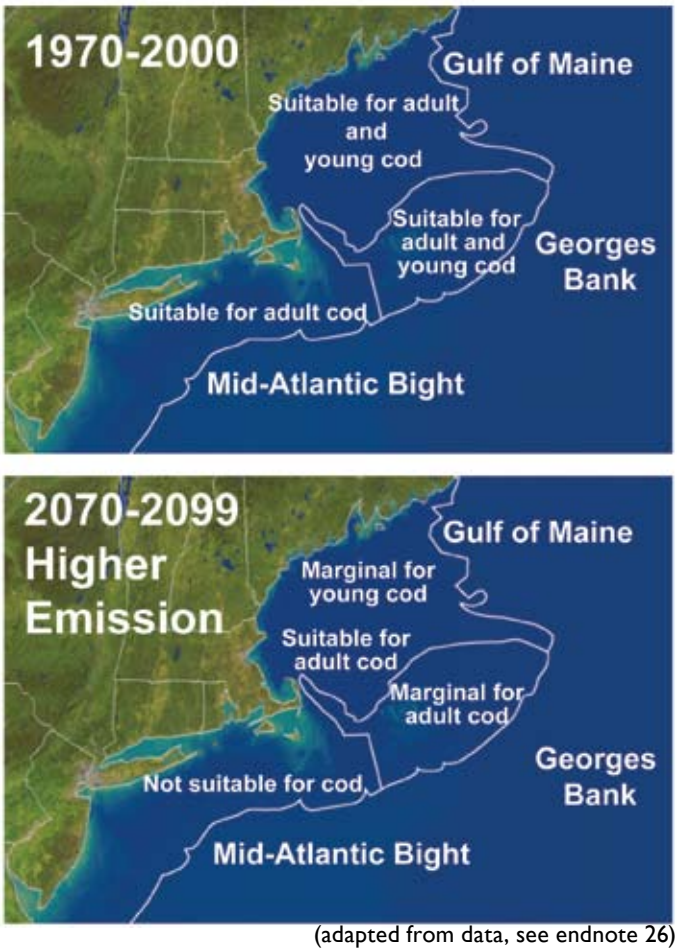
The center of lobster fisheries is projected to continue its northward shift and the cod fishery on Georges Bank is likely to be diminished.

Lobster catch has increased dramatically in the Northeast as a whole over the past three decades, though not uniformly[20,21]. Catches in the southern part of the region peaked in the mid-1990s, and have since declined sharply, beginning with a 1997 die-off in Rhode Island and Buzzards Bay (Massachusetts) associated with the onset of a temperature-sensitive bacterial shell disease, and accelerated by a 1999 lobster die-off in Long Island Sound. The commercial potential of lobster harvest appears limited in its southern extent, today, by this temperature-sensitive shell disease and in the coming decades, by rising nearshore water temperatures. Analyses also suggest that warming conditions in the northern regions of the Gulf of Maine, longer growing season, more rapid growth, an earlier hatching season, more nursery grounds suitable for larval settlement, and faster planktonic development could increase lobster survival and settlement in these northern waters[22].

Cod populations throughout the North Atlantic are adapted to a wide range of seasonal ocean temperatures, including average annual temperatures the sea floor ranging from 36 to 54°F. A maximum ocean temperature of 54°F represents the threshold of thermally suitable habitat for cod and the practical limit of cod distribution[23]. Temperature also influences both the location and timing of spawning, which in turn affects the subsequent growth and survival of young cod. Studies indicate that increases in average annual bottom temperatures above 47°F will lead to a decline in growth, survival, and recruitment[24,25].

In ocean waters off the Northeast coast, cod are currently at the southern edge of their thermal habitat, and young cod are uncommon south and west of Georges Bank. Under a higher emissions scenario, Georges Bank, which has historically been one of the most important centers of cod production, is projected to become unsuitable habitat for young cod[26].

Cod Habitat Shifting North



(adapted from data, see endnote 26)