MANAGING RISK

Helping Cities in Massachusetts Adapt to Climate Change

MIT–USGS Science Impact Collaborative
Harmonizing Science, Politics, and Policy
in Natural Resources Management

IN THIS DOCUMENT, we feature reports prepared by interns at the Massachusetts Institute of Technology (MIT) as part of the Massachusetts Climate Change Adaptation Project. Some students are part of the MIT-USGS Science Impact Collaborative (MUSIC). Their work is linked to the new Science, Decisions and Policy Program of the US Geological Survey which emphasizes ecosystem services, adaptive management; resilience, vulnerability and risk; along with the science of science policy. These students are trained to help groups with conflicting views have productive conversations. Ultimately, our goal is to enable governmental, corporate and civil society groups to engage in collaborative environmental management.

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EXECUTIVE SUMMARY

IN FALL 2009, researchers from the Massachusetts Institute of Technology interviewed 54 people in 19 Massachusetts cities to learn what efforts are under way to manage the likely impacts of climate change. We selected four cities—Boston, Gloucester, Lynn, and New Bedford—for close examination.

Most people interviewed knew that greenhouse gas emissions might well be affecting New England's climate, and many have been working on mitigation, trying to reduce emissions locally. Pieces of legislation such as the Massachusetts Green Communities Act have motivated some cities to try to improve energy efficiency and make the shift to clean energy. However, many city officials and local leaders still have not begun to address the risks they face.

Even among cities that are on the forefront of mitigation efforts, few have begun to think about adaptation, or planning ahead to weather the worst impacts of climate change. However, the Commonwealth's Climate Change Adaptation Advisory Committee is trying to pin down the risks that will require attention. And the committee's work will be an important resource for cities seeking to increase their resilience.

Based on our close look at four cities, we have identified six steps that every city can take to kick off an effective climate change adaptation effort:

- *Begin conversations now with anyone interested in the risks associated with climate change*. Many stakeholders who have been active in mitigation can be tapped to consider what adaptation steps can be taken. This is a lot like planning for other natural disasters; we don't know when or whether an earthquake will occur, but we take precautions.

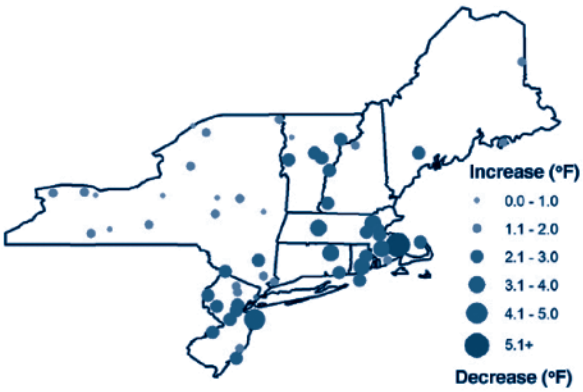
- *Use whatever data are available to assess vulnerabilities*. While global change science has not produced precise predictions, enough information is usually available to assess a community's vulnerabilities. City officials need to pay attention to those who know the local history of natural disasters, droughts, and past climate-related events.

- *Build on existing approaches to risk management and hazard mitigation*. Public agencies in many cities regularly assess flood hazards, potential coastal erosion, and other impacts that overlap the effects of climate change. These efforts present opportunities to inject emerging climate science into local planning.

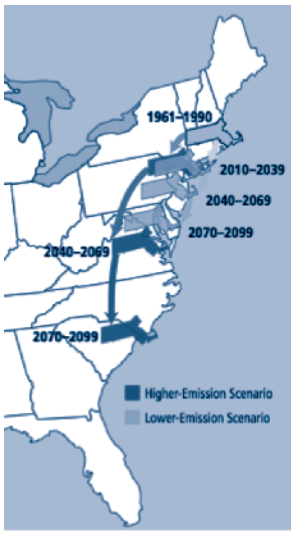
- *Incorporate climate change into everyday decision-making*. Including an adaptation perspective in all infrastructure investment and land-use decisions is more important than launching a separate climate adaptation effort.

- *Use "scenario planning" to identify "no-regrets" actions—that is, think of things that will help meet a variety of important objectives while simultaneously reducing climate change risks*. Instead of preparing a comprehensive list of everything that could be done to soften the impacts of climate change, public officials and local leaders should consider each incremental decision from an adaptation perspective. Investments and decisions should make sense for a wide range of possible futures.

- *Collaborate with other elected officials through partnership organizations*. Initiatives such as the Urban Leaders Adaptation Initiative and ICLEI–Local Governments for Sustainability's Climate Resilient Communities Program connect elected officials with others around the country so they can find out what's working elsewhere.



Change in Average Annual Temperature 1899 – 2000



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 could feel like under the lower-emissions scenario.

Source of both maps above: Northeast Climate Impacts Assessment http://www.climatechoices.org/assets/documents/climatechoices/confronting-climate-change-in-the-u-s-northeast.pdf

INTRODUCTION / BACKGROUND

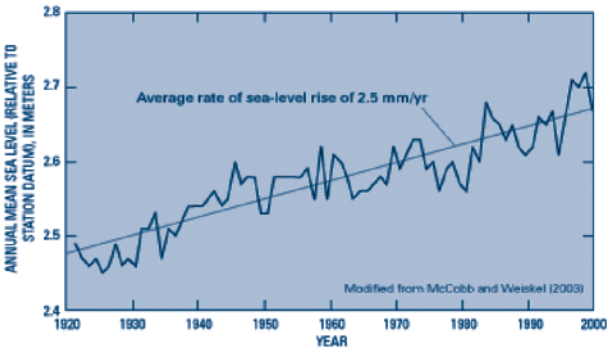
Average temperatures in New England are projected to rise 2.5 to 4 degrees Fahrenheit in the winter and 1.5 to 3.5 degrees Fahrenheit in the summer over the next several decades.[1] These temperature increases will fundamentally change many aspects of life that are dependent upon the climate, including rainfall, storm intensity, the timing of the seasons, and economic activities that are based on natural resources.

In Massachusetts, climate change is likely to cause a range of effects, from rises in sea level and coastal flooding to impacts on human health, biodiversity, and the state's economy. This overview is intended to provide some helpful context for the case studies that follow, which detail the adaptation efforts currently under way in cities around the Commonwealth. Massachusetts is also seeking to address these impacts through a statewide adaptation planning effort.

SEA LEVEL RISE

A majority of the population of Massachusetts lives near its nearly 1,500 miles of coast. Several major cities, including Boston, Quincy, New Bedford, Fall River, and Lynn are on the waterfront. In places like Boston's Back Bay, residents have for decades reshaped the coastline to meet their needs.

Since the 1970s, the Massachusetts Office of Coastal Zone Management has been helping residents deal with the changing coastal environment. Erosion and accretion along the shoreline, along with other planning concerns, have garnered increasing attention.



Annual mean sea level (1921-2000) along the Boston shore

Source: pubs.usgs.gov/circ/2003/circ1262/images/fig29_opt.gif)

Global assessments of tide gauge records have found that the sea level has risen quite dramatically over the past century. As geophysicist Bruce Douglas writes in his 1997 study, "The mean trend … is … 1.8 mm/yr ± 0.1 for global sea-level rise over the last 100+ years. A somewhat smaller set of longer records … gives 1.9 mm/yr ± 0.1 for the mean trend. These values are about an order of magnitude larger than the average over the last few millennia."[2] The annual mean sea level along Boston's shoreline has increased about 2.5 mm per year over the past 80 years.[3]

With current trends in global greenhouse gas emissions, sea levels are projected to rise even more. These rising sea levels will cause even more problems for coastal communities. Infrastructure may become submerged. Saltwater intrusion into coastal freshwater aquifers and the mouths of rivers could threaten drinking water

supplies. Coastal ecosystems and agriculture will be severely tested.

COASTAL FLOODING AND DAMAGE FROM STORMS

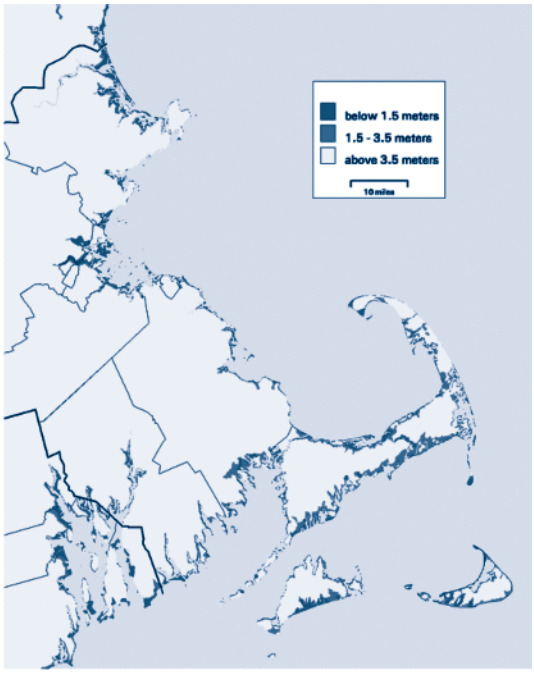
The residents of Massachusetts have dealt with hurricanes and nor'easters throughout their history. These storms have sometimes pushed water from the ocean onto the land (storm surge), flooding coastal communities. They have also, at times, caused intense coastal erosion and inland flooding. Nor'easters add heavy snow to this mix, increasing the risk of accidents and cold-related deaths.

To date, most hurricanes that have struck Massachusetts have been at the level of a tropical storm up to a Category 1 storm. However, more intense storms do hit the state occasionally. This description from the Geological Sciences program at Brown University provides a sense of the kind of destruction a major storm can cause:

> The September 21, 1938, hurricane, the last intense (Category 3 or greater) hurricane to strike Long Island, NY, and southern New England made landfall over central Long Island and tracked north into central New England, still maintaining a distinct eye (Minsinger 1988, Brooks 1939). Wind velocities to the right of the storm's track exceeded 190 km/hr and a maximum wind gust of 299 km/hr was recorded at the Blue Hills Observatory in Milton, Massachusetts. … A storm surge combined with an astronomically high tide rose over 3 meters above normal spring tide levels along the open coast, while focusing in Narragansett and Buzzards Bays, resulted in over 5 meters of storm surge in many areas (Paulsen 1940, Redfield and Miller 1957). Significant overwash, coastal modification, and erosion occurred from Long Island, NY, to southeastern Massachusetts as a result of the combined effect of storm surge and wave action associated with this hurricane (Wilby et al 1939, Nichols and Marston 1939). Over 600 lives were lost and property damage was estimated at approximately 400 million dollars (Brooks 1939). As a result of increased population and resources in the region, a storm of similar intensity striking southern New England today, would likely result in approximately 17 billion dollars of property damage (Pielke and Landsea 1998).[4]

Communities along the Massachusetts coast have come to expect the occasional severe storm. Some have created hurricane barriers (e.g. New Bedford). Others have dam structures to help manage inland flooding from storms, such as the Charles River Dam, which helped prevent flooding in Boston during the Blizzard of 1978 (a nor'easter).[5]

Climate change is projected to increase the frequency and severity of storm surges and coastal flooding from nor'easters and hurricanes. According to a 2007 report by the Northeast Climate Impacts Assessment, what is now considered a once-in-a-century coastal flood in Boston is expected to occur, on average, as frequently as



Sea Level Elavations

Elevations are based on computer models, not actual surveys. Coastal protection efforts may prevent some low-lying areas from being flooded as sea level rises. The 1.5-meter contour depicted is currently about 1.3 meters above mean sea level. Therefore, some of the areas depicted in red will be above mean sea level for at least 100 years and probably 200 years. Nevertheless, because mean spring high water (i.e., high tide during new and full moons) is typically 60 cm above sea level, the 1.3-meter contour would be flooded a few times per month by a 70 cm rise in sea level. Over the next century, sea level is most likely to rise 55-60 cm along most of the US Atlantic and Gulf coasts. The 3.5-meter contour roughly illustrates an area that might be flooded over a period of several centuries.

Source: www.epa.gov/climatechange/effects/coastal/slrmaps_ne.html.

every two to three years by midcentury and every other year by late century.

Such an increase in frequency and intensity could cause major damage if existing infrastructure is not assessed for its ability to withstand such forces and upgraded if necessary.

STORMWATER MANAGEMENT

Stormwater management already presents challenges for Massachusetts as a growing population and increasing regulation of water pollution have rendered much of the historic water infrastructure obsolete. Urban runoff and discharges from stormwater outfalls are together the single largest source of water quality problems in the Commonwealth's rivers, lakes, ponds, and marine waters. Most of the older urbanized communities in Massachusetts (e.g. Boston, New Bedford, Worcester) have combined sewer outflow systems that allow some sewage to be discharged into waterways during large rain events.

Not only is pollution a problem, but old infrastructure also contributes to regular flooding in several communities in the state (e.g. Somerville). While these failures of the state's water infrastructure are clear to many, upgrading these systems can cost tens of millions of dollars, and resources have been insufficient to complete upgrades to date. In several communities, water management upgrades are under way.

Climate change could exacerbate the problems created by the state's antiquated water infrastructure by increasing the volatility of the water cycle in the state—wet periods could get wetter and dry periods drier. By 2100, average precipitation in the spring and winter is projected to increase 20 percent to 30 percent in the Northeast. February 2008's statewide average of 8.7 inches of precipitation, about 270 percent above normal, made it the wettest February on record. In recent years, the statewide cumulative precipitation of Massachusetts has been 40 percent above normal levels.

An August 2009 study by the Massachusetts Institute of Technology and the California Institute of Technology[6] suggests that precipitation in extreme events could go up by about 6 percent for every 1 degree Celsius increase in temperature. In the last decade, Boston has already experienced two "100-year storms" and three "50-year storms"[7] (meaning that the probability of a storm of that severity or greater occurring in one given year is 1/100 and 1/50 respectively[8]). An even greater intensity in rainstorms due to climate change could result in more soil saturation, which would lead to even more runoff.[9] The state's pipelines and dams could also fail, as they are not designed to withstand such intense rainstorms.

FRESH WATER AVAILABILITY

Largely because billions of gallons of the Commonwealth's water are lost through

leaks, many parts of Massachusetts regularly do not have adequate water to meet current demand. For example, 160 rivers and streams in Massachusetts currently suffer from low flows or water levels. In some summers, when stream flows are naturally at their lowest levels, over pumping of wells in the Ipswich River basin has caused nearly half of the 45-mile-long river to run dry. In 2003, the conservation group American Rivers listed the Ipswich, which supplies 330,000 people, as the third most endangered river in the United States.[10]

One water-scarce community, Brockton, MA, is building a desalination plant (which removes salt from seawater) to supply the city with additional fresh water and to sell to neighboring towns. The $70 million Brockton plant will be the first desalination plant in New England.[11]

Climate change could stress the state's drinking water systems even further. Risks include:

- *Drought*: Short-term droughts (one to three months) could occur as often as once per year in parts of the Northeast.
- *Flooding*: Flooding from heavy rainfall could contaminate the water supply with sediment, sewage, pollutants, and pathogens.
- *Snow*: Reduced snowpack and earlier snowmelt may reduce the replenishment of groundwater. One study has shown that a shift in the timing of winter/spring and fall peak flows are already affecting when lake ice melts in Massachusetts.[12]

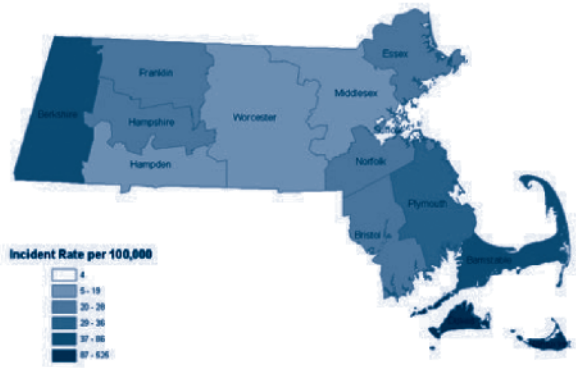
HUMAN HEALTH AND WELFARE

Climate change will affect the public health of Massachusetts in many ways, but four problems stand out:

- *Vector-borne diseases*
- *Marine-related diseases*
- *Air pollution-related illnesses*
- *Illnesses caused by extreme weather events*

Increase in Vector-Born Diseases

Predicted climate trends—including longer summers, warmer winters, and seasonal droughts followed by heavy rainfall—will undoubtedly increase mosquito breeding.[13] For Massachusetts, West Nile virus poses the most critical threat. A vector-borne disease carried by mosquitoes, West Nile has recently been shown to be more prominent among mosquitoes living in warmer climates.[14] Similarly, increases in the tick population are likely to increase the threat of Lyme disease in the Northeast, which is already home to 90 percent of Lyme disease cases.[15]



Massachusetts Department of Public Health
Lyme Disease in Massachusetts: 2004 Incidence Rates by County

Source: http://www.umass.edu/agland/diagnostics/tick/images/clip_image001.jpg

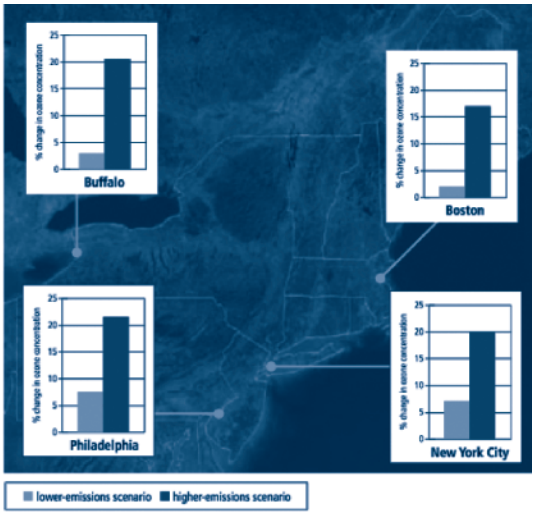
Increase in Marine Diseases

Along the Massachusetts coast, diseases linked to the health of the ocean, such as Red Tide, are also expected to rise as temperatures increase. Hot summers tend to

favor toxic algal growth, which reduces oxygen levels in the water supply, posing a threat to marine populations as well as to humans who may eat contaminated fish and shellfish.[16] In large concentrations, the toxic algae will cause the more serious and significant problems of red tides, algal blooms that can kill fish outright. The pathogens that cause food-borne diseases (notably E. coli, salmonella, cyclospora, and Hepatitis A) also grow better in warmer, moister climates.[17]

Increases in Air Pollution and Resulting Pulmonary and Immunological Responses

Various forms of air pollution will also endanger human health. Climate change has already caused a large increase in the concentration of surface ozone (especially in urban areas),[18] which is linked to respiratory and pulmonary problems, as well as childhood asthma, and which exacerbates many other pre-existing conditions.[19] Surface ozone concentrations are accelerating rapidly, boosted by increases in temperature and carbon dioxide emissions.[20] Pollen-producing plants also pose a serious health risk in Massachusetts—increases in carbon dioxide and temperature trigger an earlier onset of the spring allergy season and increase pollen production, especially among ragweed and birch, prevalent in Massachusetts.[21] Because approximately 1 in 10 people in Massachusetts has asthma,[22] an increase in pollen production and potency of the resulting allergens will have remarkable consequences, increasing the incidence and severity of asthma and allergic diseases.



Increasing Risk of Poor Air Quality in Northeast Cities
Hotter summers could set the stage for an increase in the number of days that fail to meet federal air-quality standards. In the absence of more stringent controls on ozone-forming pollutants, the number of days with poor air quality projected to quadruple in Boston, Buffalo, New York City, and Philadelphia under the higher-emissions scenario. Under the lower-emissions scenario such days could increase by half. These graphs show the average projected change in eight-hour maximum ozone concentrations for each city.

Source: Northeast Climate Impacts Assessment
http://www.climatechoices.org/assets/documents/climatechoices/confronting-climate-change-in-the-u-s-northeast.pdf

Increase in Extreme Heat Events

Finally, extreme weather events (especially extreme heat) pose serious risks to human health in Massachusetts. Heat waves, which cause heat stress, exhaustion, stroke, and exacerbate many other pre-existing conditions, have serious health implications.[23] Between the early 1980s and 2000s, complications from extreme heat events killed more people in the United States than complications from hurricanes, tornadoes, floods, lightning, and earthquakes combined.[24] In fact, the number of days over 90 degrees Fahrenheit is expected to increase by 20 to 40 days in Boston in the next 40 years.[25] Extreme heat will be felt most keenly in urban areas, where the "urban heat island effect" results in even greater warmer temperatures and where populations are typically more at risk for health problems associated with air pollution.[26] Cycles of floods and droughts can also have serious health risks, promoting mosquito and rodent reproduction and in extreme situations displacing people and their food supplies.[27]

NATURAL RESOURCES AND BIODIVERSITY

As a state full of forested and coastal ecosystems, Massachusetts faces significant damage, alteration, and loss of biodiversity due to climate change. Alterations and degradation of critical habitats will have statewide impacts on ecosystem, animal, and human health. Particularly at risk are:

- *Forests statewide*
- *Estuaries (especially in southeastern Massachusetts)*
- *Coastal wetlands (most notably salt marshes)*

These habitats provide a critical foundation for agriculture, recreation, commercial fishing, and even water filtration. Their changing character has serious local and statewide implications.

Forests

Massachusetts's forests—and many of the species that live in them—are particularly threatened by climate change. Tree species are expected to migrate northward to a maximum of 350 or 500 miles, increasing pressure on associated animal species.[28] Although forest productivity is actually expected to increase due to higher CO2 levels, the character of the species in forests will change dramatically. Spruce/fir and maple/beech/birch forests will be severely impacted by climate changes, making them more vulnerable to disease, pests, and competition.[29] This change of habitat will, in turn, significantly reduce the presence of migratory birds, especially the songbirds that are now an important part of Massachusetts' forests.[30]

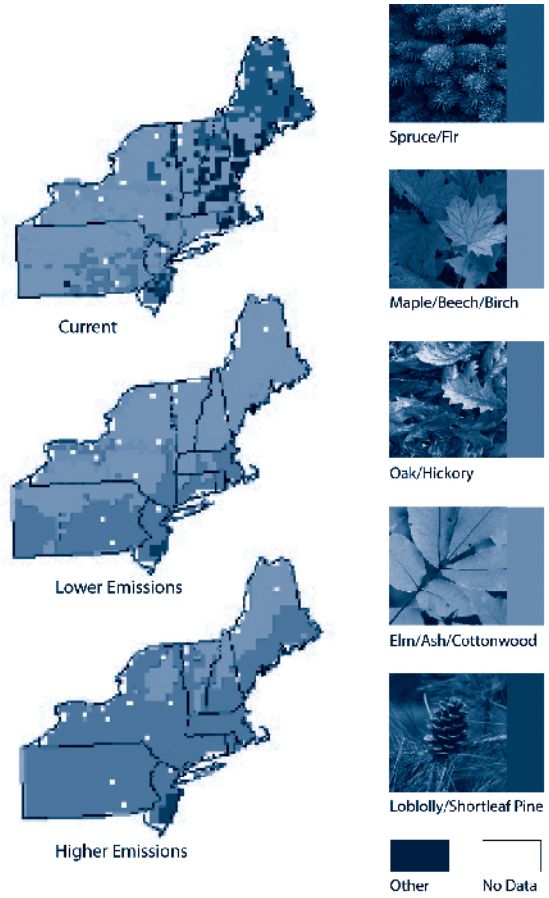
Climate change will also provide expansion opportunities for invasive species, such as the hemlock woolly adelgid, a pest that thrives in warmer water and that has become an increasing problem for the valuable hemlock trees that line many water sources in the state.[31] The adelgid kills the hemlocks and this loss of shade causes local stream temperatures to rise. This threatens native fish (such as trout) that are often fished recreationally, which in turn provides an environment even more conducive to adelgid growth.[32] Massachusetts has more than 3 million acres of forests and a variety of different ecosystems are dependent upon them. The possibility of these forests having very different tree species within the next century will have widespread implications that are only beginning to be understood.

Estuaries

Estuaries (semi-enclosed bodies of water connected to the ocean) are at serious risk for destruction and loss of biodiversity both from climate change and from human pollution. Salinity increases (due to sea-level rise) and temperature increases from climate change will exacerbate pollution problems and promote algal growth, which removes a significant amount of oxygen from these coastal systems.[33] Changes in salinity, temperature, and oxygen levels will continue to reduce biodiversity in these environments, and may even eliminate estuary ecosystems altogether.[34] Estuaries provide a unique habitat for many types of shellfish, productive greenhouse gas–absorbing sea grasses, and breeding grounds for marine fisheries throughout southeastern Massachusetts. Massachusetts Bay, Cape Cod Bay, Nantucket Sound, and Buzzards Bay—all areas important to Massachusetts for cultural, economic, and health reasons—are at high risk for habitat degradation.[35]

Coastal Wetlands

Coastal wetlands, particularly salt marshes, are possibly the most at-risk ecosystems in Massachusetts. Due to extensive pollution, increasing temperatures and salinity, as well as development, salt marshes have already begun disappearing along the Massachusetts coast.[36] As sea level rises in Massachusetts (at a higher rate than the



Contracting Habitat
Much of the Northeast is currently dominated by hardwood forests composed of maple, beech, and birch; higher altitudes and latitudes are dominated by spruce/fir forests. As the climate changes this century, suitable habitat for spruce and fir species is expected to contract dramatically under either emissions scenario (compared with observed forest distribution in the 1990s, shown here as "current"). Suitable maple/beech/birch habitat is projected with move significantly northward under the higher-emissions scenario, but shift far less under the lower-emissions scenario. (The "other" category includes species such as red, white, and jack pine.)

Source: UCS/NECIA
http://www.climatechoices.org/ne

global average), salt marshes may not be able to rise with it effectively.[37] As one of the most biologically diverse and productive ecosystems in the world, Massachusetts' salt marshes are important absorbers of greenhouse gases, as well as habitats for fish and shellfish, waterfowl, migratory birds, and many endangered species.[38] And unlike forests, salt marshes are not capable of "migrating" northward—they simply live or die.[39] The extensive human impacts of pollution and development have already endangered this ecosystem, making it even more vulnerable to climate change.[40]

LOCAL ECONOMIES RELIANT UPON ECOSYSTEM SERVICES

The Massachusetts economy comprises various primary, secondary, and service sectors, employing 3,444,500 people. Climate change is likely to affect many of these sectors, altering the Commonwealth's entire economy.

Agriculture

Agriculture currently contributes about $416 million to Massachusetts' economy annually. Economic viability has been an issue over the past 50 years as prices for agricultural products haven fallen by about two-thirds, with only a 1 percent improvement in agricultural productivity. As the climate changes, affecting temperature, rainfall, CO2 concentration, weeds, insects, and diseases, it will impact the viability of current crops and livestock. Farmers will face uncertainty, higher costs, and the need to invest in new crop varieties. If appropriate changes are not made on schedule, the vitality of Massachusetts' agricultural industry may diminish. As farmers begin to change their output, the market and consumer expectations will also be forced to adapt.

Fishing

Fishing has played an integral part in shaping Massachusetts' culture, character, and economy. In 2003, the direct and indirect contributions of commercial fishing to the region totaled $10.4 billion. Of that, an estimated $4.4 billion was revenue generated for the state.[41] In 2005 in Massachusetts the annual commercial landings for all species totaled $426.9 million. A federal report also determined that Massachusetts' commercial fishing industry directly or indirectly supports an estimated 83,000 jobs, which is the third highest of all states.[42] The densely populated coastline already poses a challenge to fishing industry.

Climate change and global warming will change the viability of Massachusetts' fish species and force changes in the economies of fishing communities. Cod stocks, which are historically and economically important to the state, have already begun to be depleted. As temperatures rise in Georges Bank, historically New England's most important fishing ground, cod growth and survival will be threatened. Overall, Massachusetts' waters may become too warm to support the species. Warming waters also threaten lobsters, which currently provide the highest dockside value for Massachusetts' fishermen. By midcentury the waters south of Cape Cod are likely to be too warm for lobsters. Their habitat is also threatened

in the shallow, near-shore waters of Massachusetts Bay. If cod and lobster can no longer survive in Massachusetts' ocean waters, the fishing industry—and with it the state's economy—will face significant changes.

Forestry

Forests dominate much of Massachusetts' landscape, with 3.2 million acres of privately owned forestland and 285,000 acres of state forests and parks. Forests provide recreation and tourism opportunities, wildlife habitat, and timber, while protecting watersheds, conserving soil, and storing carbon. In the northern New England states (Maine, New Hampshire, New York, and Vermont) the forest industry and forest-based tourism combined contributed $19.5 billion to the economy in 2005. Forestry and related industries provide more than 300,000 jobs in New England and New York, and in August 2009, 1,200 Massachusetts individuals worked in mining or logging.[43]

The increased temperatures and higher CO2 concentrations brought by climate change can potentially alter the character of Massachusetts' forests. Climate change will affect what trees are able to survive in the region and what species will migrate. Particularly vulnerable are Berkshires' spruce/fir forests, since conditions for these forests are predicted to disappear. The effects of this are manifold and include endangering Massachusetts' treasured bird species, and exacerbating existing stresses on the pulp and paper industry. In order to minimize economic impact, timber managers will have to decide when the changes coming from climate change are clear enough to warrant changing over to tree species more suited for soils that do not freeze.

Winter Recreation

Winter recreation is a vital part of Massachusetts' economy. Winter snow and ice sports annually infuse $7.6 billion into New England's regional economy, with alpine skiing and other snow sports accounting for $4.6 billion and snowmobiling accounting for $3 billion. The Massachusetts winter recreation industry has already begun to contract. As winter temperatures rise, snowfall declines, and lake ice shrinks, winter recreation will be profoundly affected. Climate change will shorten the average ski season and increase snowmaking requirements, increasing operating costs. By midcentury, ski resorts may no longer be viable in Massachusetts, and by late century within New England they may only be viable in western Maine. Overall, climate change threatens Massachusetts' winter recreation and tourism, along with the livelihood of many citizens.

Transportation

According to a report by the National Research Council in 2008,[44] climate change will seriously harm coastal-area transportation systems. For example, roads, railways, transit systems, and airport runways may flood due to rising sea levels; pipeline supports and bridge foundations may rust from increasing precipitation events; and other infrastructure is likely to fail due to more frequent and intense hurricanes and storm surges.

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Boston: Actively Engaged in Mitigation and Embarking on Adaptation

By Tyler Corson-Rikert

CASE STUDY #1

OVERVIEW OF BOSTON AND CLIMATE CHANGE

The city of Boston has made climate action a significant priority in recent years, implementing numerous programs to increase energy efficiency and promote clean energy. Climate change mitigation has been the city's primary focus, but climate adaptation is increasingly a priority. The city benefits from multiple studies that provide a clear picture of its vulnerabilities to climate change. Moreover, the city government has taken steps to incorporate the input of diverse stakeholders and the citizenry at large in its decisions on climate mitigation and adaptation. In 2009, Mayor Thomas M. Menino appointed a Climate Action Leadership Committee and a Community Advisory Committee to produce recommendations for a new climate action plan and a long-term public engagement strategy around climate change. Together these initiatives place Boston among the most proactive cities in the United States in both reducing greenhouse gas emissions and beginning to build resilience to the likely impacts of climate change.

Photo: Alex S. MacLean, "City of Boston," October 23, 2009. Accessed March 22, 2010 via http://hdl.handle.net/1721.3/44362.

Boston can expect a coastal flood equivalent to today's 100-year flood every two to four years on average by midcentury and almost annually by the end of the century.

BOSTON'S VULNERABILITIES TO CLIMATE CHANGE

Boston faces a wide range of risks related to climate change, including rising sea levels, more intense storms, large rainfall events, and heat waves. Such events could produce very high economic and social costs, depending on what actions the city takes to reduce its vulnerability. The Boston Globe cited a report by the World Wide Fund for Nature and Allianz insurance company stating that Boston ranks fourth among US cities for the value of assets threatened by a predicted 26 inches of sea level rise by 2050: a total of $463 billion.[45] Rising sea levels are perhaps the most readily understandable impact on the city, but changes in temperature, water quality, public health, and infrastructure due to climate change will also be significant. Two useful assessments of a wide range of climate change vulnerabilities in the Boston area are the EPA-funded report Climate's Long-Term Impacts on Metro Boston (CLIMB) and the report by the Union of Concerned Scientists titled Confronting Climate Change in the US Northeast.[46] Advocates for East Boston residents are particularly concerned about heat waves. Climate change may bring days or weeks of extreme temperatures, severely affecting the elderly and young children.[47] The heat would compound existing air pollution from Logan Airport,

diesel trucks, and other environmental burdens, increasing rates of asthma and other respiratory conditions.[48]

The 2006 CLIMB report, written by researchers at Tufts University, Boston University, and the University of Maryland, assesses the risks climate change will pose for the Boston region (including the city of Boston and 100 surrounding municipalities), calculates the costs of these impacts, and identifies specific policies to reduce vulnerabilities and costs. The report provides an example of planning that acknowledges the uncertainties both of climate change and of potential policy responses. It begins by posing three broad scenarios for how municipalities could deal with climate impacts: taking no action and dealing with consequences as they occur under present management policies; working to reduce potential damage through protective structures; and making a proactive effort to reshape physical structures and development to increase resilience. The report estimates the likely consequences of each course of action given what is known about future climate change. Its clear conclusion is that early action to adapt to climate change is by far the cheapest alternative, with no action yielding the highest costs. CLIMB focuses on infrastructure vulnerabilities, highlighting the risks to metro Boston of coastal and river flooding due to major rainfall events and rising sea levels, impacts on river water quality, the increased energy use and public health impacts of heat waves, and transportation delays during extreme weather events. The report's recommendations include:

> Implementing both structural and nonstructural coastal flood-management strategies before 2050 ... maintaining policies to improve health care, enacting regulations to encourage more energy-efficient housing stock, integrating water quality management to include land use, drainage, and wastewater treatment, and continuing to maintain redundancy in road networks.[49]

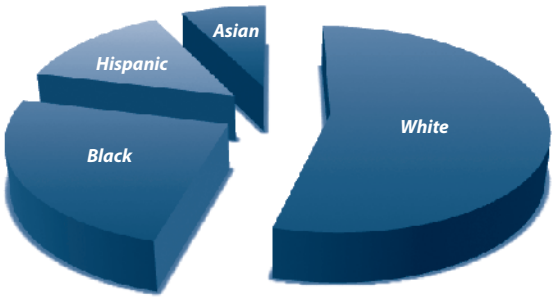
The report's authors emphasize the potential for strategic policies and investments, particularly in land-use planning and new infrastructure, to reduce multiple classes of climate hazards. They note that factors such as the relatively high number of uninsured structures owned by low-income households on flood plains will likely lead to disproportionate impacts from climate change on different demographics within each municipality. Finally, the report highlights the importance of action by local governments alongside a wide range of other actors such as nongovernmental organizations and businesses.[50]

The 2007 Union of Concerned Scientists report Confronting Climate Change in the US Northeast looks at climate risks facing the Northeast generally, including a brief case study on Boston. The report concludes Boston "can expect a coastal flood equivalent to today's 100-year flood every two to four years on average by midcentury and almost annually by the end of the century."[51] The report notes that such flooding in Boston would impact coastal defenses, waterfront buildings, transportation, and sewer and storm water systems. It illustrates with maps the

BOSTON DEMOGRAPHICS

2006 Population	595,698
Percentage change 2000 to 2006	+ 1.1%
2000:	
Percentage foreign born	26%
Percentage with high school diplomas	79%
Percentage with bachelor's degrees	36%
1999:	
Median household income	$39,629
Percentage living below the poverty line	20%

Source: "State & County QuickFacts: Boston, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2507000.html.



RACE/ETHNICITY BREAKDOWN, 2000
Source: "State & County QuickFacts: Boston, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2507000.html.

EXCERPT OF MAYOR MENINO'S APRIL 2007 EXECUTIVE ORDER:[52]

Whereas, climate change poses risks to Boston residents, visitors, businesses, institutions, and infrastructure, including risks associated with heat waves, changing disease patterns, sea level rise, changing precipitation patterns, increased severity of storms and flooding, and stress on water and energy systems;

The City shall prepare an integrated plan that outlines actions to reduce the risks from the likely effects of climate change, and coordinate those actions with the City's plans for emergency response, homeland security, natural hazard mitigation, neighborhood planning and economic development.

predicted end-of-century 100-year flood zones for the Government Center/waterfront, Back Bay, and South Boston waterfront areas of the city.[53]

In 2005, Mayor Thomas M. Menino signed the US Mayors Climate Protection Agreement, advocating for federal and state climate change policies and resolving to strive to meet or exceed Kyoto Protocol targets.

CLIMATE CHANGE MITIGATION EFFORTS IN BOSTON

Since 2000, the city of Boston has taken a series of steps to reduce its contribution to global climate change, culminating in the March 2009 creation of the Boston Climate Action Leadership Committee (CALC). Climate change first became a topic of discussion within the city government through Environment Department staff, who advocated for green building and energy efficiency. This led to Mayor Menino's 2000 decision to join the ICLEI-Local Governments for Sustainability's Cities for Climate Protection Campaign.[54] The mayor's creation of an Energy Advisory Committee in 2001 (succeeded by the current Energy Management Board) and a Green Building Task Force in 2002 followed, creating institutional structures to advance climate mitigation efforts. In 2005 Menino signed the US Mayors Climate Protection Agreement, advocating for federal and state climate change policies and resolving to "strive to meet or exceed Kyoto Protocol targets for reducing global warming pollution by taking actions in our own operations and communities."[55] In December 2007 the city issued a Climate Action Plan describing the risks that climate change poses to Boston and the city's existing and newly initiated efforts to reduce greenhouse gas emissions.[56] The city's work centered from the start on project-based policy development, using focused efforts to produce significant and visible accomplishments.[57] The mayor created the CALC and the Community Advisory Committee in 2009 to make recommendations on the update of the city's Climate Action Plan and to chart Boston's "collective response to climate change."[58] The Boston Foundation and Barr Foundation provided funding for these committees as well as Renew Boston, an initiative to create green jobs and connect residents and businesses with information, technical assistance, and federal funding for energy efficiency retrofits.[59]

The Environmental & Energy Services Cabinet under Menino leads Boston's climate effort, coordinating the Climate Action Leadership and Community Advisory committees as well as the efforts of the various city departments. However, Environmental & Energy Services does not have direct authority over the majority of city functions that produce greenhouse gas emissions and influence the activities of citizens, businesses, and institutions. Therefore, Environmental & Energy Services offers education, facilitation, and technical assistance to help other departments achieve the goals that Menino laid out in his executive order. Some departments are reluctant to prioritize climate mitigation while others, such as the Property & Construction Management Department, which took responsibility for developing a protocol on green roofs, are more enthusiastic.[60]

ENGAGING STAKEHOLDERS ON CLIMATE MITIGATION AND ADAPTATION IN BOSTON

Mayor Menino created the Boston Climate Action Leadership Committee to provide policy recommendations to shape both the city's climate change mitigation and its adaptation work. The committee is a 22-member group representing a broad spectrum of the community, including leaders from government, business, academic institutions, environmental nonprofits, and community organizations (see inset box for a list of members and their affiliations).[61] Its tasks include updating the Climate Action Plan and emissions reduction goals, recommending additional climate mitigation efforts, assessing and recommending actions to reduce risks from climate change, communicating to the wider city, and identifying climate action-related economic and job opportunities.[62] Several working groups consisting of committee members, city staff, and outside experts assist in tackling particular areas, including climate adaptation.[63] The committee will give the mayor its recommendations in April 2010, providing a detailed framework for climate action. City departments will then have until December 2010 to develop final plans for implementation.[64]

The Community Advisory Committee is providing the city guidance on what message it should bring to its residents, businesses, and institutions.

Menino also created the Community Advisory Committee (CAC) to provide input to the Climate Action Leadership Committee's work and help engage the public, businesses, and institutions. The committee comprises 38 citizen representatives from different neighborhoods and is holding five public, professionally facilitated meetings over the course of the year. Participants were selected through a nomination process open to anyone in the community.[65] The CAC is providing the city guidance on what message it should bring to its residents, businesses, and institutions.[66] At the first meeting in September 2009, CAC members learned about the plan for their work, the science of climate change, and strategies for reducing greenhouse gas emissions.[67] In subsequent meetings, the CAC has provided input on the design of community workshops and longer-term community engagement efforts, and responded to draft CALC recommendations on mitigation and adaptation strategies.[68]

The city received funding from the Barr Foundation to organize five community workshops in February and March 2010 to garner input from the public on climate mitigation and adaptation proposals, as well as potential public engagement strategies. The first event, held February 27, engaged high school-aged youth, and the four workshops held in the following weeks targeted different groups or neighborhoods. The workshops utilize facilitated small group discussions and keypad polling to generate and communicate feedback. The goal is to gather input from the CAC and community workshops and present it, through the CALC, to the mayor.[69]

The city of Boston's emphasis on public input into its climate action plan distinguishes its response from those of most similar-sized cities around the country. To assist in the design and implementation of these initiatives, Boston chose to hire professional facilitators with extensive experience in energy, climate change, stakeholder processes, social justice, and community organizing. The

consultants' expertise has complemented the city staff's technical knowledge and political insight, helping to ensure that public input is effectively integrated into efforts to address climate change.[70]

This unique commitment shows that the city and the funding foundations recognize that a wide spectrum of concerns surrounds climate change and that a long-term public engagement strategy is needed to successfully mitigate and adapt to climate change. Community advocates in East Boston spoke of this as a welcome change from what they perceived as a history of inadequate public participation in decision making. In the words of John Walkey of the Chelsea Creek Action Group,

> For Boston … it has been a 40- or 50-year history of community groups fighting to get at the table and have a say in what goes on. With something like adaptation that is so huge, putting in sea walls and things like that, it makes sense to think of it from the centralized, top-down kind of perspective, and the history of Boston is that that's how they work with most everything anyways, so it's nothing new … Without [funding from the foundations to create the Community Advisory Committee] we would have eventually been asked into the process, but much further along, and with a lot less opportunity to absorb the information and to get it out to people in the appropriate form so that we can get feedback back in from people who aren't experts. That takes time.[71]

The Community Advisory Committee, city staff and the professional facilitators are working to shape a long-term engagement strategy that will keep the public involved in Boston's climate mitigation and adaptation action.

CLIMATE ADAPTATION EFFORTS IN BOSTON

Boston's climate work over the past decade focused largely on mitigation, culminating in such forward-thinking initiatives as Renew Boston and the Community Advisory Committee. The city is now leading the way among large cities in its efforts to create a comprehensive strategy for climate adaptation. Mayor Menino's April 2007 executive order identified specific risks that climate change will pose to Boston and instructed the city to develop a coordinated plan to address those risks (see inset box). The December 2007 Climate Action Plan detailed risks facing Boston and New England in the categories of human health, coastal systems, water resources, ecosystems, agricultural production, and the economy. Boston's new climate action plan will contain an explicit and proactive adaptation strategy, unlike most climate action plans in other cities that have mentioned adaptation only in passing.[72]

Boston's new climate action plan will contain an explicit and proactive adaptation strategy, unlike most climate action plans in other cities that have mentioned adaptation only in passing.

The Leadership Committee's work group on adaptation met for the first time in December 2009 to "evaluate the risks to Boston from sea-level rise and other likely consequences of climate change, and recommend actions for the city and the

community to take to reduce these risks."[73] In late January 2010, the work group presented a draft adaptation strategy to the CALC, calling for a comprehensive adaptation program, research into the city's vulnerabilities, and integration of adaptation considerations into public and private planning processes and reviews (see inset box for a condensed version of the recommendations).[74] The Community Advisory Committee has also had an opportunity to comment on the adaptation strategy, which the CALC will present in a final form to Menino in April 2010.[75] The adaptation strategy in the new climate action plan will be nowhere near as detailed as the city's mitigation program, but in the CALC's judgment this is the appropriate stage for Boston to be at in its planning at this time.[76] The document will provide a framework, establish priorities, and identify initial steps to begin addressing the challenge.[77]

Currently the city of Boston knows much more about mitigation than adaptation, although the city benefits from communication with other cities and organizations working on adaptation, as well as from the state's adaptation planning effort. The Environment Department has been in touch with adaptation planning efforts in King County, Washington, and Keene, NH, and in 2008 the city hosted an ICLEI workshop on adaptation.[78] Carl Spector, executive director of the Boston Air Pollution Control Commission, said that the adaptation process that ICLEI has developed will serve as a useful guide.

In the fall of 2009, Boston helped sponsor a workshop on climate adaptation with the Lincoln Institute of Land Policy and the Consensus Building Institute, which two Boston officials attended. The Massachusetts Climate Change Adaptation Advisory Committee's report to the state Legislature will also provide an excellent resource for Boston. The Boston CALC's work group on adaptation has drawn on the state report to determine which risks are most significant for Boston and which recommendations would best enhance the city's resilience.[79] While Boston is ahead of the state on climate mitigation, it hopes to piggyback on the state's adaptation planning effort.[80]

Some city departments have begun to consider climate risks in their decision-making through staff discussions and simple policy adjustments. Adaptation-related projects currently under way include a collaboration between the Environment Department, the Boston Redevelopment Authority, and the Massachusetts Office of Coastal Zone Management to develop a framework for regulations on coastal development and a +/- 6-inch accuracy LIDAR (light detection and radar) topography survey of the city. Funded by the Department of Energy grant for Solar Boston, this project should provide a better understanding of flooding risks.[81] The Massachusetts Water Resources Authority located Boston's sewage treatment plant built on Deer Island in 2001 two feet higher than initially planned to reduce future flooding risks.[82] According to Vivian Li, executive director of the Boston Harbor Association and a member of Boston's Conservation Commission, the commission has begun in the last year to require that new waterfront buildings be built a foot or two higher as a precaution against rising sea levels. The first such example is

BOSTON CLIMATE ADAPTATION WORK GROUP RECOMMENDATIONS, JANUARY 21, 2010: [83]

The City of Boston (CoB) needs to develop an initial adaptation plan as part of its 2010 Climate Action Plan update. The following document outlines the essential elements and strategies for that plan. These recommendations were developed by the Adaptation Work Group for consideration by the Leadership Committee.

PRINCIPLES, FRAMEWORK, AND PRIORITIES

- **CoB should establish an immediate, sustained, and comprehensive climate adaptation program.**
- **CoB should start its adaptation efforts by focusing first on preparing for sea-level rise, increased frequency and intensity of heat waves, and increased intensity of storms (summer and winter).**
- **Considerations of climate change for the purposes of adaptation planning should always include the upper ranges of reputable projections.**
- **Wherever possible, CoB should work with other levels of government to address climate adaptation on a statewide, regional, and even national level.**

INFORMATION, MEASUREMENT, AND ANALYSIS

- **CoB should conduct as soon as possible a detailed assessment of Boston's vulnerability to climate change, focusing on sea-level rise, heat waves, and storms (both summer and winter).**
- **As part of its three-year climate action plan revision cycle, CoB should regularly review climate change projections and environmental, socio-economic, and demographic data, and adjust its adaptation and mitigation plans in response to important trends.**
- **CoB should establish a task force to examine the potential effects from and potential responses to likely, long-term threats (50 years and beyond) from sea-level rise and other consequences of climate change, as well as low-probability, but catastrophic shorter-term events.**

MEASURES AND PLANNING

- CoB should immediately and explicitly incorporate climate adaptation into all planning and review processes for both public and private activities.
- All CoB capital, infrastructure, and neighborhood planning should explicitly consider the effects of climate change over the next 100 years.
- Every CoB department and agency should undertake a formal review of the possible consequences of climate change on its ongoing programs and infrastructure in the next 10 years, and implement changes or establish programs and policies based on that review. Some examples of areas of concern:
  - Comprehensive Emergency Management Plan
  - Revenue and Budget
  - Regional Transportation System
  - Urban Heat Island
  - Emergency Cooling Centers
  - Storm Water Management
  - Boston Harbor and Logan Airport
  - Deer Island Sewage Treatment Plan
  - Boston Harbor Islands National Recreation Area
- All new private development and institutional master plans, through the City's existing planning and environmental review processes, should evaluate the vulnerability of projects and institutions to climate change over the life of the project or institution and specify how it will address both short-term and long-term vulnerabilities.
- CoB should develop and implement a long-term plan that ensures the safety of all people living or working in Boston and, to the extent practical, protects existing buildings, businesses, institutions, and neighborhoods.

The full version of the recommendations is available at: www.cityofboston.gov/Images_Documents/Adaptation%20Working%20Grouop%20Recommendations

the Spaulding Rehabilitation Hospital, operated by Partners HealthCare, which is moving to a new site in Charlestown.[84]

CHALLENGES AND POSSIBLE STRATEGIES FOR CLIMATE ADAPTATION IN BOSTON

Adaptation Versus Mitigation

Boston's actions on climate adaptation will largely build on the existing institutional framework for climate mitigation, although adaptation presents distinct challenges for the city. Efforts to reduce greenhouse gas emissions have benefited from the complementary long-standing goals of energy efficiency and cost savings, renewable energy, pollution reduction, job creation, and economic innovation. The conversation has often been more about energy than climate. It is simpler for Environmental & Energy Services to tell each city department to use less energy and reduce costs. But adaptation presents no such near-term savings, requiring instead up-front costs to decrease the probability of future damage. As Spector of the Boston Air Pollution Control Commission commented:

> With mitigation you can see the cost savings immediately. With adaptation what you get is costs avoided. You aren't going to see it in the same way. It's probabilistic, and in a lot of instances it's different agencies, different departments that are going to take the measures.[85]

At times, mitigation and adaptation can actually conflict. For example, installing air conditioners during a heat wave might protect the health of young children and the elderly, but that would run counter to efforts to reduce greenhouse gas emissions. Furthermore, it is not always clear what actions are most likely to increase resilience. As Spector said,

> In every group, every set of functions has to figure out how [climate change] will affect those responsibilities embodied in those functions. The best example is from a daylong workshop I attended in another New England community where they got together all the top people to talk about what the effects of climate change would be and what they would have to do. And the police chief said that climate change means that he has to have more cops on the street looking for drunk drivers because when there's a heat wave more people go into bars and they drink more beer and they get into their cars to drive home. Now as soon as he says it, you get it, but you and I are not going to think of that. But he knows his responsibilities, he knows what he has to do … he can figure out, he can see the consequences … so you've got to engage people. So part of the challenge of adaptation is you have to engage all the different elements of the government more deeply.[86]

All city departments need to confront climate risks, but it is difficult to engage workers who are busy facing many other priorities. Ideally, planners need to think about what it would mean to have a 100-year storm every two to four years[87]

But the uncertainties on key variables, such as how much sea level will rise, are substantial. And, many city departments are not used to working with probabilistic, uncertain data and thinking 50 years into the future as climate adaptation requires. The enormous costs and fundamental changes that adaptation may require make planning even more challenging.[88]

Diverse Stakeholders

The diversity of concerns within the city presents another key challenge to Boston in working toward adaptation. While many of the stakeholders are the same as those involved in mitigation, adaptation presents different concerns. Whereas climate mitigation involves energy-saving measures and the introduction of clean energy sources across the entire city (though with different challenges for different groups), adaptation requires responses to very different vulnerabilities in different areas and among different stakeholders. A low-lying coastal neighborhood will face very different risks than a higher area. A large business with costly investments, high competition, and a large workforce will have different concerns than a community organization serving the health and human services needs of a low-income community. As Spector commented,

> Fundamentally [with adaptation] it is the same groups of people [who are stakeholders], but different aspects are going to engage different groups. … People in East Boston or South Boston are going to be really concerned about flooding. The people in Mattapan and Roxbury are going to be really concerned about heat waves. So everyone is getting affected, but with adaptation the salient point is going to be different with different groups, where that's not the same with mitigation… . I think the adaptation message will need to be more fragmented. Other groups are going to be worried about getting bitten by mosquitoes, about threats of disease. If you don't have air conditioning you're more concerned about heat waves than if you do. ... Within city government it's the same thing. The sewer guy is concerned about one thing. The public health commission or the community centers are concerned about a different thing.[89]

The state Climate Change Adaptation Committee's five working groups—which cover different types of impacts, each with scores of experts—testify to the diversity and complexity of issues that must be considered. The city will need to have different messages for, and respond to the unique needs of, different groups of stakeholders.

Businesses

Boston businesses find it difficult to incorporate climate change risks into their planning. The uncertainties are great; it is unclear how significantly these risks will affect their operations; and when the worst happens, it will likely be a long time in the future. Business owners do not usually plan more than five or ten years out. Climate risks may become significant, but there are many other future concerns

CLIMATE ADAPTATION RESEARCH IN EAST BOSTON

A research team that includes Ellen Douglas of the Environmental Earth and Ocean Sciences Department at the University of Massachusetts–Boston, Paul Kirshen of Battelle, the Urban Harbors Institute of UMass–Boston, and the Woods Hole Group, is currently working with nonprofit Neighborhood of Affordable Housing (NOAH) in East Boston to develop such locally tailored, multipurpose adaptation solutions.[90] NOAH has recruited participants from the community to participate in a series of workshops on climate change, its impacts on East Boston, and how to find solutions. In the first session, researchers asked participants to free-associate around the term climate change, and in the second they presented a lecture on climate change and then opened the floor to discussion of possible adaptation strategies. The East Boston residents immediately raised significant issues with conventionally accepted approaches to protecting communities, particularly sea walls. They grew angry at the suggestion of high sea walls because they see their water views as one of the few environmental amenities they have amid numerous environmental burdens. They also questioned the focus on measures homeowners can take to fortify their structures against flooding when a large fraction of the housing stock in their neighborhood is rented from absentee landlords. The research team and NOAH have been working to devise solutions that take these citizen concerns into account. As Kirshen said,

> When we were doing the CLIMB study, one of our subareas was all of Boston, the whole shoreline, so we could talk generally about an alternative such as a sea wall or something. But when you zero it down you have to start dealing with the real issue, and what's really there.[91]

They are exploring such ideas as wetlands, constructed sand dunes, and modular sea walls that would achieve greater resilience as well as flexibility. The housing stock could perhaps be fortified through cooperation with tenant rights groups, and the impacts of heat waves could be reduced by improving baseline air quality. As Brenda Cotto-Escalera of NOAH said,

> There is already work that is being done that is not called climate change work. We are working on open space, we want wetlands restoration in our area, we want things that will lessen the effects of heat islands. Things like that that are already tangible for the community because they see the green, they see the benefits, they see the air is better. Through that route you can really engage the community.[92]

The third meeting for this process, in the spring of 2010, will bring people in from the Massachusetts Office of Coastal Zone Management to talk about possibilities for funding adaptation measures, an important question for East Boston. Possible conceptual designs for adaptation will be presented. Evacuation as an option will be explored. As the neighborhood faces numerous challenges—including health woes, immigration reform, joblessness, and crime—it may be difficult to achieve a consensus that climate adaptation is an important issue to address. NOAH and the Chelsea Creek Action Group have had great success enlisting youth in environmental science and activism around such environmental justice issues as resisting the siting of polluting facilities, but it may be harder to inspire volunteers to work on climate change issues. There is no question, though, that local community leadership and input into adaptation plans will greatly increase public support for the actions that are necessary.[93] In Cotto-Escalera's words,

> The idea is that you build the capacity of a community that is there for the long run and believes that their actions can create change, that has political power because of its numbers, and that will be there to deal with whatever comes because within the area of environmental justice … climate change is one of those things that is going to be here for a while.[94]

With this community organization, the East Boston community could engage the business community, city government, state and federal agencies, foundations, and land trusts to together take the steps to build the neighborhood's resilience to climate change.

(such as Social Security and Medicare) that will impose bigger costs sooner, making them more likely to attract the attention of business leaders. Those issues, too, demand policy solutions. According to Jim Klocke, executive vice president of the Greater Boston Chamber of Commerce, the Boston business community regularly communicates with the city government about a wide range of issues it faces, and will approach climate change the same way. According to Klocke, Menino and Environmental & Energy Services have been very smart about "making cutting-edge policy [on climate change] in a way where the economy can continue growing, generating revenue, and supporting jobs."[95]

Waterfront Property Owners

For Boston waterfront property owners, too, climate change has not yet become an issue of great concern. As the Boston Harbor Association's Li pointed out, many property owners remain unconvinced that sea levels will rise greatly and, even if they do, that that is really relevant to their short- and medium-term investments. Li said she does not believe that imprecise climate change and sea-level rise projections are the reason, but rather prevailing business culture and legitimate skepticism about whether the current dire predictions around climate change will prove accurate. One factor that she believes might change their positions is insurance rates. If it became prohibitively expensive to insure waterfront structures, then property owners and developers might begin to take climate change into account in their decisions. Until then, property owners will continue to plan on shorter, arguably more practical, timelines.[96] The other influencing factor, of course, is government regulation. In this realm, changes such as the Conservation Commission's recent consideration of sea-level rise in permitting new structures may begin to shape development and real estate practices.

Neighborhoods: East Boston

Climate change will mean different things to different neighborhoods depending on their unique geographies, demographics, and current environmental contexts. East Boston is recognized as one of the neighborhoods of Boston most vulnerable to rising sea levels and changes to groundwater, due to its low elevation and construction on fill. East Boston and the Chelsea Creek area also currently bear some of the heaviest environmental burdens in Boston, with poor air quality that could be seriously exacerbated by climate change–related heat waves. The long history of environmental injustice in the area, and the population's low income and high proportion of immigrants and renters make for a highly challenging context in which to consider the impacts of climate change.[97] East Boston is a clear example of why climate change adaptation cannot be solved through top-down application of technical solutions. Rather, adaptation must be a cooperative endeavor engaging local residents alongside city officials and technical experts, to shape solutions that account for unique local contexts and create tangible near-term benefits alongside longer-term increases in resilience.

CONCLUSION

Crafting Boston's approach to reducing greenhouse gas emissions and, in

particular, to increasing the city's resilience to the effects of climate change, will require recognition of the unique challenges climate change poses to different stakeholders within the city. Boston has made great progress in developing and implementing innovative programs to reduce greenhouse gas emissions. In recent months the Climate Action Leadership Committee and Community Advisory Committee have advanced this important climate mitigation work, while beginning the development of long-term strategies for public engagement and adaptation to climate change. By investing in a robust and well-integrated community stakeholder process in planning its climate action, the city of Boston has recognized the importance of understanding its many vulnerabilities to climate change in terms of the economic and social contexts of different neighborhoods, constituencies, and economic interests. It is imperative that Boston maintain a high level of public involvement in crafting climate change policies and programs, for while mitigation and adaptation are daunting technical challenges, the success of the efforts will play out largely in the social and economic realities of the city.

Therefore, as the city takes on climate adaptation it is important not only to gather technical information on the risks, but also to engage the individuals, communities, businesses, and institutions that will face these hazards.

CLIMATE ACTION LEADERSHIP COMMITTEE MEMBERS[99]

Cochairs

Mindy Lubber, *President, CERES*
James W. Hunt III, *Chief of Environmental and Energy Services, City of Boston*

Members

James McCarthy, *Harvard University; Board Member, Union of Concerned Scientists*
Kalila Barnett, *Executive Director, Alternatives for Community & Environment*
Theodore Landsmark, *President, Boston Architectural College*
Timothy Healy, *Chief Executive Officer, EnerNOC*
Bud Ris, *President and Chief Executive Officer, New England Aquarium*
Bryan Koop, *Senior Vice President, Boston Properties*
John Connolly, *At-Large Boston City Councilor*
Tedd Saunders, *Executive Vice President, Hotel Lenox; President, Eco-Logical Solutions*
Ray Hammond, *Pastor, Bethel AME Church; Chairman, Ten Point Coalition*
James Coyle, *General Agent, Boston Building Trades*
Richard Dimino, *President, A Better City*
Judith Nitsch, *President, Nitsch Engineering*
Mark Buckley, *Vice President, Staples*
Chuck McDermott, *General Partner, RockPort Partners*
Margaret Williams, *Executive Director, The Food Project*
Stephanie Pollack, *Associate Director, Center for Urban and Regional Policy, Northeastern University*
David Queeley, *Director, Trust for Public Land*
Viki Bok, *Jamaica Plain Resident*
Rebecca Park, *Boston Latin School, Youth Climate Action Network*
Galicia Escarfullery, *Hyde Square Task Force*

WAYNE KLOCKNER, STATE DIRECTOR OF THE NATURE CONSERVANCY IN MASSACHUSETTS:

"During these times when budgets are so stressed and hard choices are having to be made, it's particularly tough to convince local communities to invest in something longer term like that … I think a lot of adaptation is actually established best practices in other contexts as well. It's not as though some of the things that are going to become critical to do in response to climate change are brand-new and different. If rivers are going to flood more often and more severely, limiting development in the flood plain is going to be a good thing to do, but it's always been a good thing to do. Sea-level rise has been a reality for just about as long as we've been able to measure it, just at a much slower pace. That does not negate the fact that thinking about sea-level rise in the context of coastal development is a smart thing to do, it's just now going to become an even smarter thing to do and sooner because of climate change. So if there is a way we can couch those arguments less in a 'someday there might be this' kind of context and rather more in the context of best practices regardless of climate change, we will enhance the public's receptiveness to responding sooner. I think that sea-level rise is a good example of one where people ought to be aware of how serious its potential impact is. But it has to be done in a way that isn't 'the sky is falling,' because I think that engenders a tendency on the part of a lot of folks to just hunker down and not want to think about it. So we have to make it relevant to them in time frames that are more meaningful and immediate."[98]

"If there is a way we can couch those arguments less in a 'someday there might be this' kind of context and rather more in the context of best practices regardless of climate change, we will enhance the public's receptiveness to responding sooner."

By investing in a robust and well-integrated community stakeholder process in planning its climate action, the city of Boston has recognized the importance of understanding its many vulnerabilities to climate change in terms of the economic and social contexts of different neighborhoods, constituencies, and economic interests.

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Gloucester: A Vulnerable City with Many Assets for Building Resilience

By Tyler Corson-Rikert

CASE STUDY #2

OVERVIEW OF GLOUCESTER AND CLIMATE CHANGE

Gloucester is a coastal Massachusetts city and famous fishing port on an island 25 miles northeast of Boston. Sixty-two miles of coastline are within city limits. Commercial fishing, a $54 million industry, remains a pillar of Gloucester's economy, along with tourism and maritime businesses. The city faces serious challenges in striving to develop a 21st century economy and upgrade critical infrastructures in the midst of the national recession. But, it is home to many progressive citizens who want to insure the city's future in light of such concerns as climate change.[100]

Photo: Steven Erat, "Gloucester, Massachusetts" January 2, 2006 via Flickr, Creative Commons Attribution.

Gloucester currently has few policies or initiatives that directly confront climate-change risks. However, the city has incorporated an active group of citizens into a formal Clean Energy Commission and is undertaking flood mapping updates, natural hazard mitigation planning, and disaster response planning—efforts that will lay the foundation for any future initiatives to increase the city's resiliency in a changing climate.

GLOUCESTER'S VULNERABILITIES TO CLIMATE CHANGE

Gloucester faces many climate change risks, though its coastal location makes rising sea levels and storms the most prominent threats. Other potential impacts identified by city and state officials include storm water flooding, erosion, heat waves, vector-borne diseases, and harm to the local economy.

Gloucester currently has few policies or initiatives that directly confront climate-change risks.

Sea-Level Rise

Although no study has been done of Gloucester's vulnerabilities to sea-level rise and storm surge flooding, the significance of these risks is clear given the city's 62-mile coastline. A lot of Gloucester's infrastructure, buildings, and businesses are right on the waterfront, including a state Designated Port Area. However, the land rises quickly as you move inland. In West Gloucester there are more low areas, but few residential properties are on the water. Moreover, coastal properties tend to be more expensive, and few low-income residents live along the shore. Therefore, coastal property owners are often more able to afford repairs after damage. However, there is no question that if sea level rose by feet rather than inches the economic

and social impacts on Gloucester would be significant. Of particular concern are the plans for rebuilding the sewage treatment plant. Although citizens have insisted at public meetings that the new facility be designed to withstand climate change, there are no plans to relocate the facility from its current location.[101] The causeways that provide access to the city are also clear sources of vulnerability. At times, when high winds and tides have aligned, waves have surged over roads and damaged them—such as during a 1991 storm.[102]

The Federal Emergency Management Agency (FEMA) and the Massachusetts Department of Conservation and Recreation (DCR) are currently working with Gloucester to update Flood Insurance Rate Maps identifying current 100-year flood zones.[103] That modeling and mapping will be completed in the summer of 2010 and inform a second effort, planned in conjunction with FEMA and the Metropolitan Area Planning Council, to devise a natural hazard mitigation plan.[104] These two efforts are focused on current hazards, but nevertheless offer insight into the vulnerabilities presented by flooding due to sea-level rise and storm surge.

Storm Water

In addition to ocean flooding, inadequate storm water infrastructure could cause flooding outside of mapped flood zones. Flooding from storm water runoff has occurred in the past in the Maplewood Avenue residential and commercial area and at Poplar Park. During the 2006 Mother's Day Storm, a flooding stream wiped out the access road to the elderly housing development in Poplar Park, and the basements of many homes in Gloucester flooded. Old dams that could potentially fail during flood events are an additional threat to residents and property.[105]

The more intense storms expected from climate change would certainly stress the city's water supply and storm water infrastructure. For 20 days in August 2009, Gloucester residents had to boil their water because of high levels of coliform in the city's aging water supply system, an event that, while not attributable to climate change, highlights the system's vulnerability. In Mayor Carolyn Kirk's words,

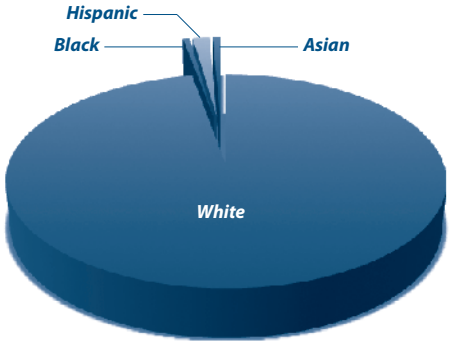
> We believe that heavy rains in June contributed to causing a bloom of algae in the water supply and then during a heat wave in August the water quality deteriorated so much that the plant could not keep up and there was a failure. We had a boil water order for 20 days. Whether or not that was climate change I do not know, but deteriorated infrastructure definitely contributed. Any stresses on the infrastructure by nature cause great problems.[106]

The city is working now under consent orders from the Massachusetts Department of Environmental Protection (DEP) and the US Environmental Protection Agency to upgrade its water and sewage treatment plants and resolve combined sewer overflow issues in its storm water system.

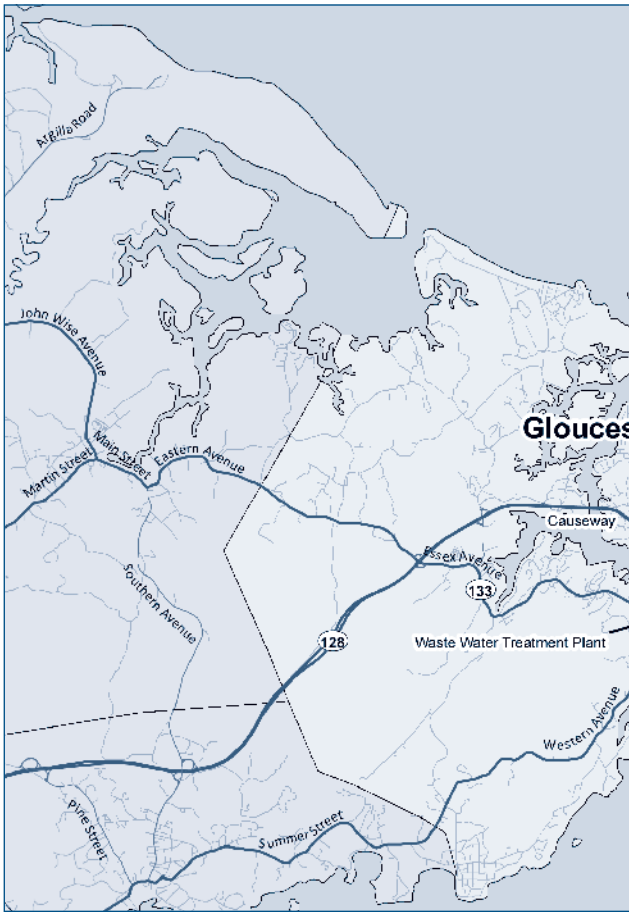
GLOUCESTER DEMOGRAPHICS

2006 Population	30,564
Percentage change 2000 to 2006	+ 1%
2000:	
Percentage foreign born	5%
Percentage with high school diplomas	86%
Percentage with bachelor's degrees	28%
1999:	
Median household income	$47,722
Percentage living below the poverty line	9%

Source: "State & County QuickFacts: Gloucester, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2526150.html.



RACE/ETHNICITY BREAKDOWN, 2000
Source: "State & County QuickFacts: Gloucester, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2526150.html.



The more intense storms expected from climate change would certainly stress the city's water supply and storm water infrastructure.

Gloucester's citizen-initiated effort to reduce greenhouse gas emissions provides a possible model for engaging city stakeholders in the related issue of climate adaptation.

Public Health

Health department officials have identified several risks from climate change, including increases in mosquito- and tick-borne diseases like West Nile and Lyme disease, heat waves, and storm impacts on physical and mental health. Gloucester currently has high rates of tick-borne Lyme disease but the area's saltwater mosquitoes are immune to vector-borne diseases such as West Nile.[107] Public Health Director Jack Vondras has expressed concern that climate change could cause Lyme disease to worsen, and that area mosquitoes might become susceptible to West Nile. If climate change brings more rainfall and marshes stay wet longer, then mosquito-borne diseases would likely become more prevalent.

Economy

Mayor Kirk and other city officials have expressed concerns about the potential for climate change to damage Gloucester's fishing, maritime, and tourism industries.[108] Tourism is very important to the city's economy, with jobs in food service, hotels, and visitor attractions making up 11 percent of total employment. The city's attraction lies in its natural environment, Gloucester's distinctive harbor and marine industries, and the area's rich history. Municipal beaches, which sea-level rise and storm activity could erode, bring in over a million dollars in revenue each year.[109] Many visitors come to observe the working waterfront and fishing industry, which could also be threatened by changing climate and sea-level rise. The fishing industry is already very vulnerable due to environmental changes and government regulation; therefore, climate-induced biological changes in the ocean could prove catastrophic. Moreover, fishing and other maritime industries rely on waterfront infrastructure that sea-level rise could threaten. On a positive note, a consultant to the city's Community Development Department recently highlighted the possibility that climate change-produced storm activity and coastal erosion might increase demand for the construction and engineering services of Gloucester's maritime industries to protect property along the Atlantic coast.[110]

CLIMATE CHANGE MITIGATION EFFORTS IN GLOUCESTER

Gloucester's citizen-initiated effort to reduce greenhouse gas emissions provides a possible model for engaging city stakeholders in the related issue of climate adaptation. Around 2002 a small group "interested in grassroots activities to bring people together and raise awareness around energy issues" formed the Cape Ann Energy Network.[111] The group worked to connect city residents to state clean energy programs, organized an energy fair, and held a series of workshops, increasing awareness of energy and climate change issues in the community.[112]

In August 2009, the Gloucester City Council formally incorporated a Clean Energy Commission to "promote clean energy options in Gloucester, including energy efficiency, conservation, and the development of clean and renewable energy."[113] Its specific directives include developing strategies to reduce the city's energy costs, tracking state and federal mandates and grant programs, providing guidance to

city staff and the public, and identifying "climate adaptation and mitigation issues and strategies to safeguard the long-term economic and cultural vitality of the city."[114] Mayor Kirk appointed a number of the Cape Ann Energy Network's leaders to the commission.[115] According to Kirk, "Originally anything around energy was a task force that had no standing. My administration researched best practices and looked at progressive cities where committees had been established by ordinance, giving them influence and stature in an advisory role to the City Council."[116] Since its founding, the commission has focused primarily on helping the city apply for stimulus money and become a certified Green Community under the Massachusetts Department of Energy Resources Green Communities Program.[117]

CLEAN ENERGY COMMISSION MEMBER JILL BUCHANAN:

"First, our Energy Commission is quite new—less than a year old. We haven't addressed climate adaptation at this point because we feel it's important first to address the more obvious and politically easier issue of reducing the city's carbon footprint. There's money to be obtained for this and money to be saved as a result, so it's a much easier sell. Once we gain traction and trust in this area we hope to address the issue of adaptation more directly. But this is a city that is financially very strained. The focus is on keeping basic services and schools functioning, so to start out asking the city to create an adaptation plan would not likely lead to success. Hopefully, in a year or two, but not to start out."[118]

CLIMATE ADAPTATION EFFORTS IN GLOUCESTER

Overview

The city of Gloucester is currently doing little explicitly to increase its resilience to climate change, but it has multiple efforts under way that provide a strong foundation for taking on climate-change risks in the future. An emergency response planning team is preparing the city to effectively handle a wide range of situations, including storms, flooding, heat waves, and epidemics of the sort climate change might produce. It is also working with FEMA, the state DCR, and the Metropolitan Area Planning Council to map current flood risks and plan for the mitigation of natural hazards. Finally, the city is in the midst of making massive, state- and federally mandated investments to upgrade its water supply, waste treatment, and storm water infrastructure.

Emergency Response

The Gloucester Health Department participates actively in city and regional emergency response planning for health crises and natural disasters that might occur in the near term, but would also likely worsen and become more frequent in a warming climate. The department is working alongside the police, Fire Department, Coast Guard, hospitals, day cares, school systems, and other entities to plan and drill how to respond to incidents ranging from terrorism to heat waves to blizzards. The team plans a major drill in spring 2010 modeled on an ice storm and have discussed simulating a hurricane in the future.[119]

The city of Gloucester is currently doing little explicitly to increase its resilience to climate change, but it has multiple efforts under way that provide a strong foundation for taking on climate-change risks in the future.

The Gloucester Public Health Department has also received funding from the Centers for Disease Control and Prevention through the Massachusetts Department of Public Health to help coordinate regional emergency responses to a wide range of hazards through the North Shore–Cape Ann Emergency Preparedness Coalition.[120] The 15 communities involved (including Lynn) work together on best practices and mutual aid agreements.[121] Such emergency planning clearly increases Gloucester's capacity to respond to natural disasters and infectious diseases that might arise due to climate change. Yet that planning is not intended to look more than a few years ahead. Vondras of the Gloucester Public Health Department said that his department does not sit down and think specifically about the long-term, severe risks expected from climate change; there is a limit to what they have time

to do. While they have devoted more and more resources to emergency planning in recent years, the department must still carry out its traditional duties, including inspecting restaurants and dealing with infectious disease outbreaks such as the H1N1 flu pandemic.[122]

Coastal and River Flooding

The Gloucester Community Development Department is currently coordinating with the Massachusetts DCR and FEMA to update area Flood Insurance Rate Maps. The maps depict the likely extent of the 100-year flood, a flood that has a 1 percent chance of occurring in any given year. This is the measure used to set flood insurance rates. FEMA produces the maps through careful modeling of hydrology and storm surge interactions with topography. Draft maps are available on the Community Development Department's website; final versions will be released in April 2010 and are expected to be adopted in July 2010 after review by local officials and a public comment period.[123] The new maps will be a great resource to the city of Gloucester both for land use and natural hazard mitigation planning.

However, the maps are intended to show current, not future conditions, according to Richard Zingarelli, whose Office of Flood Hazard Management at the DCR is contracted by FEMA to provide technical assistance to Massachusetts communities and facilitate information flow between the mapping effort and local governments and citizens. "There are no projections of effects of climate change on those maps," Zingarelli said. Nevertheless, the FEMA maps can be used in conjunction with climate change forecasts that predict how often today's 100-year storm may occur under a future climate system. It is important to understand, though, that such estimates would be quite rough because the projected sea-level rise cannot simply be added onto current maps. An accurate understanding of post-sea-level-rise flooding would require new modeling to understand the complex interactions of storm surge, waves, and topography.[124]

Natural Hazard Mitigation Planning

The city of Gloucester is also working with the Metropolitan Area Planning Council (MAPC) to develop a natural hazard mitigation plan so that it can apply for further FEMA funding. This effort is related to the emergency response planning in the breadth of entities consulted and the range of hazards considered, but focuses instead on actions that can increase resiliency before events occur. Joan Blaustein of the MAPC is developing the plan for Gloucester, meeting with planning, public works, and water and sewer officials to gather information on critical infrastructure, emergency shelters, schools, nursing homes, and substations—any facility that would be part of an emergency response or is particularly vulnerable. Hazards considered include natural flooding, dam failures, earthquakes, high winds, brush fires, and landslides. The goal is to understand where events have occurred or could occur, their causes, and what the city could do to reduce its vulnerability. According to Blaustein, what follows is an

> Effort at goal setting and objectives, and then the heart of the plan, what

> FEMA is looking for, is potential mitigation efforts. What is the solution for this particular area, the flooding here? .... Generally what [the MAPC] has found is that although most coastal communities are aware of the potential for additional flooding, they are so busy trying to just play catch-up with existing needs that they don't tend to be that focused on "We'd better plan for this 30 to 40 years down the road."[125]

Although these natural hazard mitigation plans do not address climate change and sea-level rise, the process of developing the plans, identifying specific hazard mitigation actions, and applying to FEMA for funding will greatly enhance the city of Gloucester's knowledge about the community's vulnerabilities and ways to increase resiliency.

Infrastructure

Much of Gloucester's older critical infrastructure is in poor condition, having been neglected for 25 to 30 years while the City, in response to court-ordered clean-water mandates, invested in extensive sewer systems in outlying areas. The city's water treatment, distribution, and storage systems need large investments to meet current standards. The city is under a consent order from the Massachusetts Department of Environmental Protection requiring it to upgrade its water system. It is receiving help from the DEP and seeking further state and federal aid for the expected $50 million to $60 million project. The city is also under a federal consent order requiring it to separate sewer water from storm water (excess storm water causes sewage to overflow into the river or Gloucester Harbor), a $60 million project, and the sewer plant needs $13 million to $15 million of work. According to Mayor Kirk, "the city is investing in areas where it has absolutely no choice based on urgent priorities and regulators' demands. In my perspective, those are the priorities—especially the water system—not climate change."[126] In upgrading its infrastructure, the city of Gloucester is working to just meet current standards, not go above and beyond to utilize state-of-the-art technologies or incorporate climate adaptation considerations into the system. As Kirk said,

> To some extent our hands are tied. When the waste treatment plant was built the technology was already 20 years behind current innovations. … Sometimes regulators won't let us go to the most progressive solutions because the rest of the system won't accommodate them; the ripple effects become unmanageable. If we could start all over again, we would. We're barely up to current standards, let alone the state of the art.[127]

Clearly, the city has little financial leeway to add costs to these infrastructure upgrades, but it might be possible to take climate change risks into account when planning expensive investments that the community will count on far into the future.

ESSEX COUNTY GREENBELT ASSOCIATION'S CLIMATE ADAPTATION WORK

The city of Gloucester benefits from the long-term vision and land conservation work of the Essex County Greenbelt Association (ECGA). This local land trust is focused on protecting land for its ecological, agricultural, and scenic quality, with a particular emphasis on preserving landscape corridors, or greenbelts, between different natural areas. These assets are critical for resilient ecosystems. According to the ECGA's executive director, Edward Becker,

> We are just beginning to think about how to respond to climate change. We are reading the literature and starting to participate in discussions around adaptation. This fits in with our long-term mission on preserving corridors so that species have the ability to migrate in response to changing climate conditions. We are starting to write about climate change, educate ourselves, and educate our membership. We are looking at how we should begin to reflect climate change in what we are working on in our planning, both in land acquisition and stewardship—how we manage our properties.

The ECGA benefits from its relationship with the Marine Biological Laboratory of Woods Hole, which leases land from the ECGA for the Plum Island Ecosystems Long-Term Ecological Research site.[128] The laboratory researches the effects of sea-level rise on marshes and species, particularly the

prevalence of invasive species whose spread may be influenced by climate change. The ECGA has not conducted primary research itself, but has listened with interest to findings such as the ability of marsh plants, to a certain degree, to build up and keep pace with rising sea levels. The ECGA has a long-standing interest in protecting uplands directly adjacent to marshes for wildlife, which may have a side benefit of preserving space for the onshore migration of wetland communities as sea levels rise. Despite the regulatory protection of wetlands, the ECGA has made acquiring marshes and adjacent buffers areas a priority. The ECGA does not advocate for land use changes at the local level, focusing instead on its core mission as a land trust. Nevertheless, Becker says that ECGA "recognizes that [land use regulations] will make the lion's share of any difference. Land acquisition will always have a smaller impact. It has always been the case that the real effect on the landscape is the planning and zoning regulations." Becker participated this year in a session that The Nature Conservancy coordinated in conjunction with the state Climate Change Adaptation Advisory Committee on enhancing the resilience of natural communities to climate change. The ECGA is interested in the committee's recommendations in light of how they may influence land acquisition as well as the association's education and fund-raising efforts.[129]

CHALLENGES AND POSSIBLE STRATEGIES FOR CLIMATE ADAPTATION IN GLOUCESTER

The climate-related efforts under way in Gloucester provide a strong foundation, but developing an integrated climate adaptation strategy will still be a great challenge for the city. The general financial climate and the mandated infrastructure investments greatly constrain Gloucester's efforts. City officials understand many of the risks that climate change poses to the city, but it is difficult for them to take on new initiatives. Mayor Kirk said she welcomes the state climate adaptation planning effort, as long as its recommendations do not turn into unfunded mandates for Gloucester.[130]

Integrating Climate Adaptation Into Decision Making

One way to increase Gloucester's resilience to climate change would be for relevant city departments to consider climate change risks in their routine decision making. According to Kirk, current city ordinances and infrastructure planning do not take climate change into account. The challenge, as the mayor pointed out, is that such evaluation requires that staff be knowledgeable about climate change hazards and the effects of their decisions on the community's vulnerability. While the city has consultants who could provide such information for infrastructure projects, in other areas staff would require training.[131] For example, currently the state offers little guidance on what should and should not be built in flood plains.

According to Community Development Director Sarah Garcia, city regulatory systems could take climate change risks into account if there were clearly stated guidelines for expected climate change. Climate change impacts could be considered locally in special permits or conservation permitting, statewide through the Building Code, or federally via the FEMA flood maps. The new Flood Insurance Rate Maps that FEMA is creating will affect policy in that they determine the Conservation Commission's jurisdiction for reviewing projects, but these maps have not included any predicted expected sea level rise. The city also requires a lowlands special permit, issued by the city council, for construction of buildings on sites below 10 feet above sea level or on floodplains. Garcia said,

> We don't have a lot of formal waterfront planning that takes into account climate change. It would be helpful to us if there were accepted guidelines on expected sea level rise on which we could base our planning. We could then take a 50 year view, adapting our plans and regulations in ways that would not be immediately threatening to any individual or the community.[132]

City regulatory systems could take climate change risks into account if there were clearly stated guidelines for expected climate change.

In a developed city like Gloucester, long-term planning analysis of existing buildings and infrastructure will develop the resilience the community needs to smoothly adapt to the climate change challenge.[133]

Better Data

One obstacle to better regulation of development in flood-prone areas is the lack of detailed, up-to-date mapping and projections. Planning Director Gregg Cademartori participated in a coastal zone subgroup meeting of the state Climate Change Adaptation Advisory Committee, and he said that much of the discussion centered on what amount of sea-level rise to plan for. The new 100-year flood maps to be released by FEMA in 2010 will help define current risks in Gloucester, but not future effects of sea-level rise and storm surges interacting with the topography. The city has some datasets from the Massachusetts Office of Coastal Zone Management, which partnered with NOAA to obtain LIDAR (light detection and ranging) topography survey, which is a good start to modeling sea level rise impacts. As Samuel Cleaves of the Clean Energy Commission said, "If you want to create a bylaw or ordinance about building along the coast with sea level-rise in mind, then you need to know where to draw the line in the sand."[134] The Community Development Department already has some LIDAR data, however it is costly to obtain, and may only be expanded by a state initiative.[135] However, the topography survey would still leave open the question of what sea-level rise projection to use for policy making.

Engaging Stakeholders

Another key question for Gloucester is how to involve community stakeholders and the public in any effort to adapt to climate change. The city currently engages with the public on relevant issues only through meetings held to present natural-hazard mitigation plans, through public hearings before the release of the new FEMA flood maps, and occasionally at public hearings on proposed waterfront developments. In Blaustein's experience the natural hazard meetings are not well-attended because the plans "are not on people's radar screens … there's not anything immediate happening." She said that if Gloucester decides to take on climate adaptation she would definitely recommend a stakeholder process. This process would need to be much bigger than the current natural-hazard planning program, which has limited funding and just aims to create a specific plan, not a strategy for the whole community.[136] Similarly, the public hearings around new FEMA flood maps focus only on technical or highly localized issues, as Zingarelli of the Massachusetts Office of Flood Hazard Management explained:

> The sort of information that is being solicited as part of [the public hearings] is very specific to the technical aspects of the maps and how they were developed … . [These formal appeal and public comment periods] will not provide a whole lot of information toward how the community would use the data and what sort of outreach is needed to go through that process. One thing I would say is that any kind of changes in zoning or land use would need fairly extensive outreach at the local community level … town meetings, local information meetings, and so forth … where you're soliciting from the residents of the community their views on how this all should occur.[137]

"Any kind of changes in zoning or land use would need fairly extensive outreach at the local community level … town meetings, local information meetings, and so forth … where you're soliciting from the residents of the community their views on how this all should occur."

Community Development Director Garcia said she believes that many Gloucester officials and citizens would be interested in engaging in discussions about how to make the community more resilient to climate change.[138] The city has many knowledgeable citizens, many officials whose work relates to climate change issues, and clear vulnerability to rising sea levels and other impacts. The Clean Energy Commission's work on reducing greenhouse gas emissions certainly highlights the potential for productive citizen involvement in decisions over how best to advance the city's interests related to climate change.

Current natural hazard mitigation activities, infrastructure upgrades, planning regulations, and emergency preparedness work are beginning to address many of the city's vulnerabilities.

A community effort around adaptation could also advance Garcia's goal of promoting Gloucester as a center for climate change-related research.[139] The city is home to research efforts in fields such as fisheries management, marine biology and biotechnology, marine technology, and aquaculture, and is working to attract marine renewable energy research in such areas as wave, tidal, and offshore wind technology development.[140]

CONCLUSION

Gloucester is a coastal community with great vulnerability to climate change, particularly from coastal and storm water flooding, heat waves and vector-borne diseases, and disruption of the local economy. Through the work of the Community Development Department and the Clean Energy Commission, the city has begun to take the mitigation side of climate change seriously. Gloucester has not yet taken explicit action to increase its resiliency to the effects of climate change, but current natural hazard mitigation activities, infrastructure upgrades, planning regulations, and emergency preparedness work are beginning to address many of the city's vulnerabilities. Significant financial, institutional, and data obstacles remain, but there are citizens and leaders in Gloucester who understand climate change risks and will have much to contribute to securing the city's future as the climate changes.

NOTES

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132. Garcia and Cademartori, interview.

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Lynn: Taking on Many Challenges, But Not Climate Change Adaptation

By Tyler Corson-Rikert

CASE STUDY #3

OVERVIEW OF LYNN AND CLIMATE CHANGE

Lynn is a coastal Massachusetts city facing economic challenges that overshadow the less immediate concern of climate change. Public safety is also a big challenge to the city and a damper on economic development. While most people think Lynn is a wonderful community, there is an outside perception that it is not safe to live and do business there. The city of Lynn is trying to leverage its assets—its proximity to Boston and its waterfront—to build a more robust economy.[141]

Photo: Robert A. Wilson, "City of Lynn"
Courtesy of the photographer.

In light of the city's immediate economic concerns, Lynn has taken little action either to reduce greenhouse gas emissions or to adapt to a changing climate. The city government does not have an explicit climate action plan, nor any concerted effort to lower energy use, increase efficiency, or switch to cleaner energy sources. However, the City Council does have a Renewable Energy Committee, and a group of individuals and organizations in Lynn has formed the Lynn Coalition for Green Development, which advocates for green jobs, energy efficiency, and other sustainability initiatives. Action on climate change in the city has so far centered on opportunities to save money and develop the economy. There has been little attention to the risks that climate change poses.

The city government does not have an explicit climate action plan, nor any concerted effort to lower energy use, increase efficiency, or switch to cleaner energy sources.

LYNN'S VULNERABILITIES TO CLIMATE CHANGE

Sea-Level Rise

While there has been no specific study of the likely impact of climate change on Lynn, reference to the Union of Concerned Scientists' report Confronting Climate Change in the US Northeast suggests that the city will face rising sea levels, increased storm activity, more high-rainfall events, droughts, heat waves, and a surge in vector-borne disease. As a coastal city, sea level is one of the most obvious concerns, with levels estimated to rise 7 to 75 inches by the end of the century.[142] Currently, Lynn's waterfront is dominated by industry: a liquid natural gas tank, the Lynn Regional Wastewater Treatment Facility, and a state Designated Port Area are all sited on the water, protected against current sea levels by a sea wall. However, the city is making future waterfront development a priority; its new Waterfront Master Plan outlines a strategy for maintaining the existing working waterfront

areas in the Designated Port Area while promoting mixed-use development and pedestrian access.[143]

The city and its consultants are also working on a Municipal Harbor Plan with new development expected to begin once the plan is completed and the national economy improves. The city has not addressed the risk of sea-level rise in its plans, but state and federal permits necessary for specific waterfront projects may contain related stipulations—particular in coming years as agencies such as the Army Corps of Engineers develop standards to mitigate the effects of sea-level rise.[144] Tony Dunn of the Lynn Coalition for Green Development expressed concern that historically neglected neighborhoods along Bennett and Alley streets (Ward 6), just inshore from the Waterfront Master Plan area, might face flooding. Important regional transportation corridors, including Route 1A (the Lynnway) and commuter rail, also run through this area.[145] Besides the main harbor waterfront, Lynn also has low-lying areas along the Saugus River that would not bear the brunt of a storm, but could flood if storm surge coincided with high tide.[146]

Flooding from Rainfall

Large rainfall events pose another significant flooding risk, as Lynn residents have already seen. In 2006, the Mother's Day Storm dropped 13-14 inches of rain in 24 hours, overwhelming the storm water system and flooding much of the city. This flooding occurred largely outside the flood plain, with water running down streets because debris had collected in drains and storm water retention ponds had filled. According to Daniel O'Neill, executive director of the Lynn Water and Sewer Commission, the city's storm water system is designed for a five-year storm with an extra margin of protection, but larger or back-to-back storms can simply bring in too much water for the system to handle. If the frequency of high-rainfall events increases, flooding may occur more often throughout the city.

Moreover, the storm water system relies on gravity flow, so its outlets are located on piles near sea level. Sea-level rise could make it necessary to move the outlets higher up to prevent backup, although in O'Neill's judgment the outlets are high enough to be unaffected.[147]

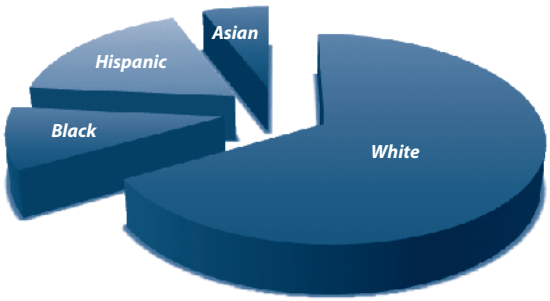
CLIMATE CHANGE MITIGATION EFFORTS IN LYNN

The city of Lynn is not currently focused on climate change issues, although there have been efforts to advance energy efficiency and renewable energy. North Shore Community College has been a leader in the community, with President Wayne Burton signing onto the American College and University Presidents Climate Initiative and supporting the work of Director of Facilities Management Rick Reney to reduce the college's carbon footprint through the installation of solar panels and more efficient heating, cooling, and lighting systems.[148] While building owners and companies around Lynn are beginning to think about energy efficiency and sustainability, the current economic climate, various technical issues, and the intricacies of state and federal energy efficiency programs make action difficult.[149]

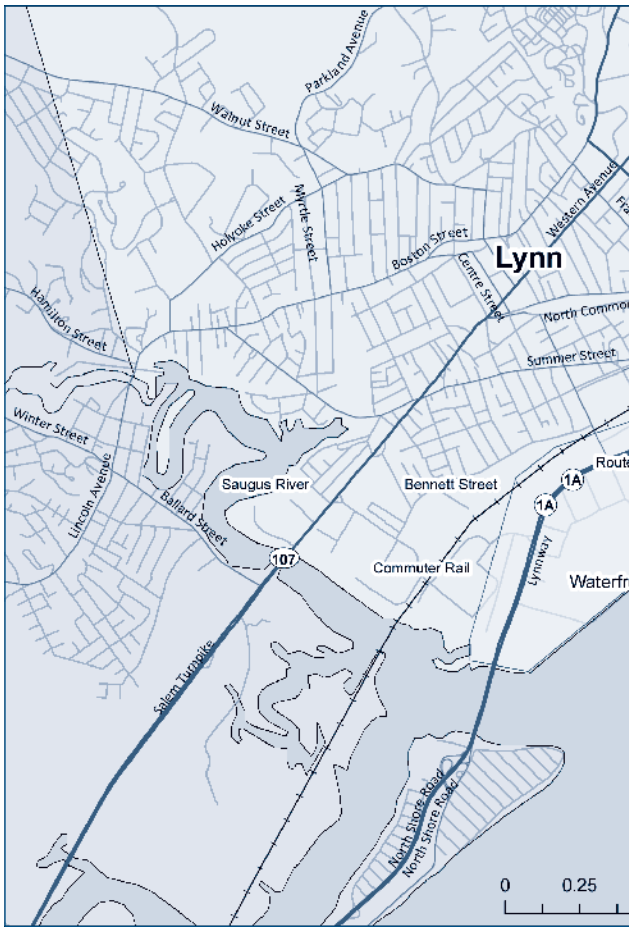
LYNN DEMOGRAPHICS

2006 Population	87,991
Percentage change 2000 to 2006	- 1.2%
2000:	
Percentage foreign born	23%
Percentage with high school diplomas	74%
Percentage with bachelor's degrees	16%
1999:	
Median household income	$37,364
Percentage living below the poverty line	17%

Source: "State & County QuickFacts: Lynn, Massachusetts." US Census Bureau, quickfacts.census.gov/qfd/states/25/2537490.html.



RACE/ETHNICITY BREAKDOWN, 2000
Source: "State & County QuickFacts: Lynn, Massachusetts." US Census Bureau, quickfacts.census.gov/qfd/states/25/2537490.html.



The city's storm water system is designed for a five-year storm with an extra margin of protection, but larger or back-to-back storms can simply bring in too much water for the system to handle.

The idea of creating a new green economy in Lynn around energy efficiency, renewable energy, and green jobs has generated significant interest.

That said, the idea of creating a new green economy in Lynn around energy efficiency, renewable energy, and green jobs has generated significant interest. A company called North Shore InnoVentures recently opened a green business incubator in Lynn.[150] Lynn could also become a site for renewable energy generation. The Lynn City Council has a Renewable Energy Committee that has pursued siting a wind turbine near the water and sewer treatment plant, and that project could be a pilot for further wind power development. The advocacy group Lynn Coalition for Green Development is partnering with other local organizations on state and federal funding opportunities, advocating for green policies in the city, and developing a local workforce trained in home weatherization and renewable energy installation skills. The coalition consists of member organizations and individuals, including the faith-based Essex County Community Organization; a political action group, Neighbor to Neighbor Massachusetts; an advocacy group for a low-income neighborhood, the Highlands Coalition; an umbrella organization for local labor unions, the North Shore Labor Council; an adult education center, Operation Bootstrap; and individuals with expertise in education, the building trades, and urban agriculture.[151]

CLIMATE ADAPTATION-RELATED IN LYNN

The city of Lynn has not begun to plan for the impacts of climate change. The city's Department of Public Works (DPW) has been focused on more immediate needs. According to Commissioner Jay Fink, these include upgrading streets to comply with the Americans With Disabilities Act and adding bikeways. If roads were wiped out by storms, the DPW would repair them, but that has not occurred in recent years. Nor'easters regularly force the closure of the highly exposed causeway from Lynn to Nahant, but that is not under the city of Lynn's jurisdiction. Roads along the Lynn waterfront, such as Lynn Shore Drive, are protected by sea walls.

Fink said he is not sure how climate change might begin to enter into decision making, whether by becoming a local priority or through new state guidelines or funding. The state does offer grant money for storm abatement projects that could be used to protect roadways from damage. However, there has not been any organized natural hazard mitigation planning in Lynn involving the DPW.[152]

Sea-Level Rise

A current focus of Lynn's Economic Development and Industrial Corporation (EDIC), a non-profit corporation that serves as the city's development bank, is to prepare the way for new development along Lynn's waterfront.[153] In 2007, Sasaki Associates completed a Waterfront Master Plan for the EDIC, laying out a vision for high-density mixed use, open space, and continuation of the existing working waterfront.[154] Work is under way on a Municipal Harbor Plan that will ease state and federal approval of future development projects so that building can commence when the national economy recovers. Varoujan Hagopian of Sasaki Associates said that neither the Waterfront Master Plan nor the Municipal Harbor

Plan addresses climate change risks. Climate considerations might arise when specific development proposals require state and federal approvals from agencies such as the Department of Environmental Protection, Department of Coastal Zone Management, or the Army Corps of Engineers. However, those agencies have not yet fully developed policies around climate change resilience.

Buildings for non-water-dependent uses must be set back 100 feet from the waterway in the portions of the Waterfront Master Plan area designated under state Chapter 91 regulations regulating the use of tidelands.[155] However, this requirement is intended to preserve waterfront access for the public, not to protect property from storm damage. The Army Corps of Engineers will need to evaluate current projections of sea-level rise and set thresholds for certain mitigation measures, possibly taking into account various contingencies. Hagopian said he believes that this will occur within the next year or so. The standards are not likely to be drastic. "They will probably come up with a measure about what is reasonable for people doing development in a waterfront area,"[156] he said. In any case, he is confident that climate change and sea-level rise will enter decision making from the top down. In the meantime, this plan for waterfront development is very important to Lynn. With 300 acres of contiguous waterfront property, Lynn has an opportunity to create an entirely new downtown reconnected to the water, which had been largely cut off by transportation corridors and industrial uses. Attracting interest from developers and going through permitting and construction on many phases will take two or three decades, but the plans hold great promise for the city to attain a level of prosperity that many surrounding communities enjoy.[157]

With 300 acres of contiguous waterfront property, Lynn has an opportunity to create an entirely new downtown reconnected to the water, which had been largely cut off by transportation corridors and industrial uses.

Flooding from Rainfall

Neither the Lynn Office of Economic and Community Development nor the EDIC have focused on climate adaptation issues to date. John Moberger, the community facilities manager, said that when his department conducts street improvements and regrades and installs new drainage, it relies on engineering consultants and the city's Water and Sewer Commission to ensure that the system can handle expected volumes of storm water.[158]

The Lynn Water and Sewer Commission also has not considered climate change explicitly, but its current planning and infrastructure investments do promote resilience. Executive Director Daniel O'Neill says that one of the commission's biggest challenges at the moment is solving the problem of combined sewer overflows. The city has spent $35 million over the past five years to build 25,000 feet of separate piping to capture storm water before it enters the wastewater system. The state Department of Environmental Protection has mandated this work because the city has been averaging about 19 overflow events a year, far above the maximum four allowed under EPA regulations. The outflows occur at four outfalls, one at a recreational beach, another near a shellfish bedding area. In O'Neill's words,

> Our overflows aren't discharging millions and millions of gallons [of

> waste]. It's not pleasant, but it's just 10,000 gallons or so. With two tides, the whole ocean there, it gets flushed out pretty quickly. But you don't want to be playing there during a storm.[159]

The city's investments will reduce episodes of pollution and the volume of storm water the wastewater treatment plant must process. The new 12- to 18-foot piping will also reduce the flooding that occurs when heavy rainfall events overwhelm the drainage system. However, the city's sewer and storm water infrastructure remains in need of rehabilitation since much of its 200 miles of pipe is at least a century old. Back in the 1980s, federal and state grant money was available for such upgrades. Now the city's best option is to apply for low-interest loans from a state revolving fund to meet the high cost without impacting ratepayers too severely. O'Neill does not anticipate state grant money becoming available for such projects. Regulations to decrease the volume of water entering the system complement efforts to increase system capacity. It is a standard requirement that new building projects provide storm water detention systems sufficient to handle rainfall from a 10-year storm event. O'Neill suggested that finding ways to increase storage capacity throughout the system would be key to mitigating increases in rainfall that may accompany climate change.[160]

The city's sewer and storm water infrastructure remains in need of rehabilitation since much of its 200 miles of pipe is at least a century old.

Fresh Drinking Water

The city of Lynn has not done any planning related to natural hazard mitigation or climate change, but it does plan for the long-term security of its water supply. Unlike most North Shore communities, Lynn has its own water treatment plant, drawing on nearby rivers through a system of pipes and reservoirs. In 2008 Lynn renewed its permit with the state Department of Environmental Protection to withdraw 11.55 million gallons of water per day from the Ipswich and Saugus rivers. O'Neill said that the city has already had discussions with Swampscott and Nahant about their interest in buying water from Lynn. He also noted that "some watershed groups rightfully want to preserve water levels in the streams" and through the DEP permitting process secured the city's agreement to reduce somewhat its summertime withdrawals.[161] In those negotiations it was difficult to get a handle on what constituted a safe yield from the rivers. O'Neill explained that,

> One study said that each community should take less out of the river—for Lynn only 9.5 million gallons, not 11.5. To do that you can put lawn-watering restrictions in—that may work in some places. But we do not have many sprawling lawns; our houses are more densely packed. Most of our water is to use.[162]

The fact that there may already be insufficient water in the local rivers to support both natural ecosystems and municipalities' demands suggests that if climate change increases the irregularity of rainfall and droughts occur, the city could face shortages. O'Neill is confident, however, that Lynn is better off with its local water system than are neighboring communities that rely on water piped in from distant

reservoirs managed by the Massachusetts Water Resources Authority.

Emergency Management

The city of Lynn does engage in emergency planning that could help the community respond to climate change–related crises such as storms, floods, and heat waves. The city has had a Local Emergency Planning Committee since the 1970s. Originally focused on hazardous materials, the committee has broadened its scope to prepare for a wide range of emergencies. Planning efforts and drills organized by the committee involve elected officials, members of law enforcement, emergency management professionals, firefighters, a variety of health-care professionals, environmental advocates, transportation and public works officials, members of the media and community groups, as well as facility owners and operators.[163]

Lynn is also, like Gloucester, a member of the North Shore Cape Ann Emergency Preparedness Coalition. According to Assistant Emergency Planning Director Joseph Zukas, a particular challenge in Lynn is how to effectively engage the city's diverse immigrant communities during emergencies. The concern is that linguistic and cultural obstacles may arise when there is an urgent need, such as to evacuate people from flood-prone areas or to assist the elderly during a heat wave. Therefore the Local Emergency Planning Committee regularly engages with community groups, the Lynn Housing Authority, senior service organizations, and hospitals to ensure that response plans and working relationships are in place.[164] In preparing for natural disasters today, the Lynn Local Emergency Planning Committee is helping make the community more resilient in the face of a changing climate.

In preparing for natural disasters today, the Lynn Local Emergency Planning Committee is helping make the community more resilient in the face of a changing climate.

CONCLUSION

Climate change adaptation is not a current priority for the city officials, organizations, and citizens of Lynn. Rather, public safety, the national recession, economic development, job creation, and energy efficiency occupy people's attention. Leslie Gould, president of the Lynn Area Chamber of Commerce, summed up the predicament this way:

> My reaction is that it's not the right way to go, but it's human nature. If we were told there would be tsunami next month, we would find a way to build a breakwater. Sometimes it takes a tragedy to cause the change. Then there's the unexpected. It's very hard to fight Mother Nature. You could build the best wall and it still might come down. … Speaking for the Chamber of Commerce, on a day-to-day basis we're focusing on trying to keep our membership alive, keep our programming scheduled now because of the economy. We're knee-deep in a recession. Chamber directors are just trying to get people to maintain their dues.[165]

Luckily, it is the job of some city officials like those on the Water and Sewer Commission and the Local Emergency Planning Committee to plan for current

contingencies that overlap with challenges climate change might bring, such as flooding, droughts, heat waves, and other natural disasters. Their work—along with the eventual imposition of state and federal standards that affect such areas as waterfront development—will help Lynn begin to integrate climate change concerns into a wide range of routine planning, investment, and regulatory decisions.

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New Bedford: Mitigation as a Stepping Stone to Adaptation

By Jessica Agatstein

CASE STUDY #4

OVERVIEW OF NEW BEDFORD AND CLIMATE CHANGE

Located in the southeastern portion of Bristol County, New Bedford is roughly 50 miles south of Boston and 30 miles southeast of Providence, RI. A coastal city located on Buzzard's Bay, New Bedford is the No. 1 fishing port in America (in terms of the dollar value of its catch). New Bedford is also known as the "Whaling City" for its importance as an international whaling port during the 1800s. In addition to New Bedford's fisheries, other industries of economic importance to the city include manufacturing, the service sector, and increasingly, tourism.

Photo: Timothy Valentine, "Palmer's Island Light" October 3, 2008 via Flickr. Creative Commons Attribution.

New Bedford's population of roughly 100,000 struggles with relatively high unemployment, crime, and drop-out rates within their city, exacerbated by the current economic recession. In 2008, New Bedford's four-year graduation rate for high school students dropped to 56.1 percent, and in October 2009 the unemployment rate was approximately 12 percent.[166] Roughly 11 percent of the workforce has a bachelor's degree or higher, and 20 percent of individuals live below the poverty line; therefore, New Bedford faces the challenge of supporting a largely unskilled workforce.[167] Schools and city officials speak of these statistics often and focus much of their attention on improving them. Mayor Scott Lang was recently re-elected with these issues as key planks in his platform.

In the last several years, city officials and business representatives have adopted many programs that join economic development priorities with climate change mitigation.

Although New Bedford is also confronting the global economic crisis, city officials and residents have begun to address the challenges associated with climate change. Elected officials have worked to create local policies to capitalize on the opportunities provided by state and federal governments to develop energy efficiency and clean technology. In the last several years, city officials and business representatives have adopted many programs that join economic development priorities with climate change mitigation.

As a coastal city, New Bedford faces many of the highest risks associated with climate change, yet the city has not yet adopted a comprehensive plan for climate change adaptation. With the organization and momentum the city has created to minimize damage to the climate through clean technology and efficiency, it could

begin to address adaptation to the risks associated with climate change as well.

NEW BEDFORD'S VULNERABILITIES TO CLIMATE CHANGE

New Bedford likely faces an array of risks associated with climate change, though the city's specific vulnerabilities have not been evaluated. The most useful study to date is the Union of Concerned Scientists' 2007 report Confronting Climate Change in the US Northeast. The report thoroughly identifies observed and predicted risks based on the most recent climate change research, and many of its observations are applicable to New Bedford. In addition, the report Climate's Long-Term Impacts on Metro Boston, funded by the Environmental Protection Agency, can provide some valuable scientific insight and reasonable references for coastal areas near Boston, such as New Bedford.

Sea-Level Rise and Flooding from Storms

Climate-change predictions suggest that rising sea levels and increasingly intense coastal storms in Massachusetts will produce a 100-year flood every nine years by midcentury.[168] This could have dramatic effects on New Bedford, which already experiences road flooding during heavy rains, especially downtown.[169] The Federal Emergency Management Agency and the Massachusetts Department of Conservation and Recreation recently updated flood risk maps for New Bedford, and some flood zones were expanded to reflect the improved understanding of future risks.[170] New Bedford's waterfront is home to several key industries, tourist attractions, residential areas, and a wastewater treatment plant, all of which could be harmed as flooding becomes more frequent and severe in the coming decades. Nearby wetlands and coastal areas could also see erosion, and coastal roads could potentially be degraded. However, no research has identified which specific New Bedford locations and infrastructure are most at risk.

The city's infrastructure does have some extra protection against the relatively unknown risks of storm surges due to climate change. The New Bedford Harbor Hurricane Barrier, built and maintained by the US Army Corps of Engineers, provides flood protection to 1,400 acres of land and infrastructure in the city. This barrier provides a great deal of coastal flooding protection and is estimated to have prevented nearly $20.1 million in damages since its completion in 1966.[171] However, the barrier does not protect the entire city (as one can see in the map above), and coastal flooding affects the city almost every year.

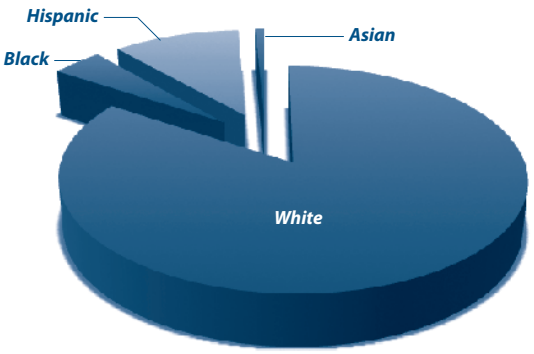
Threats to Fisheries and Ecosystems

Climate change is also expected to reduce water quality for fish and aquatic plants, potentially threatening New Bedford's valuable fishing industry.[172] Scientists currently predict that the ocean off southern Massachusetts will reach the maximum temperature tolerance of many fish species later this century, creating an even larger burden on Massachusetts' fishing industry.[173] Though the industry has already seen remarkable changes to fish populations in Georges Bank, a rich offshore fishing ground, climate scientists and fisheries management experts

NEW BEDFORD DEMOGRAPHICS

2006 Population	92,538
Percentage change 2000 to 2006	- 1.3%
2000:	
Percentage foreign born	20%
Percentage with high school diplomas	58%
Percentage with bachelor's degrees	11%
1999:	
Median household income	$27,569
Percentage living below the poverty line	20%

Source: "State & County QuickFacts: New Bedford, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2545000.html.



RACE/ETHNICITY BREAKDOWN, 2000
Source: "State & County QuickFacts: New Bedford, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2545000.html.

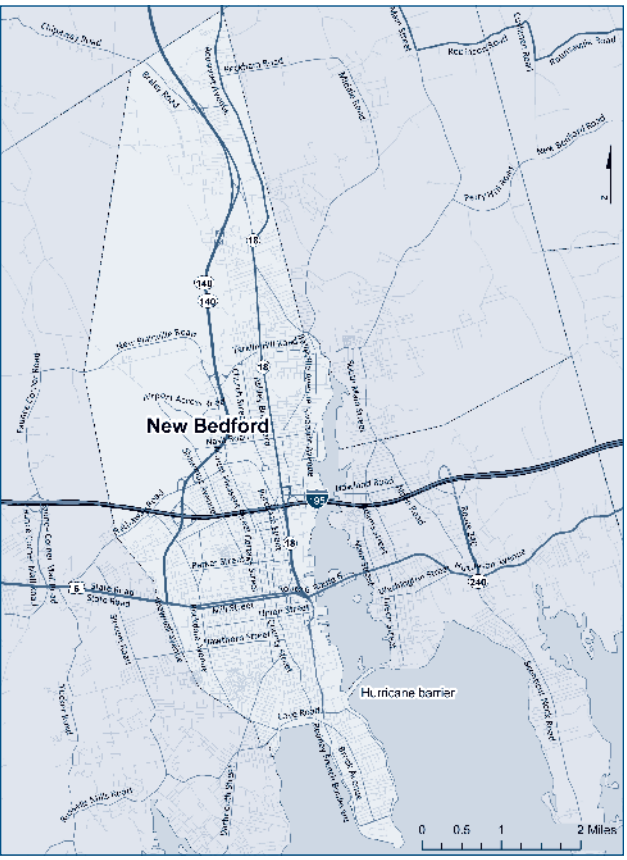
New Bedford's waterfront is home to several key industries, tourist attractions, residential areas, and a wastewater treatment plant, all of which could be harmed as flooding becomes more frequent and severe in the coming decades.

have been unable to decouple damage caused by overfishing from the impact of a changing climate. Scientists know that fish populations are fluctuating, but they have not been able to directly link these fluctuations to climate change.[174] It is therefore particularly hard to predict the implications of climate change on future fish populations. Fish populations and local fisheries are already suffering and no doubt will continue to confront unknown changes. The industry may also be affected by additional federal regulation in the coming decade.[175]

New Bedford faces a variety of public health concerns associated with climate change, including more extreme heat waves and increases in vector-borne diseases such as West Nile and Lyme disease. The elderly and the urban poor are particularly vulnerable to these health risks.

Other Potential Climate Risks

New Bedford faces a variety of public health concerns associated with climate change, including more extreme heat waves and increases in vector-borne diseases such as West Nile and Lyme disease. The elderly and the urban poor are particularly vulnerable to these health risks.



CLIMATE CHANGE MITIGATION EFFORTS IN NEW BEDFORD

Over the past several years, the city of New Bedford has become more involved in reducing greenhouse gas emissions through official programs and through efforts led by nonprofits, local universities, and individual activists. In May 2007, Mayor Lang established a Sustainability Task Force and commissioned an extensive report on how best to move New Bedford toward a more environmentally sustainable future. Though the report explicitly identifies ways in which the city government, businesses, and individuals can effect change in the city, there has been much debate as to whether the report's recommendations are being successfully implemented.

After the publication of the Sustaining New Bedford report, the city began to build momentum in its climate change efforts, though Lang has noted that the climate change initiatives tend to be program-based rather than policy-based.[176] The city is attempting to address this problem through a master plan update, which will be completed by early to mid-2010.

The city recently hired a Mayoral Fellow, funded by the local nonprofit Marion Institute, to focus on a Green Jobs, Green Economy initiative. The fellow, Kalia Lydgate, has been working to help the city of New Bedford become a certified Green Community under the Massachusetts Department of Energy Resources Green Communities Program, which helps municipalities take advantage of federal stimulus funding directed toward sustainability. She will also be working to develop an energy usage and consumption report in the spring of 2010.[177] The city is undergoing energy audits of its municipal buildings and recently received a federally funded technical support grant to affect appropriate responses to the audit's results.[178] In addition to grant application and allocation work, the city is discussing a variety of efforts designed to address the struggling economy and its strain on citizens; sustainability initiatives may provide some opportunities for development funding.[179]

Local nonprofits, colleges, and community organizations have also been heavily involved in climate change programs. The Sustainability Group at the University of Massachusetts at Dartmouth has begun to organize mitigation efforts at a regional level over the past several years, working with the Southeast Regional Planning and Economic Development District. The group helped to create the new Southeast Regional Council on Sustainability, which first met in May 2009.[180] In addition, the Marion Institute, UMass-Dartmouth, and other local institutions hosted the annual Bioneers by the Bay: Connecting for Change conference in New Bedford for the second time last October. The four-day conference brought roughly 2,000 activists together to discuss opportunities for sustainable change within New Bedford and on a larger scale.[181] Beside the Marion Institute, which has played an influential role in climate change programs and policies, a number of other organizations have been involved in climate change mitigation efforts, including the Southeastern Environmental Education Alliance and People Acting in Community Endeavors–YouthBuild.

Supported by action from nonprofits, community organizations, city departments and the Mayor's Office, the city's strong efforts to institute climate change mitigation policies suggest the potential for increased adaptation efforts, as the city's enthusiasm and increasing institutional capacity could easily transition into both climate change mitigation and adaptation planning.

CLIMATE ADAPTATION WORK IN NEW BEDFORD

As a city, New Bedford has not yet instituted specific climate change adaptation programs or policies. However, the city has continued to manage and repair the New Bedford Harbor Hurricane Barrier, which addresses some of the potential risks associated with increased storm frequency and intensity by protecting much of New Bedford's infrastructure and development. Most recently the US Army Corps of Engineers received nearly $1 million in federal funding to maintain and improve the hurricane barrier through the Recovery and Reinvestment Act of 2009.[182] In addition, the city's Comprehensive Emergency Management Plan includes sections on heat waves and other extreme weather events that can be caused by climate change (even though climate change is not addressed directly).

The city has done little else to prepare directly for climate change. Most attribute this to a lack of knowledge about the specific risks New Bedford faces as a city. Understanding the city's potential risks seems to be the most pertinent factor inhibiting climate change adaptation efforts.

CONCLUSION

Over the past several years, beginning with the Sustaining New Bedford report in 2007, New Bedford has recognized the importance of curbing emissions and mitigating climate change. The city has seen mayoral resolutions, the hiring of climate change-focused city officials, many federal grant applications, and various

EXCERPTS FROM THE REPORT[183]
***SUSTAINING NEW BEDFORD* (2007) BY JOHN K. BULLARD:**

Dozens of citizens from New Bedford and surrounding towns accepted Mayor Lang's invitation to chart a new course for the city. This report is the result of our work to date. In it we define problems, set goals that we hope are measurable, memorable, and motivational. And we lay out strategies for government to take and also for businesses and institutions and for us as individuals.… There is an adage in navigation that says, 'If you don't change course, you'll get where you are headed.' We know where we are headed. It is an unprecedented crisis. But inside the crisis lies the opportunity of a lifetime. It's time right now for a course change.

FROM THE REPORT'S PREFACE:

The scientists tell us that mitigation is not enough. We, like other species that share this planet, will have to adapt to the changes already in the pipeline. We need to be ready for more days over 100 degrees and protect those who can't escape the heat. We need to create alternative insurance models so young people can still get loans to buy houses and start businesses. We need to plan long-term improvements like the railroad to handle a meter of sea-level rise.

The city's strong efforts to institute climate change mitigation policies suggest the potential for increased adaptation efforts.

new programs. A tremendous amount of support is evident from nonprofits, local universities, and the community as a whole. These substantial mitigation efforts are both noteworthy and important, creating a momentum that helps people throughout the city begin to recognize the importance of climate change as an issue.

As New Bedford continues its expansive work in climate change mitigation, it could—and should—use similarly robust approaches to begin work on adaptation policies. However, without specific information on the likely local impacts of climate change, a fair number of individuals in the city remain skeptical of taking action toward adaptation. Mitigation has set the stage for adaptation—but now the key actors need the information and resources to proceed.

Properly structured federal and state grants may be able to help cities such as New Bedford to lay the groundwork for a more secure future.

Because adaptation efforts tend to be far-reaching in scope, affecting a wide range of departments in a variety of ways, cooperation between city departments can present a problem in adapting to potential risks. Mayor Lang reports that it can be difficult to communicate specific goals to the various departments within city governance, and this problem has yet to be completely solved. However the Mayoral Fellow is considering potential solutions in her climate mitigation work.[184]

Engaging city officials and other key stakeholders in New Bedford could also present a challenge in the coming years. Many of the city's current development problems appear larger and more pertinent than the as-yet-unspecified risks from climate change. As in many other Massachusetts cities facing economic woes, officials in New Bedford feel pressure to address such issues as the drop-out and unemployment rates before instituting new climate change policies. The development of the city's new master plan could create opportunities to address both climate change mitigation and adaptation in concrete ways, but the up-front costs of adaptation could be a problem. Properly structured federal and state grants may be able to help cities such as New Bedford to lay the groundwork for a more secure future.

NOTES

166. Urbon, Steve. "New Bedford School Officials Bearing Down on Graduation Rates." South Coast Today, March 8, 2009. www.southcoasttoday.com/apps/pbcs.dll/article?AID=/20090308/NEWS/903080335/-1/news; "Local Area Unemployment Statistics, October 2009," US Department of Labor, www.bls.gov/web/laummtrk.htm.

167. "State & County QuickFacts: New Bedford, Massachusetts." US Census Bureau. quickfacts.census.gov/qfd/states/25/2545000.html.

168. Frumhoff, Peter, James J. McCarthy, Jerry M. Melillo, Susanne C. Moser, and Donald J. Wuebbles. Confronting Climate Change in the US Northeast: Science, Impacts, and Solutions. Cambridge, MA: Union of Concerned Scientists, July 2007, 15.

169. Van Laarhoven, Desa. Interview by Jessica Agatstein. Telephone, November 11, 2009.

170. "FEMA Announces Redistricted Flood Zones," South Coast Today, November 12, 2009. www.southcoasttoday.com/apps/pbcs.dll/article?AID=/20091112/PUB01/911120396.

171. Update Report for Massachusetts. US Army Corps of Engineers, New England District, October 31, 2009. www.nae.usace.army.mil/news/ma.pdf.

172. Kirshen, Paul H., William P. Anderson, and Matthais Ruth. Climate's Long-Term Impacts on Metro Boston. Media Summary, 2006, 8. www.tufts.edu/tie/climb/.

173. Frumhoff et. al, 33.

174. Rothschild, Brian. Interview by Jessica Agatstein. Telephone, December 1, 2009.

175. Rothschild, interview.

176. Lang, Scott. Interview by Jessica Agatstein. Telephone, November 3, 2009.

177. Lydgate, Kalia. Interview by Jessica Agatstein. Telephone, November 3, 2009.

178. Lydgate, interview.

179. Lang, interview.

180. Jennings, Susan. Interview by Jessica Agatstein. Telephone, December 17, 2009.

181. Van Laarhoven, interview.

182. Update Report for Massachusetts. US Army Corps of Engineers, New England District, October 31, 2009. www.nae.usace.army.mil/news/ma.pdf.

183. Bullard, John K. Sustaining New Bedford, 2007.

184. Lang, interview; Lydgate, interview.

COMPARING THE CASE STUDIES WITH OTHER MASSACHUSETTS CITIES

CLIMATE CHANGE MITIGATION AND ADAPTATION PROGRESS						
Cities (where we interviewed a city official)[185]	Population[186]	City is working to become eligible for funding under the MA Green Communities Act	ICLEI Cities for Climate Protection member[187]	ICLEI milestones awarded[188]	City has a climate action plan	Climate action plan mentions adaptation to climate risks
Beverly	39,538					
Boston	**595,698**		**Y**	**1, 2**	**Y**	**Y**
Cambridge	101,365	Y	Y	1, 2, 3, 4, 5	Y	Y
Chelsea	32,792					
Easthampton	16,082					
Fall River	91,474					
Fitchburg	40,050	Y				
Gardner	20,805	Y				
Gloucester	**30,564**	**Y**	**Y**	**1**		
Greenfield	17,699	Y	Y			
Holyoke	39,765					
Lynn	**87,991**					
Medford	55,681	Y	Y	1, 2, 3, 4	Y	
Melrose	26,666					
Newburyport	17,303	Y	Y			
New Bedford	**92,538**	**Y**				
Northampton	28,592	Y	Y	1		
Peabody	51,734					
Worcester	175,454	Y	Y	1	Y	Y

185. See 'Acknowledgements' section for a list of city officials we interviewed about climate mitigation and adaptation activities.

186. "Massachusetts QuickFacts from the US Census Bureau." US Census Bureau. quickfacts.census.gov/qfd/states/25000.html.

187. "Member List — ICLEI Local Governments for Sustainability USA." ICLEI – Local Governments for Sustainability. www.icleiusa.org/about-iclei/members/member-list.

188. Milestone 1: Conduct a baseline emissions inventory and forecast; Milestone 2: Adopt an emissions reduction target; Milestone 3: Develop a Local Climate Action Plan; Milestone 4: Implement policies and measures; Milestone 5: Monitor and verify results

SUCCESSES

Some city governments are aware of the risks and challenges posed by climate change and have begun to address them. However, efforts have been focused almost entirely on mitigation, or reducing greenhouse gas emissions. Outside of Boston, there has been very little effort to think through adaptation—moves that communities can make to reduce their vulnerability to the impacts of climate change and enhance their resilience when and if sea levels do rise, storms intensify, rainfall patterns change, vector-borne diseases increase, and saltwater intrusion threatens biodiversity.

Lots of Action on Mitigation

Public awareness and media coverage of the benefits of energy efficiency and clean energy technology have motivated numerous city leaders to enact new policies, allocate funding, and hire staff to capitalize upon these opportunities. In some cities, non-governmental actors have taken the lead. Several municipalities have formed advisory boards to suggest ways to reduce greenhouse gas emissions. Local academics and other experts have been actively involved, motivated not only by a desire to reduce the impacts of climate change, but also to save citizens money and to create a market for "green" technologies.

Little Action on Adaptation

A few cities, including Boston, have begun to tackle the issue of adaptation. The city of Boston has worked since 2000 on innovative climate change mitigation programs, and benefitted from two detailed studies of Boston and the Northeast region's vulnerabilities to the likely impacts of climate change. The city's Climate Action Leadership Committee and Community Advisory Committee are working in the spring of 2010 to develop recommendations for a comprehensive city adaptation strategy. The city is now using LIDAR topography surveys to analyze its vulnerabilities in more detail and reexamining coastal development regulations. Gloucester will be evaluating its current vulnerability to storm surges and flooding as it receives updated Flood Insurance Rate Maps from the Federal Emergency Management Agency.

Many cities have considered upgrading their emergency response capabilities. These communities are studying strategies for natural hazard mitigation, water supply protection and contingency planning, hurricane defenses, and extending their storm water overflow systems. Most of these efforts have been triggered by prior experience with storms, flooding, droughts, other natural disasters, as well as disease outbreaks (like Eastern equine encephalitis). Land use regulations

redirecting development away from coastal zones, floodplains, and wetlands have helped a few communities reduce their level of vulnerability, but most cities have not yet moved in this direction.

A handful of cities have begun to incorporate climate change adaptation considerations into ongoing planning for capital improvements. For example, the Massachusetts Water Resources Authority in 2001 increased the elevation of the new Deer Island Sewage Treatment Plant for Boston by two feet in anticipation of sea-level rise. Climate action teams have also begun to identify strategies that might simultaneously reduce greenhouse gas emissions and reduce Boston's and Cambridge's vulnerability to climate change (for example, by improving the efficiency of water management systems). These citizen-led teams have tapped the expertise that many citizens hold, either through professional training (e.g. as academics or consultants) or because they have accumulated a wealth of local knowledge by living in the community for a long time. The involvement of these citizens is helping to build public support for ongoing adaptation planning.

The most successful adaptation planning efforts seem to be those aimed at reducing climate change risk as part of ongoing infrastructure planning, growth management and capital budgeting activities.

CHALLENGES

Many interviewees identified what they see as the key barriers to adaptation. These include:

- *There are no regulations requiring cities to adapt to climate change*. Agencies such as the Massachusetts Department of Environmental Protection and the Department of Coastal Zone Management have yet to put adaptation planning requirements in place. Federal agencies, including the Army Corps of Engineers, have only recently published guidelines describing how civil engineers should deal with such climate adaptation issues as sea-level rise. Interviewees from Lynn mentioned the lack of state or federal guidance or requirements as the reason the city's new waterfront master plan was created without taking sea-level rise into account.

- *There has been very little public pressure to think about adaptation*. The agendas of most public officials are driven by the concerns of their constituents. If citizens don't raise adaptation as a priority, elected and appointed officials will feel very little need to address it. Most local news outlets have not yet covered the issue.

- *Cities have not received information about the specific threats they face*. Most climate change forecasts have not been scaled down to the local level. City officials are ill equipped to interpret global and national

scientific reports on their own. They do not know where to go for reliable information they can use to make better municipal risk management decisions. Existing national reports on the projected impacts of climate change have not yet been communicated adequately to local decision-makers.

- *Climate change has not been incorporated into the normal risk management activities that cities pursue*. Cities regularly engage in a wide variety of risk management activities, such as hazard mitigation and emergency response planning. However, these activities have not yet incorporated scenarios that take the likely impacts of climate change into account. Existing protective infrastructure, such as hurricane barriers or storm water management systems, have not been evaluated to determine their vulnerability to the effects of a changing climate. The parts of city government that are often most involved in thinking about climate change, such as city sustainable development directors, have failed in some cases to communicate with those city departments that consider hazard mitigation for other reasons.

- *While reducing energy use offers immediate financial benefits, city officials have not identified the likely benefits of taking action on adaptation*. Cities face numerous near-term pressures, such as reducing crime and improving the economy. Therefore, officials lack the motivation to tackle issues that don't produce short-term gains. If adaptation could help cities garner resources to upgrade their infrastructure, lower their insurance rates, or achieve other shorter-term goals, many more cities would engage in adaptation.

RECOMMENDATIONS

Based our interviews, we offer six key recommendations:

- *Begin conversations now with whoever is interested in the likely risks associated with climate change*. Many stakeholders who have been active in local climate action teams will be interested in adaptation issues and could be engaged in thinking through how to proceed. These people more regularly understand the risks that climate change poses for their fellow citizens and their experience in mitigation activities (e.g. energy efficiency, green jobs) has shown them the multiple benefits that can be gained through taking action.

- *Use whatever data are available to assess your community's vulnerabilities*. Regional reports, such as the Northeast Climate Impacts Assessment, identify the most important categories of impacts and trends. Additional resources to support community-level adaptation planning are emerging, such as LIDAR topography surveys and the recently announced National

Oceanic and Atmospheric Administration Climate Services portal (www.climate.gov). While climate science will become more precise over time, there is already enough information in hand to assess each community's vulnerabilities (especially if city officials pay attention to those who know the local history of natural disasters, droughts, and other climate-related events). Leaders should engage key stakeholders, as well as local experts, in assessing the climate change risks they face.

- *Build on existing approaches to risk management and hazard mitigation in your community*. Public agencies in many cities regularly conduct assessments of flood hazards, potential coastal erosion, and other impacts that overlap the impacts of climate change. These planning efforts offer an opportunity to inject emerging climate science into local planning. Future state and federal efforts to manage the risks of climate change are likely to focus on such efforts.

- *Incorporate climate change into everyday planning and decision-making, with cross-departmental coordination to ensure data sharing*. Communities are nearly always engaged in infrastructure and land-use planning that could be better informed by taking climate change science into account. Incorporating an adaptation perspective into these regular planning activities is even more important than creating a distinct and separate climate adaptation plan.

- *Use "scenario planning" to identify "no-regrets" actions—that is, things you can do that meet other priorities while simultaneously helping your community adapt to climate change*. Conventional planning often takes the view that the future is most likely to be the product of historical trends. Given how different and uncertain the future could be because of climate change, this doesn't make much sense. Communities should switch to a scenario-based approach to planning. Instead of working backward from desired goals and objectives, planners should look forward, considering a range of contingent possibilities. Moves that make good sense given a range of possible scenarios are probably the smartest way to proceed. Such an approach can identify "no regrets" strategies that align existing needs with changes that reduce a community's vulnerability and increase its resilience.

- *Collaborate with other elected officials through partnership organizations*. Initiatives such as the Urban Leaders Adaptation Initiative (www.ccap.org/index.php?component=programs&id=6) and the International Council for Local Environmental Initiative's Climate Resilient Communities Program (www.icleiusa.org/programs/climate/Climate_Adaptation/adaptation) provide elected officials with opportunities to talk with other local leaders around the country. These venues allow officials to find out what's working elsewhere and how other communities are proceeding.

CONTACTS FOR HELP

FEDERAL

NOAA's Climate Program Office
http://www.climate.noaa.gov

STATE

Massachusetts StormSmart Coasts
http://www.mass.gov/czm/stormsmart/index.htm

LOCAL

Raab Associates
http://www.raabassociates.org

Jonathan Raab is working with the City of Boston to facilitate their stakeholder engagement efforts in their climate adaptation plan
raab@raabassociates.org

Consensus Building Institute
http://cbuilding.org

NGO

ICLEI's Climate Resilient Communities Program
http://www.icleiusa.org/programs/climate/Climate_Adaptation

Melissa Stults is the Director for this program
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John Walkey, *Chelsea Creek Action Group*
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Paul Kirshen, *Research Leader, Battelle Memorial Institute*
Vivien Li, *Executive Director, Boston Harbor Association*
Wayne Klockner, *State Director, The Nature Conservancy in Massachusetts*

Gloucester

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Edward Becker, *Executive Director, Essex County Greenbelt Association*
Gregg Cademartori, *Planning Director, Community Development Department, City of Gloucester*
Jack Vondras, *Director, Health Department, City of Gloucester*
Jill Buchanan, *Clean Energy Commission, Gloucester*
Joan Blaustein, *Land Resources Planner, Metropolitan Area Planning Council*
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Lynn

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Leslie Gould, *President and CEO, Lynn Area Chamber of Commerce*
Richard Gorham, *General Electric*
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Robert Wilson, *Webmaster, City of Lynn*
Tony Dunn, *North Shore Labor Council*
Varoujan Hagopian, *Principal, Sasaki Associates, Inc.*

New Bedford

Brian Rothschild, *Commissioner, Harbor Development Commission*
Derek Christianson, *New Bedford farmer*
Desa VanLaarhoven, *Executive Director, Marion Institute*
John Bullard, *President, Sea Education Association*
Kalia Lydgate, *Mayoral Fellow, City of New Bedford and Director, Green Jobs, Green Economy Initiative, Marion Institute*
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Additionally

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Michael Tautznik, *Mayor, City of Easthampton*
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Nancy Hazard, *Cochair, Greening Greenfield Committee*
Nathan Jones, *City Planner, City of Peabody*
Patricia Barry, *Director of Energy and Environmental Planning, City of Medford*
Robert Hubbard, *Director, Community Development and Planning Department and Executive Director, Gardner Redevelopment Authority, City of Gardner*

The MIT Support Team

Channa Heng
Kathryn O'Neill

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MANAGING RISK

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