NORTHEAST

The Northeast is characterized by diverse waterways, extensive shorelines, and a varied landscape. The contrasts,from mountain vistas and extensive forests to one of the most densely populated corridors in the US,are noteworthy. The Northeast includes the largest financial market in the world (New York City),the nation's most productive non-irrigated agricultural county (Lancaster, PA),and the largest estuarine region (the Chesapeake Bay) in the US. The Northeast is dominated by managed vegetation, with much of the landscape covered by a mosaic of farmland and forest. The varied physical setting of the Northeast is matched by its highly diversified economy. The majority of the population is concentrated in the coastal plain and piedmont regions,and in major urban areas. Economic activities in the region include agriculture, resource extraction (forestry, fisheries,and mining),major service industries highly dependent on communication and travel, recreation and tourism,and manufacturing and transportation of industrial goods and materials.

KEY ISSUES

- **Increase in Weather Extremes**
- **Stresses on Estuaries, Bays, and Wetlands**
- **Multiple Stresses on Urban Areas**
- **Recreation Shifts**
- **Human Health**
- **Species Changes**

Observed Climate Trends

Historically, the Northeast has experienced significant variability and extreme events related to weather and climate. Floods,droughts,heat waves,and severe storms are characteristic. For example,seven major tropical storms have crossed the mid-Atlantic region since 1986 and six years of the last 20 have been characterized by significant drought. In addition,the major cities of the Northeast have experienced episodes of increased illness and deaths during heat waves. Temperature increases of as much as 4°F (2ºC) over the last 100 years have occurred along the coastal margins from the Chesapeake Bay through Maine. Precipitation has generally increased,with trends greater than 20% over the last 100 years occurring in much of the region. Precipitation extremes appear to be increasing while the amount of land area experiencing drought appears to be decreasing. For the region as a whole,the period between the first and last dates with snow on the ground has decreased by 7 days over the last 50 years.

The Vulnerability of Urban Transportation Systems

Historical events often illustrate vulnerabilities. The December 11-12, 1992 nor'easter produced some of the worst flooding and strongest winds on record for the area. It resulted in a near shutdown of the New York metropolitan transportation system and evacuation of many seaside communities in New Jersey and Long Island. This storm provided a "wake-up" call, indicating the vulnerability of the transportation system to major nor'easters and hurricanes. Critical transportation systems are only 7 to 20 feet above current sea level. Had flood levels been only 1 to 2 feet above the actual 8.5 foot high water, massive inundation of rail and subway tunnels could have resulted, with possible loss of life. There is a possibility that sea-level rise due to climate change will add 1 to 3 feet to all surge heights by 2100, so even a weaker storm would produce damage comparable to the 1992 storm. The construction of dikes and pumping stations and the institution of effective warning systems are possible

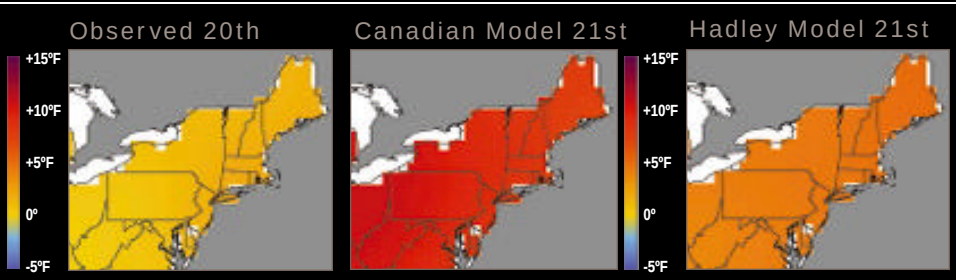
Scenarios of Future Climate

The Northeast has among the lowest rates of projected future warming compared to other regions of the US. Winter minimum temperatures show the greatest change,with projected increases ranging from 4-5°F (2-3°C) to as much as 9°F (5°C) by 2100,with the largest increases in coastal regions. Maximum temperatures are likely to increase much less than minimums, again, with the largest changes in winter. Model scenarios offer a range of potential future changes for precipitation,from roughly 25% increases by 2100,to little change or small regional decreases. The variability in precipitation in the coastal areas of the Northeast is projected to increase. Models provide contrasting scenarios for changes in the frequency and intensity of winter storms.

The view of Mount Washington in New Hampshire changes dramatically between a clear day (top photo) and a day when temperatures exceeding 90˚F exacerbate air quality problems across the region.

Temperature Change - 20th & 21st Centuries

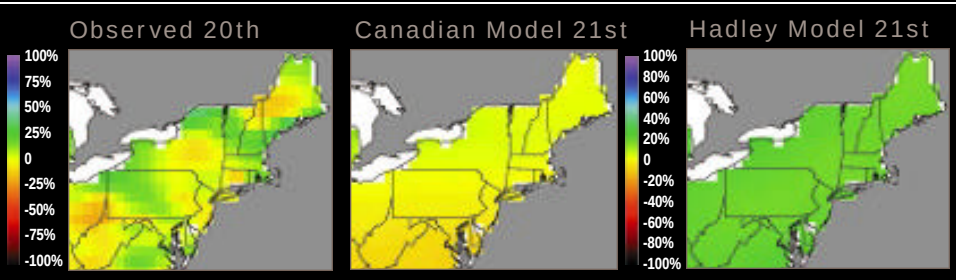
The largest warming during the last century has occurred along the coastal region (as much as 4°F).



Future model scenarios project relatively uniform increases in annually averaged temperatures. However, the Canadian model projects increases that are twice as large as the Hadley model.

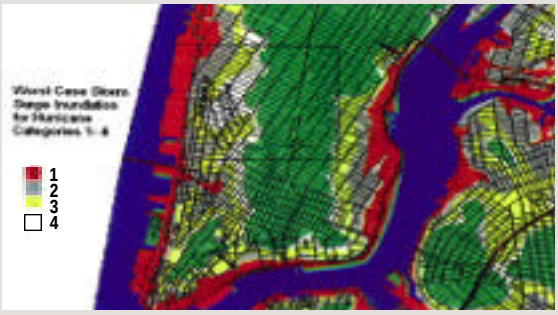
Precipitation Change - 20th & 21st Centuries

Observed precipitation changes during the last century are a patchwork of moderate increases and decreases.



The Canadian model scenario for the next century indicates near neutral trends or modest increases, while the Hadley model projects increases of near 25% for the region.

adaptation strategies. While hurricanes are much less frequent than nor'easters in the Metro East region, they can be even more destructive because the geometry of the coast amplifies surge levels toward the New York City harbor. For a worst-case scenario category 3 hurricane, surge levels could rise 25 feet above mean sea level at JFK Airport and 21 feet at the Lincoln Tunnel entrance.



NORTHEAST KEY ISSUES

Increase in Weather Extremes

The Northeast is prone to natural weather extremes and disasters including ice storms,severe flooding, nor'easters,hurricanes,and severe or persistent drought. The ice storm of January 1998,with extensive tree damage and an extended period of power failure,the severe flooding associated with tropical depression Floyd in 1999,and six significant droughts over the last 20 years amply demonstrate the importance of weather extremes to the region.

Climate change is likely to decrease the number of some types of weather extremes,while increasing others. The warming projected by climate models over the next several decades suggests possible increases in rain events over frozen ground or rapid snow melting events that can increase flooding. Over the coming century, winter snowfalls and periods of extreme cold will likely decrease. In contrast,heavy precipitation events have been increasing and warming is likely to continue this trend. Potential changes in the intensity and frequency of hurricanes are a major concern.

Adaptations: Possible strategies include relocating or elevating structures that are at risk from severe weather and flooding,though this may not be practical in many cases. Enhanced design of critical infrastructure (such as power supply) may improve the likelihood of continuous operation during extreme weather events. The complex institutional framework of community, municipal, county, regional,and statewide formal and informal governing bodies and infrastructure of the Northeast have the potential to limit the region's ability to respond to extreme events. Although there are signs of innovative management strategies,the ability of the Northeast to adapt to extreme situations will depend upon the ability of institutions to identify and prioritize vulnerable facilities and populations. The large differences in economic status and the aging of the population in the Northeast are also likely to be associated with differential impacts based on the ability to respond to climate change. Where impacts are significant, climate change is likely to have greater impact on lower-income residents, the elderly, children,and the ill (such as those with chronic respiratory ailments).

Stresses on Estuaries, Bays, and Wetlands

The estuaries,bays,and wetlands of the Northeast coastal zone are highly valued as unique ecosystems,major recreational sites,migratory waterfowl habitats,and fishery sources. The largest US estuary is the Chesapeake Bay. The bay is heavily stressed by air and water pollution from industry, agriculture,and cities. Farm and urban runoff carries particles,as well as fertilizer and other excess nutrients into the Bay. These pollutants initiate processes that reduce oxygen levels in the water. Climate change is likely to exacerbate these stresses by increasing water temperature.Changes in precipitation

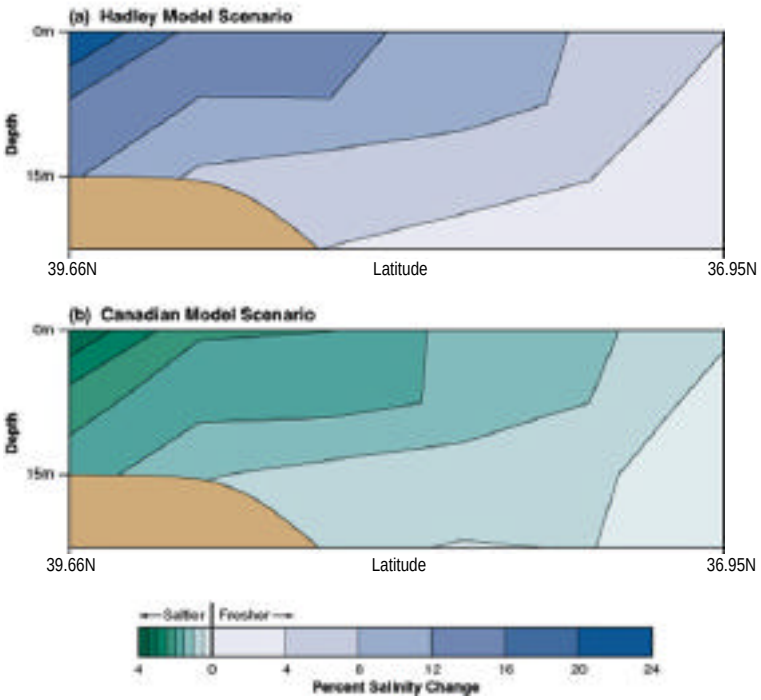
The photo shows a car which has been buried in heavy snow. It is possible that over the next few decades, the effects of warming will be counter-intuitive. If Lake Erie and Lake Ontario have shorter seasons of ice cover, it is possible that lake effect snows in cities like Cleveland and Buffalo will increase during mid-winter. Later in the 21st century, snowfall will likely decrease with the greater warming.

The estuaries of the mid-Atlantic region include the Chesapeake and Delaware Bays. These estuaries are geographically fixed, and so, unlike plant and animal species, they cannot move in response to climate change.

and runoff, much more uncertain elements of the climate scenarios,also affect coastal salinity. Both temperature and salinity have significant effects on fish populations,and human and ecosystem health. Sea-level rise is very likely to substantially increase wetland and marsh loss. Climate change impacts are therefore very likely to compound the many other stresses on the bays and estuaries of the Northeast.

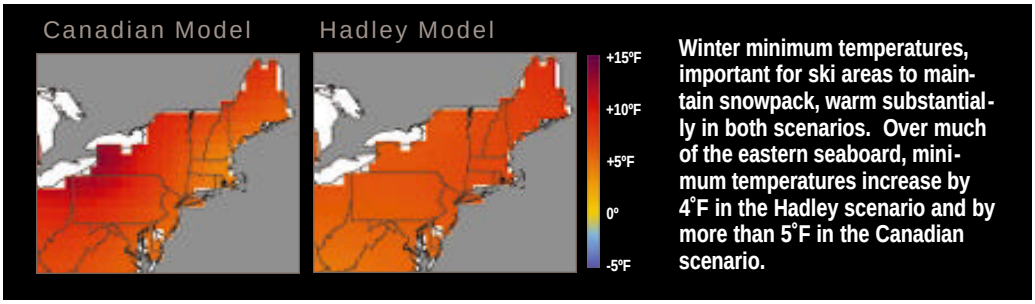
Adaptations: Strategies include measures to reduce the flow of excess nutrients into the bay from industrial, urban,and rural non-point sources, reduce atmospheric deposition,and better enforce existing wetland policies. The overall reduction of stresses from other sources could help to enhance the resiliency of coastal ecosystems to additional and sometimes uncertain stresses from climate variability and change.In addition, acquisition of lands contiguous to coastal wetlands could allow for their inland migration as sea level rises.

Percent Salinity Change in the Chesapeake Bay



The Hadley (top) and Canadian (bottom) climate scenarios each yield a very different salinity for the Chesapeake Bay based on water balance calculations for the region extending from the upper reaches of the Bay (39.66N latitude) to the Lower Chesapeake near its opening to the Atlantic. Salinity has a significant impact on populations of fish and other organisms.

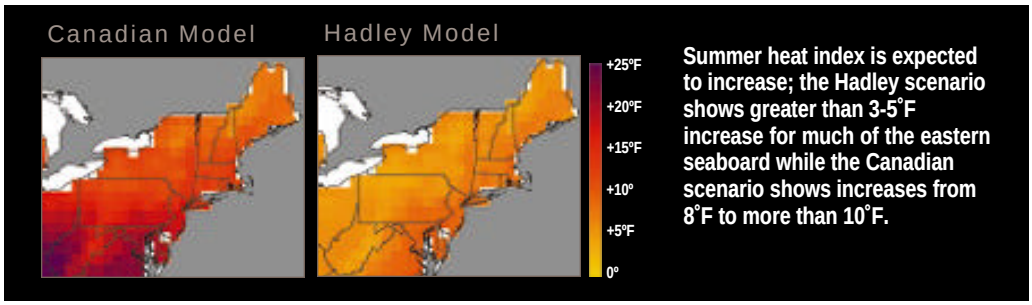
Winter Minimum Temperature



Winter minimum temperatures, important for ski areas to maintain snowpack, warm substantially in both scenarios. Over much of the eastern seaboard, minimum temperatures increase by 4˚F in the Hadley scenario and by more than 5˚F in the Canadian scenario.

Winter minimum temperatures show the greatest change, with projected increases ranging from 4-5°F (2-3°C) to as much as 9°F (5°C) by 2100.

July Heat Index Change - 21st Century



Summer heat index is expected to increase; the Hadley scenario shows greater than 3-5˚F increase for much of the eastern seaboard while the Canadian scenario shows increases from 8˚F to more than 10˚F.

NORTHEAST KEY ISSUES

Milder winters contribute to a higher survival rate for deer and mice, both of which are factors in the population of the deer tick, the primary Lyme disease vector.

Recent examples of outbreaks of West Nile Virus and equine encephalitis in northeastern urban areas have substantially raised concerns about vector-borne diseases.

Multiple Stresses on Urban Areas

Climate change will very likely intersect with many existing stresses (some climate-related and some not) on the major urban areas of the Northeast,with implications for the overall quality of life. The infrastructure of many major Northeast cities (such as water supply, communication,energy delivery, and waste disposal) is characterized by aging,insufficient capacity, and deferred maintenance. Other existing stresses include crime, chronic air-quality problems,and inadequate power supply to meet peak energy demands. Decreased snowfalls and more moderate winter temperatures are likely to result in decreased winter stresses. However, climate change has greater potential to add to existing stresses. Major potential consequences of climate change include the impacts of rising sea level and elevated storm surges on transportation systems,increased heat-related illness and death associated with temperature extremes,increased ground-level ozone pollution associated with warming,and the impact of precipitation and evaporation changes on relatively inflexible water supply systems.

Adaptations: Strategies include changing water supply management; replacing aging infrastructure with more climate-resilient systems; strengthening water quality and air quality controls to minimize the compounding of climate impacts;and using early warning systems and measures such as changing roofing colors and adding shade trees to limit urban heat that can contribute to heat-related stresses and deaths.

Recreation Shifts

Increased warmth and changes in the seasonal characteristics of precipitation are likely to have substantial impacts on recreation in the Northeast. Typical summer recreational activities involving beaches or freshwater reservoirs are likely to have extended seasons,with the region's diverse waterways becoming havens for escape from increasing summer heat. Possible negative impacts include limiting the ability of ski areas to maintain snow pack, muting of fall foliage colors,increases in insect populations,and worsening ground-level ozone pollution problems, even in the mountains of New England. Higher sea level coupled with even moderate storms will probably result in loss of beachfront property.

Warmer winters are likely to limit the viability of snow skiing in the Northeast.

Adaptations: Strategies will reflect a regional shift in recreational activity as people make trade-offs in terms of the type,location, and season of their activities.

Human Health

Populations of infectious disease vectors are often influenced by climate. Altered mosquito populations and Lyme disease vectors are possible changes in response to higher temperatures (particularly the milder winters projected by virtually all climate models) and changes in moisture. Milder winters contribute to a higher survival rate for deer and mice,both of which are factors in the population of the deer tick,the primary Lyme disease vector. However, the complexity of the relationships makes changes in the distribution and frequency of the disease under altered climate difficult to predict. While warmer and wetter conditions may alter insect vector survival, research is lacking on how these changes may influence disease occurrence. The recent examples of outbreaks of West Nile Virus and equine encephalitis in northeastern urban areas have substantially raised concerns about vector-borne diseases and illustrate that improved monitoring and better understanding of these diseases are relevant for the region. Increased rainfall and flooding,if severe,creates conditions for possible public and private water source contamination (such as with *Cryptosporidium*). However, in large measure,US public health infrastructure and response capabilities,if vigorously sustained,are likely to limit many potential impacts.

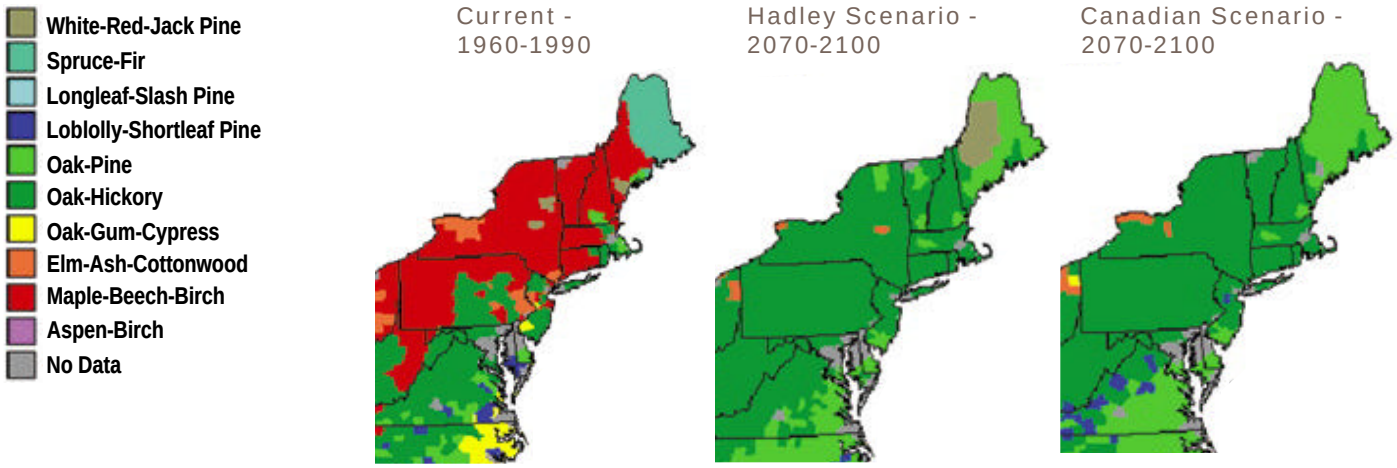
Species Changes

Changes in species composition are often associated with changes in temperature and precipitation. Key concerns involve the potential for changes in predator-prey relationships, changes in pest types and populations,invasive species,and in key species that are truly characteristic of a region or are of economic significance. For example,lobster populations are associated with cooler waters and warming is thus likely to promote northward migration of the lobster population – a key issue for New England. Coastal population pressures combined with sea-level rise are very likely to reduce habitat for migratory birds along the Atlantic Flyway. Warming is also likely to substantially limit trout populations – a key issue for Pennsylvania. Changes in species mix and introduction of climate-driven invasive species are likely to also induce unanticipated feedbacks on ecosystems.

The likely migration of sugar maple trees northward into Canada as climate warms would sharply reduce maple syrup production,a cultural tradition in the Northeast.

The diverse waterways and extensive forests of the Northeast are likely to have more warm weather recreational use.

Lobster populations are associated with cooler waters and warming is thus likely to promote northward migration of the lobster population – a key issue for New England.



The maps above show current and projected forest types for the Northeast, based on the DISTRIBmodel (see Forest sector). Note that Maple-Beech-Birch, currently a dominant forest type in the region, is completely displaced by other forest types in both the Hadley and Canadian climate scenarios.