Northeast

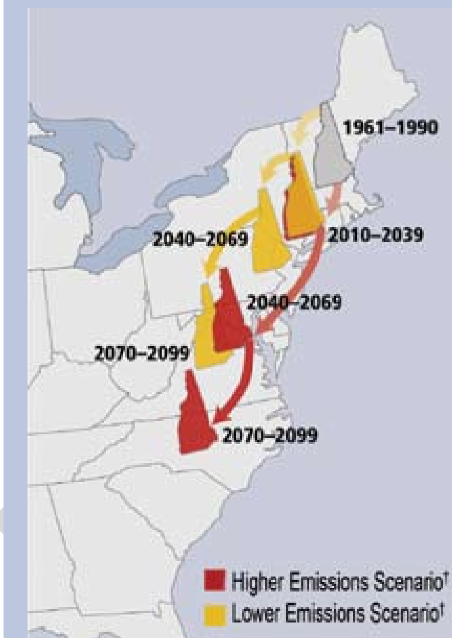
The Northeast has significant geographic and climatic diversity within its relatively small area. The character and economy of the Northeast have been shaped by many aspects of its climate including its snowy winters, colorful autumns, and variety of extreme events such as nor'easters, ice storms, and 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,
- Increased heavy precipitation,
- Less winter precipitation falling as snow and more as rain,
- Reduced snowpack,
- Earlier breakup of winter ice on lakes and rivers,
- Earlier spring snowmelt resulting in earlier peak river flows, and
- Rising sea surface temperatures and sea level.

Each of these observed changes is consistent with the changes expected in this region 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.

New Hampshire
Climate on the Move



Hayhoe *et al.*[2]/Fig. from Frumhoff[26]

Yellow arrows track what summers are projected to feel like under a lower emissions scenario† (B1), while red arrows track projections for a higher emissions scenario† (A1FI). For example, under the higher emission scenario†, by late this century residents of New Hampshire would experience a summer climate more like what occurs today in North Carolina[2].

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 would generate starkly different climate futures; the lower the emissions, the smaller the climatic changes and resulting impacts[1,2]. By late this century, under a higher-emissions scenario†:

- Winters in the Northeast are projected to be much shorter with far fewer cold days.
- 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.
- Sea level in this region is projected to rise about 2 feet, with the potential for a much larger rise, for reasons discussed in the *Global* and *National Climate Change* sections (see pages 23 and 39).

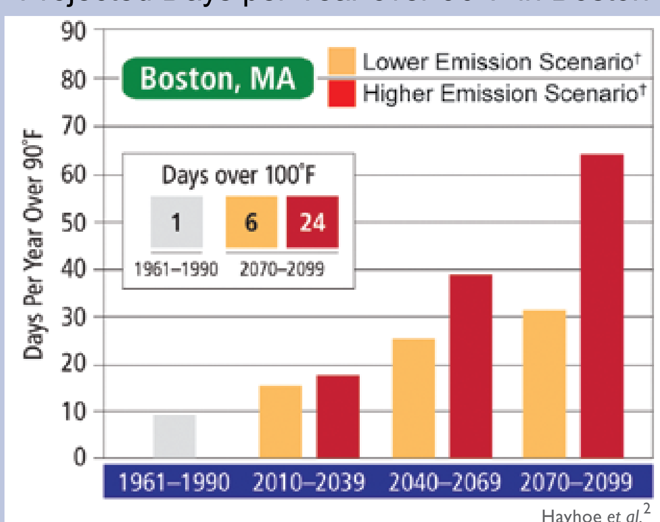
Extreme heat and declining air quality are projected to pose increasing problems for human health, especially in urban areas.

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)[3,4].

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 if there are no further additional controls on ozone-causing pollutants[3,6] (see *Human Health* sector). Sharp reductions in emissions will be needed to keep ozone within existing standards.

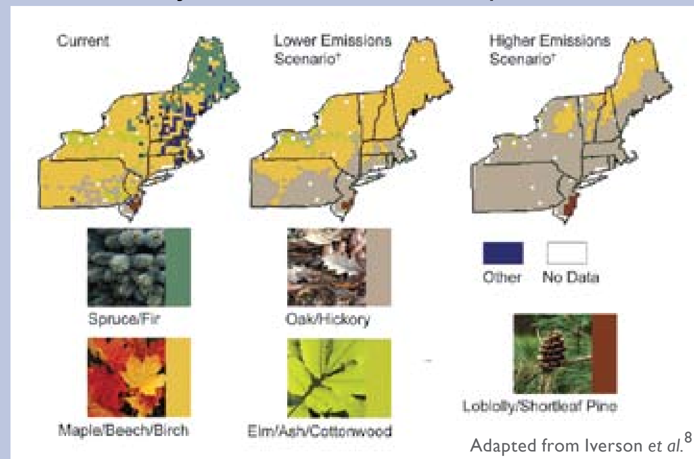
Projected changes in the summer heat index provide a clear sense of how different the climate of the Northeast is projected to be under low *versus* high emissions scenarios. Changes of this kind will require greater use of air conditioning.

Projected Days per Year over 90°F in Boston



The graph shows model projections of the number of summer days with temperatures over 90°F in Boston, Massachusetts, under low (B1) and high (A1FI) emissions scenarios†. The inset shows projected days over 100°F[2].

Projected Shifts in Tree Species



Much of the Northeast's forest is composed of the hardwoods maple, beech, and birch, while mountain areas and more northern parts of the region are dominated by spruce/fir forests. As climate changes over this century, suitable habitat for spruce and fir is expected to contract dramatically. Suitable maple/beech/birch habitat is projected to shift significantly northward under a higher emissions scenario†, but to shift far less under a lower emissions scenario[†,8].

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[†,7,8]. 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[9].

The dairy industry is the most important agricultural sector in this region, with annual production worth $3.6 billion[10]. Heat stress in dairy cows depresses both milk production and birth rates for periods of weeks to months[11,12]. 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 large decline in milk production, up to 20 percent or greater, is projected. Under the lower emissions scenario†, however, reductions in milk production of up to 10 percent remain confined primarily to the southern parts of the region.

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[1].

Severe flooding due to sea-level rise and heavy downpours is projected to occur more frequently.

Increased Flood Risk in New York City

The light blue area above depicts today's FEMA 100-year flood zone for the city (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 10 percent chance of flooding in any given year; under the lower emissions scenario†, a 5 percent chance. Critical transportation infrastructure located in the Battery area of lower Manhattan could be flooded far more frequently unless protected. A 100-year flood at the end of this century (not mapped here) is projected to inundate a far larger area of New York City, especially under the higher-emissions scenario[†,15]. The increased likelihood of flooding is causing planners to look into building storm-surge barriers in New York harbor to protect downtown New York City[16].

The densely populated coasts of the Northeast face substantial increases in the extent and frequency of storm surge, coastal flooding, erosion, property damage, and loss of wetlands[13,15]. New York State alone has more than $1.9 trillion in insured coastal property[14]. 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.

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 protective barriers could be added at a later date, as needed, at a relatively small cost.

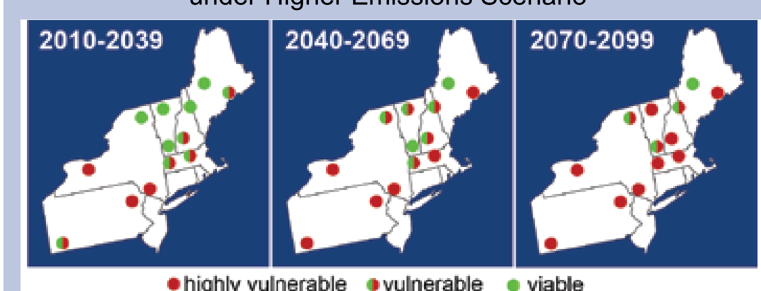
Rising sea level is projected to increase the frequency and severity of damaging storm surges and flooding. Under a higher emissions scenario†, what is now considered a once-in-a-century coastal flood in New York City is projected to occur at least twice as often by mid-century, and 10 times as often (or once per decade on average) by late this century. With a lower emissions scenario†, today's 100-year flood is projected to occur once every 22 years on average by late this century[15].

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

Winter snow and ice sports, which contribute 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[19]. Other winter traditions, ranging from skating and ice fishing on frozen ponds and lakes, to cross-country (Nordic) skiing, snowshoeing, and dog sledding, 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. 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.

Ski Areas at Risk
under Higher Emissions Scenario†



Scott *et al.*[17]/Fig. from Frumhoff[26]

The ski resorts in the Northeast have three climate-related criteria that need to be met for them to remain viable: the average length of the ski season must be at least 100 days; there must be a good probability of being open during the lucrative winter holiday week between Christmas and the New Year; and there must be enough nights that are sufficiently cold to enable snowmaking operations. By these standards, only one area in the region (not surprisingly, the one located farthest north) is projected to be able to support viable ski resorts by the end of this century under a higher-emissions scenario†,[18].

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 near-shore water temperatures. Analyses also suggest that lobster survival and settlement in northern regions of the Gulf of Maine could be increased by warming water, a longer growing season, more rapid growth, an earlier hatching season, an increase in nursery grounds suitable for larvae, and faster development of plankton[22].

Cod populations throughout the North Atlantic are adapted to a wide range of seasonal ocean temperatures, including average annual temperatures near the seafloor 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 and survival[24,25].