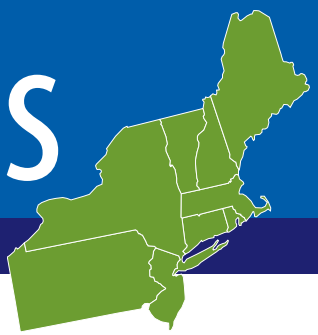
Massachusetts

Confronting Climate Change in the U.S. Northeast



From lush Berkshire valleys to the sandy Cape Cod shore, the climate of Massachusetts is changing. Records show that spring is arriving earlier, summers are growing hotter and winters are becoming warmer and less snowy. These changes are consistent with global warming, an increasingly urgent phenomenon driven by heat-trapping emissions from human activities.

New state-of-the-art research shows that if global warming emissions continue to grow unabated, Massachusetts can expect dramatic changes in climate over the course of this century, with substantial impacts on vital aspects of the state's economy and character. If the rate of emissions is lowered, however, projections show that many of the changes will be far less dramatic. Emissions choices we make today—in Massachusetts, the Northeast, and worldwide—will help determine the climate our children and grandchildren inherit, and shape the consequences for their economy, environment, and quality of life.

The research summarized here describes how climate change may affect Massachusetts and other Northeast states under two different emissions scenarios. The higher-emissions scenario assumes continued heavy reliance on fossil fuels, causing heat-trapping emissions to rise rapidly over the course of the century. The lower-emissions scenario assumes a shift away from fossil fuels in favor of clean energy technologies, causing emissions to decline by mid-century.

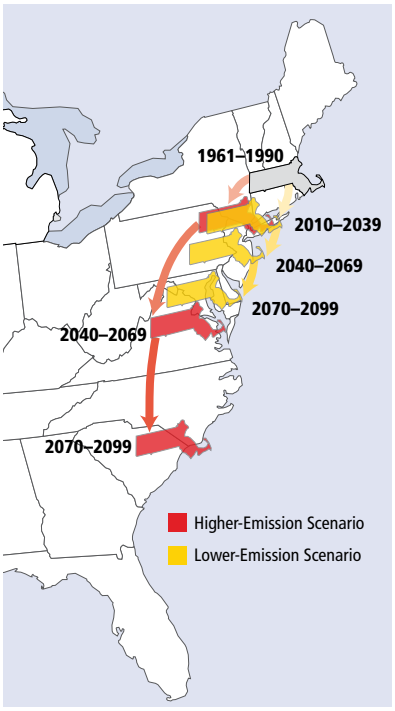
The research also explores actions that individual households, businesses, and governments across the Northeast can take today to reduce emissions to levels consistent with staying *below* the lower-emissions scenario and adapt to the unavoidable changes that past emissions have already set in motion.

MASSACHUSETTS' CHANGING CLIMATE

Temperature. Average temperatures across the Northeast have risen more than 1.5 degrees Fahrenheit (°F) since 1970, with winters warming most rapidly—4°F between 1970 and 2000. If higher emissions prevail, average temperatures across the state are projected to rise 8°F to 12°F above historic levels in winter and 6°F to 14°F in summer by late-century, while lower emissions would cause roughly half this warming. Under the higher-emissions scenario Massachusetts' cities can expect a dramatic increase in the number of days over 100°F (see the figure on p.3 and the section on health impacts).

Precipitation and winter snow. The Northeast region is projected to see an increase in winter precipitation on the order of 20 to 30 percent. Slightly greater increases are projected under the higher-emissions scenario, which would also feature less winter precipitation falling as snow and more as rain.

Snow is an iconic characteristic of Massachusetts winters—part and parcel of many favorite winter activities. Historically Massachu-



Migrating State Climate

Changes in average summer heat index—a measure of how hot it actually feels, given temperature and humidity—could strongly affect quality of life in the future for residents of the Northeast. Red arrows track what summers could feel like in Massachusetts over the course of the century under the higher-emissions scenario. Yellow arrows track what summers in Massachusetts could feel like under the lower-emissions scenario.

Photos: (from top) iStockphoto.com/Edward Giardina; iStockphoto.com/Denis Tangney; iStockphoto.com/Ivo Gretener; Jerry and Marcy Monkman; iStockphoto.com/Denis Tangney

setts has averaged one to three weeks of snow cover per winter month. Under the higher-emissions scenario most of the state is projected to lose all but a few snow-covered days per winter month by late-century. Under the lower-emissions scenario, however, most of the state would retain between one and two weeks of snow cover per winter month, on average.

Heavy, damaging rainfall events have increased measurably across the Northeast in recent decades. Intense spring rains struck the region in both 2006 and 2007, for example, causing widespread flooding. The frequency and severity of heavy rainfall events is expected to rise further under either emissions scenario.

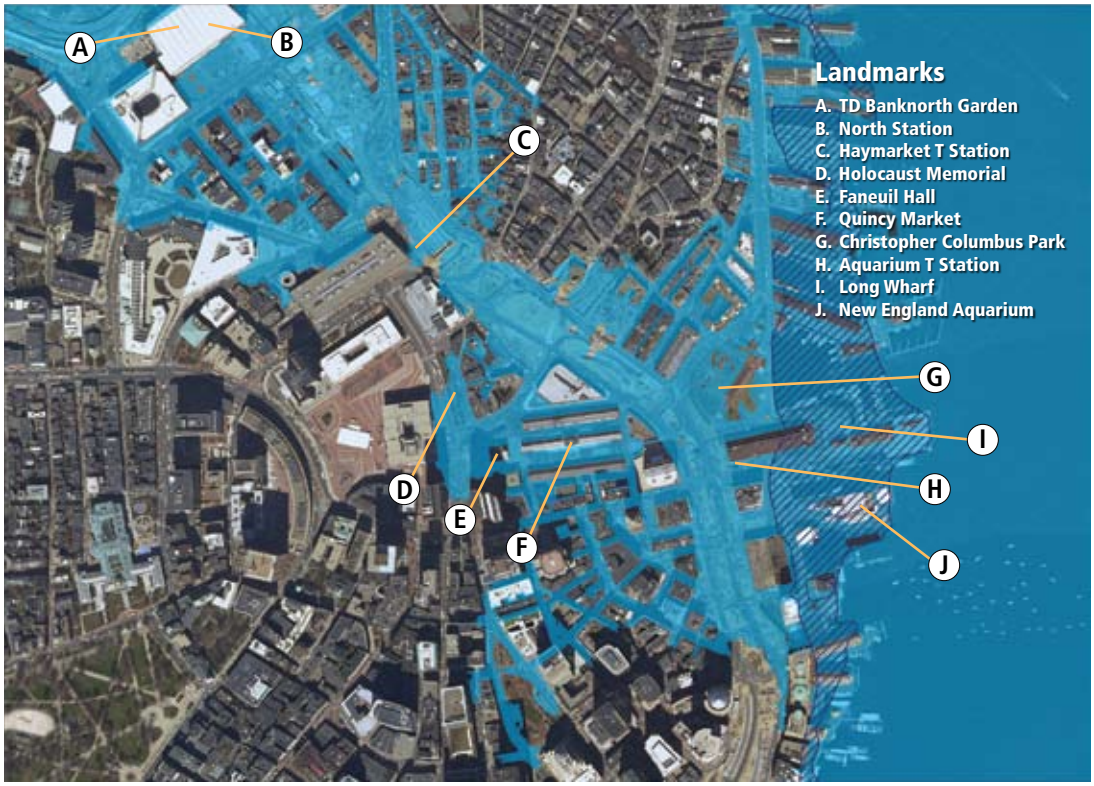
Drought and stream flow. In this historically water-rich state, rising summer temperatures coupled with little change in summer rainfall are projected to increase the frequency of short-term (one- to three-month) droughts and decrease summer stream flow, particularly if higher emissions prevail. By late-century, for example, short-term droughts are projected to occur annually under the higher-emissions scenario (compared with once every two years, on average, historically), while summertime conditions of low stream flow—already commonplace in rivers like the Ipswich—are projected to last an additional month. These changes would increase stress on both natural and managed ecosystems and water supply in the state. By contrast, little change in either drought or stream flow is expected under the lower-emissions scenario.

Sea-level rise. Global warming affects sea levels by causing ocean water to expand as it warms, and by melting land-based ice. With higher emissions, global sea level is projected to rise between 10 inches and two feet by the end of the century (7 to 14 inches under the lower-emissions scenario). These projections do not account for the recent observed melting of the world's major ice sheets—nor the potential for accelerated melting—and may therefore be conservative. However, even under these projections, Massachusetts' densely populated coast faces substantial increases in the extent and frequency of coastal flooding, erosion, and property damage.

IMPACTS ON COASTAL COMMUNITIES

The counties along Massachusetts' 192-mile-long coastline are home to 4.8 million people—75 percent of the state's population. From critical infrastructure to waterfront homes to salt marshes, much of this coastline is exceptionally vulnerable to sea-level rise. Indeed, some major insurers have withdrawn coverage from thousands of homeowners in coastal areas across the Northeast in recent years, including more than 9,000 households on Cape Cod in 2006.

Coastal flooding. Rising sea levels caused by global warming are projected to increase the frequency and severity of damaging storm surges and coastal flooding. What is now considered a once-in-a-century coastal flood



Source: MassGIS

Current 100-year flood zone
Projected 100-year flooded area (higher-emissions scenario)

The Future 100-Year Flood under the Higher-Emissions Scenario

This image shows the current 100-year flood zone (hatched darker blue) as well as the extent of the projected 100-year flood zone in 2100 (lighter blue) under the higher-emissions scenario for the waterfront/Government Center area of Boston. Important Boston landmarks (such as Faneuil Hall) and transportation infrastructure currently not at great risk of flooding could witness repeated flooding in the future unless protected from such events. Flood elevations under the lower-emissions scenario are roughly half a foot lower than the flooding depicted here (but still two feet higher than the current 100-year flood).

in Boston is expected to occur, on average, as frequently as every two to three years by mid-century and once every other year by late-century—under either emissions scenario. Boston has a lengthy history of protecting itself against the sea, but the extra stresses created by sea-level rise and more frequent and extensive flooding can be expected to severely tax both new and aging infrastructure and threaten vulnerable neighborhoods in the city and in coastal communities across the state.

Shoreline change. Sea-level rise is expected to permanently inundate certain low-lying coastal areas and dramatically accelerate erosion, particularly on important barrier beaches such as Plum Island on the North Shore and Nauset Beach on Cape Cod. Continued sea-level rise will also threaten the state's ecologically important salt marshes and estuaries (which serve as critical feeding grounds for migrating waterfowl and other birds, and nursery habitat for important commercial fish).

Massachusetts policy makers will need to take steps to protect the state's vulnerable populations and infrastructure, as well as wildlife and critical coastal wetlands. This includes public education, updating and enforcing building codes and land-use regulations, and working with the insurance industry to effectively protect property and people.

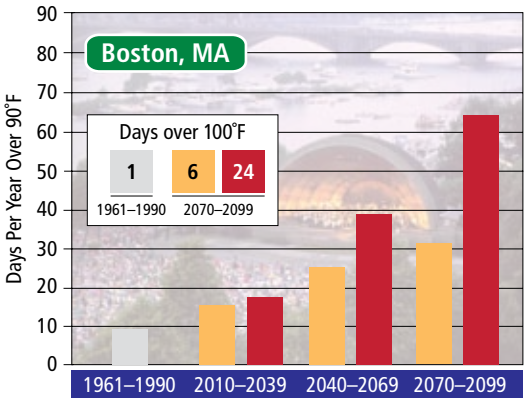
IMPACTS ON HUMAN HEALTH

Heat was the United States' leading weather-related killer in 6 of 10 recent years (between 1993 and 2003). More intense summer heat waves and deteriorating air quality caused by global warming could increase the risks of many health problems.

Extreme heat. While Bay Staters are accustomed to the occasional summer heat wave, the number of very hot days in large cities (where the urban heat-island effect can amplify temperatures) is expected to increase significantly, particularly under the higher-emissions scenario (see the figure above). This will be especially challenging for vulnerable populations, including small children, the elderly, and the poor.

Very hot days are not only unpleasant but also dangerous. As extreme heat becomes more commonplace the risk of heat stress, heart attack, and death increases. The state's larger cities such as Boston, Springfield, and Worcester will need to prepare for an increase in dangerously hot conditions by taking steps (e.g., installing better insulation, establishing heat warning systems and cooling centers) that will lessen the impact of extreme heat on vulnerable populations.

Air quality. Air pollution from ground-level ozone and other components of smog is a serious concern across much of Massachusetts. From 2001 to 2005 the average summer in Massachusetts included nearly 20 days that did not meet the U.S. Environmental Protection Agency's (EPA) air-quality standards for ground-level ozone, putting additional stress on people with cardiovascular and respiratory diseases. In the absence of more stringent controls on ozone-forming pollutants, the number of days with poor air quality is projected to quadruple in Boston by late-century under the higher-emissions scenario. Under the lower-emissions scenario such days could increase by half.



Extreme Heat in Our Cities

The number of days over 90°F in large northeastern cities is projected to increase until, by late-century, Boston could experience over 60 such days under the higher-emissions scenario. Projections under this scenario also show a dramatic increase in the currently small number of days over 100°F (as depicted in the inset box).

Higher temperatures and increasing levels of plant-stimulating carbon dioxide (CO_2) in the air are also expected to accelerate seasonal pollen production in plants in the next several decades under the higher-emissions scenario. This could extend the allergy season, increase asthma risks, and exacerbate symptoms for both urban and rural Bay Staters.

IMPACTS ON FISHERIES

Massachusetts boasts one of the nation's biggest commercial fishing industries. Global warming will increase pressures on the historically important Atlantic cod (a carving of which—the "sacred cod"—hangs in the State House) and other species, forcing changes in the traditional economy of fishing communities from Gloucester to New Bedford.

Cod. Fishing pressure has depleted Northeast cod stocks in recent decades. Compounding this, rising water temperatures will place additional pressures on cod. Georges Bank, historically the Northeast's most important fishing grounds, is projected under either emissions scenario to become too warm to support the growth and survival of young cod by late this century, but would be able to support adult cod populations under the lower-emissions scenario. Waters south of Cape Cod would be unsuitable for cod by late this century under either emissions scenario.

Lobster currently provides the highest dockside value for Massachusetts fishermen. Under either emissions scenario the nearshore waters south of Cape Cod are likely to warm by mid-century beyond the range tolerated by lobsters. Lobster habitat in certain shallow, nearshore waters of Massachusetts Bay may also be at risk.

IMPACTS ON AGRICULTURE

Agriculture has long been a key part of the Massachusetts economy, contributing $416 million annually. Climate change is expected to pose new challenges to this sector, particularly to struggling dairy farmers and growers of certain high-value fruits and vegetables. For example, increases in the frequency of short-term drought (see p.2) could necessitate increased irrigation and operational costs.

Dairy. Hot conditions produce heat stress in dairy cows, which depresses milk production. Under the higher-emissions scenario the central and eastern parts of Massachusetts are projected to reach temperatures by late-century that would reduce milk production up to 12 percent during key summer months—a significant loss for an industry with an already small profit margin. Adaptive measures such as air conditioning may curb some of these potential losses (provided the costs are within farmers' reach).

Crops. Massachusetts' fruit and vegetable crops—including a quarter of the nation's total cranberry harvest—bring in approximately $94 million annually. If higher emissions prevail, increasing summer temperatures and heat stress are expected to depress the yields of a number of these economically important crops by mid-century, while rising winter temperatures are expected to further the northward expansion of agricultural pests and weeds (such as kudzu).

Many of these important crops need long winter-chill periods for optimum flowering and fruit set. Under the higher-emissions scenario, chilling requirements for cranberries are unlikely to be met by mid-century in the state's key cranberry-producing region (the southeast). Under the lower-emissions scenario, most of the state is projected to continue to meet this chilling requirement through this century, though areas of current cranberry production face increased risk of crop failure by late-century.

Eric Michaud

Apple orchards in much of the state could be forced to abandon certain popular apple varieties (e.g., McIntosh, Empire, Granny Smith) this century under the higher-emissions scenario, though under the lower-emissions scenario, the requirements of these varieties would largely be met.

IMPACTS ON FORESTS

Forests now dominate much of the Massachusetts landscape, providing recreation and tourism opportunities, wildlife habitat, and timber, while protecting watersheds, conserving soil, and storing carbon. Climate change has the potential to dramatically alter the character of the state's forests. Particularly vulnerable are the Berkshires' spruce/fir forests—home to treasured bird species including the blackpoll warbler and yellow-bellied flycatcher. By late-century, climate conditions suitable for these forests are projected to disappear from the state under either emissions scenario. If higher emissions prevail, conditions suitable for the maple, beech, and birch forests that provide fall foliage displays are also projected to disappear by late-century. Under lower emissions, climate conditions suitable for these forests would be retained in the Berkshires and much of central Massachusetts. While long-lived trees may persist once the climate is no longer suitable, they will likely become increasingly vulnerable to disease, pests, and competition.

IMPACTS ON WINTER RECREATION

Winter recreation and tourism in the Northeast will be profoundly affected by climate change as winter temperatures continue to rise, snowfall declines, and lake ice shrinks. Warmer winters are projected to shorten the average ski season, increase snowmaking requirements, and drive up operating

costs, hurting an industry that has already contracted in recent years. Even with increased snowmaking, many Massachusetts ski resorts may no longer be viable by mid-century, as temperatures rise too high for reliable snowmaking. By late-century, with higher emissions, the only option in the Northeast for Massachusetts skiing enthusiasts would be resorts in western Maine. With lower emissions, resorts across northern New England and the North Country of New York could continue to offer reliable ski seasons.

WHAT WE CAN DO

Once the landing spot of the Pilgrims, pivotal turf of the Revolutionary War, and a home to the abolitionist movement, Massachusetts has a history of breaking new ground for the nation. By reducing emissions today, we have an opportunity to help protect our children and grandchildren from the most severe consequences of global warming. At the same time, effective adaptation strategies are needed to help reduce the vulnerability of Massachusetts' residents, ecosystems, and economies to those changes that are now unavoidable.

Of course our actions alone will not be sufficient to avoid dangerous climate change. But as a global leader in technology, finance, and innovation and a major source of heat-trapping emissions, Massachusetts (and the rest of the Northeast) is well positioned to drive national and international progress. Concerted, sustained efforts to reduce emissions in the region—on the order of 80 percent below 2000 levels by mid-century and just over 3 percent per year on average over the next several decades—can help pull global emissions below the lower-emissions scenario described here.

State and local governments have a rich array of strategies and policies at their disposal to meet the climate challenge in partnership with other states, businesses, civic institutions, and the public. These strategies and policies can reduce emissions in the following sectors:

Alex Mavradis

This 600-kilowatt wind turbine went online in Hull, MA, in December 2001. Wind energy represents one of the most attractive near-term options among renewable resources for making substantial, relatively low-cost contributions to electricity generation in the Northeast.

Electric power. Nearly 40 percent of Massachusetts' electric power comes from an aging class of inefficient coal- and oil-burning power plants that can be steadily replaced under the pressure of new market-based policies (such as the Regional Greenhouse Gas Initiative, or RGGI) that attach a price to carbon emissions, making cleaner, more efficient generation sources financially attractive, and through regional power-market reforms and state policies that place energy-efficiency gains on an equal footing with new power supply. The commonwealth can strengthen its requirement that an increasing portion of electricity supply come from renewable energy. Revenues from the sale of emissions permits under RGGI could support substantially increased investment in energy efficiency and clean energy development.

Buildings. Massachusetts' relatively old stock of residential, commercial, and industrial buildings offers substantial opportunities to reduce emissions associated with water and space heating. The state can support stronger enforcement of building energy codes, while local governments can amend zoning laws to encourage and/or require that new construction and substantial renovation projects achieve the U.S. Green Building Council's LEED certification and/or energy-efficiency levels that qualify for the EPA's Energy Star Building designation. For example, in early 2007 Boston changed its building code to require that all projects over 50,000 sq. ft. meet the first level of LEED certification.

Transportation. Cars and trucks account for 31 percent of Massachusetts' total carbon emissions. The state has adopted California's tailpipe emissions standards, which require reductions of approximately 30 percent below 2002 levels by 2016, beginning with the 2009 model year (implementation is contingent upon a ruling expected from the EPA). State and local governments can help further reduce vehicle emissions

through sustained investment in public transportation, incentives to purchase low-emissions vehicles, and incentives and regulations that promote "smart growth" strategies such as concentrating development near existing downtowns and public transportation routes. In addition, Massachusetts can adopt standards to reduce the carbon content of fuels.

Industries and large institutions can reduce emissions while lowering energy costs by improving the energy efficiency of their buildings and facilities, and by installing combined-heat-and-power and on-site renewable energy systems.

Forestry and agriculture policies in Massachusetts can be refined to promote management practices and systems that cost-effectively reduce emissions. Such practices include increased carbon capture in soils, more efficient use of nitrogen fertilizers, and expanded on-farm use of wind and bioenergy—provided the latter is produced in a sustainable manner.

CONCLUSION

Global warming represents an enormous challenge, but we can meet this challenge if we act swiftly. The emissions choices we make today in Massachusetts, the Northeast, and globally will shape the climate our children and grandchildren inherit. The time to act is now.

A Citizen's Guide to Reducing Emissions

1. **Become carbon-conscious.** The problem of global warming stems from a previous lack of awareness of our "carbon footprint" and its effect on climate. Individuals and families can start by using one of several publicly available carbon-footprint calculators that will help you understand which choices make the biggest difference.
2. **Drive change.** For most people, choosing a vehicle (and how much they should drive it) is the single biggest opportunity to slash personal carbon emissions. Each gallon of gas used is responsible for 25 pounds of heat-trapping emissions.
3. **Look for the Energy Star label.** When it comes time to replace household appliances, look for the Energy Star label on new models (refrigerators, freezers, furnaces, air conditioners, and water heaters use the most energy).
4. **Choose clean power.** Consumers in Massachusetts can purchase electricity generated from renewable resources that produce no carbon emissions from your local utility. If your local utility does not offer a "green" option, consider purchasing renewable energy certificates.
5. **Unplug an underutilized freezer or refrigerator.** One of the quickest ways to reduce your global warming impact is to unplug a rarely used refrigerator or freezer. This can lower the typical family's CO_2 emissions nearly 10 percent.
6. **Get a home energy audit.** Take advantage of the free home energy audits offered by many utilities. Even simple measures (such as installing a programmable thermostat) can each reduce a typical family's CO_2 emissions about 5 percent.
7. **Lightbulbs matter.** If every U.S. household replaced one incandescent lightbulb with an energy-saving compact fluorescent lightbulb (CFL), we could reduce global warming pollution by more than 90 billion pounds over the life of the bulbs.
8. **Buy good wood.** When buying wood products, check for labels that indicate the source of the timber. Forests managed in a sustainable way are more likely to store carbon effectively—thus helping to slow global warming.
9. **Spread the word and help others.** A growing movement across the country seeks to reduce individual, family, business, and community emissions while inspiring and assisting others to do the same.
10. **Let policy makers know you are concerned about global warming.** Elected officials and candidates for public office at every level need to hear from citizens. Urge them to support policies and funding choices that will accelerate the shift to a low-emissions future.

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This summary was prepared by the Union of Concerned Scientists based on *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, a report of the Northeast Climate Impacts Assessment (NECIA, 2007). NECIA is a collaborative effort between the Union of Concerned Scientists and a team of independent scientific experts to assess how global warming may further affect the climate of the U.S. Northeast and to explore options for meeting the climate challenge.

For more information on our changing Northeast climate and what you can do, or to download a copy of the full report and additional state summaries, visit *www.climatechoices.org*.