New Hampshire

Confronting Climate Change in the U.S. Northeast

From the towering Presidentials to sandy Hampton Beach, the climate of New Hampshire 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, New Hampshire 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 New Hampshire, 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 New Hampshire 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.

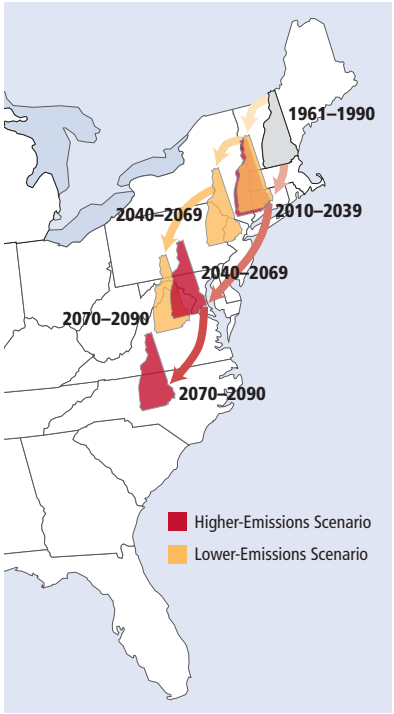
The research also explores actions that individual households, businesses, and governments in the Northeast can take today to reduce emissions to levels consistent with staying *below* the lower-emissions scenario and adapt to the unavoidable changes that past emissions have already set in motion.

NEW HAMPSHIRE'S 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 New Hampshire are projected to rise 9°F to 13°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, New Hampshire's larger cities can expect a dramatic increase in the number of days over 100°F. (See figure on p.4 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 New Hampshire winters and an integral part of many favorite winter activities and traditions. But



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 Granite State. Red arrows track what summers could feel like in New Hampshire over the course of the century under the higher-emissions scenario. Yellow arrows track what summers in New Hampshire could feel like under the lower-emissions scenario.

Photos: (from top) Jerry and Marcy Monkman; Jerry and Marcy Monkman; Jerry and Marcy Monkman; Corbis; iStockphoto.com/Mike Teixeira

rising temperatures over the past few decades have caused snow to become wetter (or more "slushy") and decreased the average number of snow-covered days across the state. If higher emissions prevail, much of the state—historically snow-covered for nearly the entire winter—would see its snow season shrink by almost 50 percent by mid-century. Under the lower-emissions scenario the snow season in the state would be reduced by roughly one-third in this time frame.

Heavy, damaging rainfall events have already increased measurably across the Northeast in recent decades. Between 2005 and 2007, New Hampshire suffered major river flooding, resulting in lost lives, destroyed homes, and millions of dollars in damage. The frequency and severity of such events is expected to rise further under either emissions scenario.

Jerry and Marcy Monkman

Change for northern hardwood forests is likely under the higher-emissions scenario, but how quickly the current mix of maple, beech, and birch gives way to other forest types depends on factors such as competition from other species and damage from pests and wildfire.

Drought. 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, particularly under the higher-emissions scenario. By late-century for example, these droughts are projected to occur annually under the higher-emissions scenario, compared with once every two to three years historically, increasing stress on both natural and managed ecosystems across the state.

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 this 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, New Hampshire's small but treasured coast faces substantial increases in the extent and frequency of coastal flooding, erosion, and property damage.

IMPACTS ON FORESTS

Forests dominate 84 percent of the New Hampshire 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 the prized spruce/fir forests of the state's North Country and Presidential Range. Only under the lower-emissions scenario are climate conditions suitable for these forests projected to endure into the next century. Even with lower emissions, however, major losses in suitable conditions are expected by late this century—losses that would eventually diminish these forests and threaten the animal species dependent on them, such as the snowshoe hare, Canada lynx, and Bicknell's thrush. Under the lower-emissions scenario, patches of high-elevation spruce/fir habitat required by the Bicknell's thrush could persist in the mountains of New Hampshire, but under the higher-emissions scenario this bird's distinctive song could eventually be muted across the entire region as its suitable habitat gradually disappears.

The potential reduction of spruce/fir forests could also harm New Hampshire's pulp and paper industry, as spruce and fir are a primary source of sawlogs (used for lumber) and pulpwood (used for paper products). Warm winters interfere with traditional timber harvesting practices in the region, which rely on frozen soil conditions to minimize damage caused by heavy equipment. With projected winter warming, the trend toward an earlier or intermittent "mud season" is expected to continue.

Also threatened in New Hampshire's highest elevations are remnants of treeless alpine tundra, such as Mount Washington's Alpine Garden. This tundra habitat supports a rare and fragile plant community and is highly vulnerable to further climate change.

Maple/beech/birch forests cover much of the landscape, dazzling us each autumn with their colorful foliage and providing sap in late winter for maple syrup. Although warmer temperatures could increase forest productivity in the near term, under the higher-emissions scenario climate conditions suitable for these forests are expected to decline across much of New Hampshire by late century. Under the lower-emissions scenario, most of New Hampshire is expected to retain suitable maple/beech/birch habitat through the end of the century.

In each of these forest types, long-lived trees may persist for some time even as the climate becomes unsuitable for them; however, they may also become more vulnerable to competition from better-suited species (such as oak and hickory) and other stresses such as pests and disease.

New Hampshire's hemlock trees (which shade streams, providing cool conditions required by native brook trout and other fish) face both shrinking suitable habitat and the northward march of the hemlock woolly adelgid, an invasive insect that has already destroyed hemlock stands from Georgia to Connecticut. If higher emissions prevail, areas with climate conditions suitable to hemlock trees are projected to shrink by roughly 40 percent by late-century; under the lower-emissions scenario the loss would be less than 20 percent. With warmer winters projected under the higher-emissions scenario, the adelgid is poised to infest hemlocks as far north as the Canadian border by late-century, but would be prevented from spreading into the northernmost part of the state under the lower-emissions scenario.

IMPACTS ON WINTER RECREATION

The Granite State's reputation as a cold weather getaway is well established. But New Hampshire winters have changed and, over the course of the century, may look and feel profoundly different.

Skiing. New Hampshire ski areas generate more than $650 million a year, providing playgrounds for in- and out-of-staters, thousands of jobs, and training grounds for Olympians. Milder winters are expected to shorten the average ski season, increase snowmaking requirements, and drive up operating costs in an industry that has already contracted in recent years.

While today's Granite Staters take for granted a short drive to their choice of ski destinations, by late-century New Hampshire's ski resorts (and most of those in the Northeast) may no longer be viable under the higher-emissions scenario. Under the lower-emissions scenario, ski areas in the northern part of the state are expected to persist, although much of their success may depend on access to water for snowmaking. Under both emissions scenarios, viable ski operations in northern New Hampshire will need to increase their snowmaking capacity roughly 30 percent over the next several decades, and nearly 70 percent by mid-century under the higher-emissions scenario (nearly 40 percent with lower emissions).

Snowmobiling. As the first flakes fall, Granite State snowmobile enthusiasts tune up their sleds. New Hampshire trails are part of a six-state network of snowmobile terrain—from Pennsylvania to Maine—totaling 40,500 miles and adding to a $3 billion-a-year regional industry. The impracticality of snowmaking on this vast system means a much shorter snowmobiling season throughout the region. Within the next several decades, the snowmobiling season in southern New Hampshire is projected to shrink by more than half—to roughly 20 days each winter under both emissions scenarios. By late-century, if higher emissions prevail, the southern New Hampshire season would be reduced to just a few days per year, while northern New Hampshire would be the only area in the Northeast still able to support a two-month-long snowmobiling season.

Ice fishing. Ice fishing derbies are a winter institution in New Hampshire. These community events, however, are

Chee-Onn Leong

From skiing and snowboarding to snowmobiling, ice fishing, and sledding, many residents of New Hampshire embrace winter recreation. But the state's winters are warming. Over the course of this century more winter precipitation is projected to fall as rain, and snow and lake ice are expected to melt more quickly, reducing opportunities for popular winter activities.

threatened by global warming, which will continue to thin lake ice cover and shorten its duration. Combined with fewer opportunities for sledding, snowshoeing, and other favorite outdoor activities, winter recreation as it is now known in New Hampshire is at great risk.

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 will increase many health risks.

Extreme heat. While Granite State residents have dealt with the rare summer heat wave, the number of very hot days, particularly in larger cities, is expected to increase significantly by late-century under the higher-emissions scenario. Manchester and Concord, which currently experience about 10 days per summer with temperatures above 90°F, are projected to see almost 70 such days by late-century under the higher-emissions scenario, more than 20 of which could exceed 100°F (see the figure above). Under the lower-emissions scenario, these cities are projected to experience roughly 30 days above 90°F per summer, with just six days above 100°F.

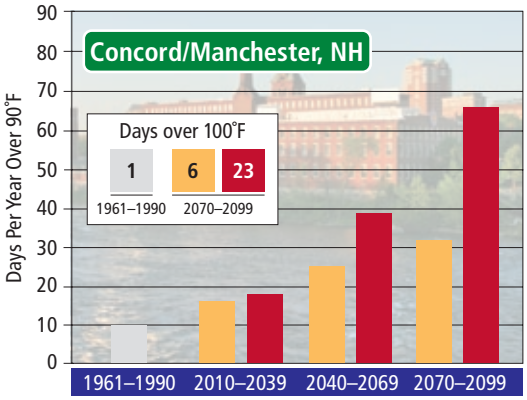
Very hot days are not only unpleasant but also dangerous. As the number of these days increases, so does the risk of heat stress, heart attack, and even death. Historically unaccustomed to these kinds of temperatures, cities across New Hampshire will need to prepare for an increase in dangerously hot conditions by taking steps (e.g., installing better insulation and establishing 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 in New Hampshire, where 1 in 10 people suffer from asthma. From 2001 to 2005 the average New Hampshire summer included six days that did not meet the U.S. Environmental Protection Agency's air quality standards for ground-level ozone.

Global warming is expected to worsen air quality in the region, putting more 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 in larger cities like Concord and Manchester is projected to roughly quadruple by late-century under the higher-emissions scenario. Under the lower-emissions scenario such days could increase by half.

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

Vector-borne disease. Mosquitoes and ticks carry West Nile virus (WNV) and Lyme disease-causing bacteria, respectively, and spread them to animals or people. Factors affecting the spread of such vector-borne diseases are complex. However, projections for the Northeast of warmer winters, hotter summers, and more frequent summer dry periods punctuated by heavy rainstorms are the same conditions that can set the stage for more frequent WNV outbreaks.



Extreme Heat in Our Cities

The number of days over 90°F in northeastern cities is projected to increase until, by late-century, the Concord/Manchester area could experience nearly 70 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).

IMPACTS ON AGRICULTURE

Agriculture is a small but vibrant sector in New Hampshire, with many of today's farms producing dairy products and high-value specialty crops. Global warming will present both opportunities and challenges to New Hampshire's growers and producers; for example, increases in the frequency of short-term drought (see p.2) could necessitate increased irrigation and operational costs, while a longer growing season could benefit those farmers seeking to invest in warmer-weather crops that are currently hard to grow in the state.

Crops. New Hampshire fruit and vegetable crops bring in approximately $18 million annually. By late-century, if higher emissions prevail, increasing summer temperatures and heat stress could depress yields of a number of economically important crops such as cabbage, potatoes, and apples. Winter warming could affect certain apple varieties as well as native Concord grapes by disrupting flowering and fruit development. Northward expansion of agricultural pests and weeds is expected to further impede crop production during the course of the century, and potentially pressure farmers to increase their herbicide and pesticide use (or, in the case of organic farms, invest more heavily in labor-intensive weed and

pest control). Under the lower-emissions scenario, impacts on New Hampshire crops this century are expected to be relatively small.

IMPACTS ON COASTAL COMMUNITIES

New Hampshire's 18-mile coastline is the shortest of U.S. ocean-bordering states, but in summer months the area population swells as residents and tourists escaping inland heat flock to the sandy beaches and seaside communities. More than 6,200 acres of salt marshes and the ecologically important Great Bay estuary provide feeding grounds for migrating waterfowl and nursery habitat for important commercial and recreational fish such as striped bass. Climate change threatens New Hampshire's coast by accelerating sea-level rise, which is expected to increase the frequency of damaging coastal flooding and potentially inundate valuable coastal wetlands.

WHAT WE CAN DO

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 New Hampshire's residents, ecosystems, and economies to those changes that are now unavoidable.

Here in New Hampshire, and across the world, there is growing momentum to meet the climate challenge. In March 2007, for example, 164 New Hampshire towns voted in favor of a climate resolution at town meetings calling for a national program to reduce heat-trapping emissions and curb climate change.

Of course our actions alone will not be sufficient to avoid dangerous climate change. But the state's first-in-the-nation primary offers a unique opportunity for its residents to elevate discussion of how to meet the climate challenge to the national level. 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:

Electric power. As a participant in the Regional Greenhouse Gas Initiative, New Hampshire can reap substantial energy cost savings, promote economic development, and reduce emissions by auctioning 100 percent of the emissions credits created under the program and investing the proceeds in energy efficiency and renewable energy development. The enactment in 2007 of an aggressive renewable electricity standard of 25 percent by 2025 as well as approval of the state's first utility-scale wind project on Lempster Mountain indicate that policy makers are heeding the message of the town meeting resolution. Reforming utility rate structures so that electricity providers profit from helping their customers improve efficiency rather than from higher sales volume would be another important step forward.

Buildings. New Hampshire's relatively old stock of residential, commercial, and industrial buildings offers substantial opportunities to reduce emissions associated with water and space heating. Local governments can lead by example by seeking to attain the U.S. Green Building Council's LEED certification and/or designation as a U.S. Environmental Protection Agency (EPA) Energy Star Building for their own new construction and renovation projects, and could amend zoning laws to encourage and/or require the same of private projects. The state can update and support stronger enforcement of its building energy code.

Transportation. Cars and trucks account for 36 percent of the state's total carbon emissions. New Hampshire can join all the other Northeast states in adopting California's tailpipe emissions-

Plymouth State University

One of Plymouth State University's newest buildings, Langdon Woods Residence Hall, earned the LEED gold-level green building certification. The building, which is home to 347 students, opened in 2006 and has saved the university about $230,000 annually.

reduction standards. Adopting "smart growth" practices, such as concentrating development near existing infrastructure and investing in public transit systems before widening highways and bridges or building new roadways, will help the state reduce traffic congestion and vehicle emissions over the long term. In addition, New Hampshire 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 systems and on-site renewable energy systems.

Forestry and agriculture policies in New Hampshire can be designed to promote management practices and systems that cost-effectively reduce emissions. Opportunities for capturing carbon or avoiding CO_2 emissions from forests include protection, reduced-impact timber harvesting, reforestation, 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 New Hampshire, 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.** New Hampshire residents can purchase "Green-e" renewable energy certificates that offset fossil-fuel use by funding renewable energy and energy-efficiency projects that meet high standards for ensuring the projects reduce heat-trapping emissions.
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.

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

Two Brattle Square
Cambridge, MA 02238
(617) 547-5552

1707 H St. NW, Suite 600
Washington, DC 20006
(202) 223-6133

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*.