Carbon Dioxide, Climate Change, and the Boston Region MPO

A Discussion Paper

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INTRODUCTION

Climate change will likely have significant impacts on the Boston region. If climate trends continue as projected, the climate and weather patterns in Boston at the end of this century will look more like those now found in Richmond, Virginia, or Atlanta, Georgia.[1] More severe weather events, a rise in sea level coupled with storm-induced flooding, and warmer temperatures would impact the region's infrastructure, economy, human health, and natural resources.

Greenhouse gases (GHG) contribute to climate change, and 84% of the United States' GHG emissions are composed of carbon dioxide (CO_2), a common emission from motor vehicles and the burning of fossil fuels.[2] In Massachusetts, transportation sources emit more CO_2 than any other sources.

Transportation planning policies and decision-making can affect a reduction in the transportation sector's CO_2 emissions. To have a significant effect, however, some important considerations and trade-offs must be faced. Improving mobility for alternative mode users, particularly transit, may result in reduced mobility for motorists. For example, shifts in investments to increase transit mode split may reduce funding for highway projects.

The purpose of this document is threefold. Part I provides the Boston Region Metropolitan Planning Organization with an overview of climate change and its local impacts. Part II provides a summary of the MPO's plans and programs that are already resulting in the reduction of GHG emissions. Part III provides specific potential "next step" actions to deliberately continue existing programs or start additional GHG-reducing initiatives.

Current Policy Context

To better understand the current political context surrounding climate change, this section outlines current policies in the region that are relevant to climate change and CO_2 emissions. In August 2001, the Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) adopted the first and only regional action plan in North America for addressing climate change. This agreement, known as the Climate Change Action Plan 2001, reflected the conviction of the NEG/ECP that climate change is a significant environmental concern that will have a major impact on the region's environment and economy. In 2004, the Massachusetts Climate Protection Plan adopted the same targets as the Climate Change Action Plan 2001.

With the Climate Change Action Plan, the NEG/ECP, and subsequently the Commonwealth, made a commitment to take steps to address climate change by setting specific GHG emission reduction targets for the region and the Commonwealth:

- Short-term: Reduce GHG emissions to 1990 levels by the year 2010.

- Medium-term: Reduce GHG emissions 10% below 1990 levels by the year 2020.
- Long-term: Reduce GHG emissions sufficiently to eliminate any dangerous threat to the climate; current science suggests this will require reductions as much as 75–85% below current levels.

In line with these targets, Governor Deval Patrick signed the Regional Greenhouse Gas Initiative (RGGI) in January 2007, committing Massachusetts to a multi-state effort to reduce emissions of CO_2 and address global climate change. States participating in RGGI are developing a regional strategy for controlling emissions, including a market-based, multi-state cap-and-trade program[3] that will require electric power generators to reduce their emissions of CO_2.

On April 2, 2007, the Supreme Court ruled in "Massachusetts v. Environmental Protection Agency" that the Environmental Protection Agency (EPA) has the authority to regulate heat-trapping gases in automobile emissions. The decision increases the likelihood that the EPA will approve Massachusetts's and 11 other states' programs to limit tailpipe emissions, beginning with the 2009 model year.

On April 12, 2007, Mayor Menino enacted an executive order that requires Boston city government to cut GHG emissions to 80 percent below 1990 levels by the year 2050. As a first step, the city government must cut emissions by seven percent below 1990 levels by 2012.

Six days later, Governor Patrick signed an executive order that directs agencies to cut energy use 20 percent below 2002 levels by 2012 and 35 percent by 2020. It also requires them to cut their GHG emissions to 25 percent below 2002 levels over the next five years, to 40 percent by 2020, and to 80 percent by 2050.

Most recently, Governor Patrick changed Massachusetts environmental policy so that private developers planning projects large enough to warrant a state environmental review are required to estimate GHG emissions for these projects and reduce the emissions with measures such as energy-efficient lighting, alternative fuels, or commuter shuttles. This policy change takes impacts such as emissions from smokestacks and heating with fossil fuels into consideration, as well as the effect of thousands of workers driving to a new development.

PART I: OVERVIEW OF CLIMATE CHANGE

Climate change refers to unstable weather patterns caused by increases in the average global temperature. There is a consensus among climate scientists that these changes result from atmospheric concentrations of CO_2, methane (CH_4), nitrous oxide (N_2O), and other heat-trapping gases. These GHGs form a blanket of pollution that stays in the atmosphere.

Increasing concentrations of GHGs are causing a rise in average global temperatures. Greenhouse gases warm the earth's atmosphere and are so-called because they simulate the effect of a greenhouse, trapping heat within the atmosphere and contributing to an increase in the earth's temperature. GHGs may be the fundamental cause of sea level rise and climate instability

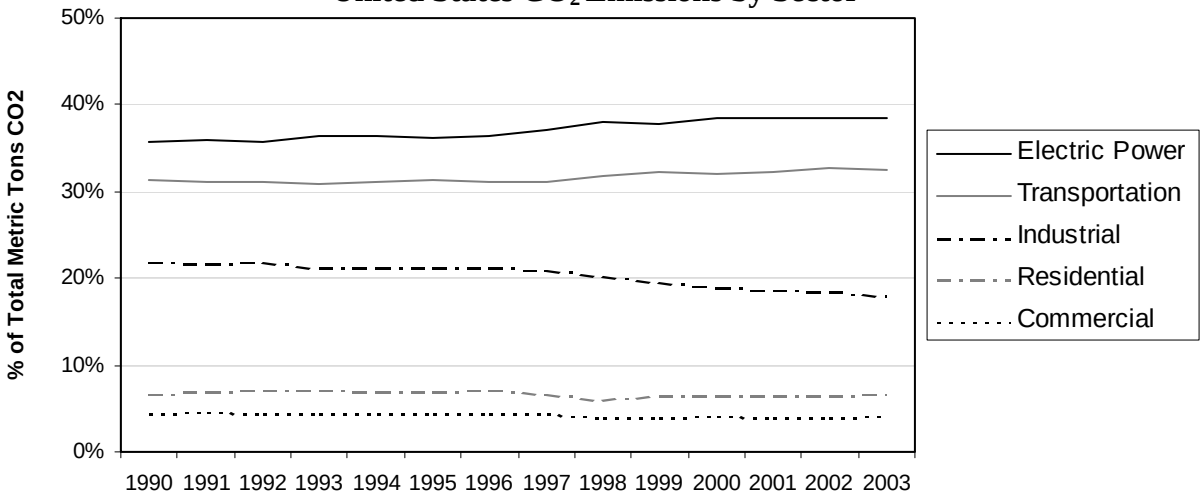
characterized by severe weather events such as storms, droughts, floods, and heat waves. Appendix A contains information on global climate change trends and impacts.

National, Regional, and State Trends and Impacts

Trends

The United States is responsible for more than one-third (36%) of the world's CO_2 emissions – more than any other country.[4] In the United States, CO_2 emissions rose 20.4% percent between 1990 and 2005.[5, 6] As a sector, transportation is the second largest CO_2 emitter in the United States (Figure 1).

FIGURE 1
United States CO_2 Emissions by Sector[7]



Emissions per capita in Massachusetts are lower than the national average, with the state emitting 1.9% of the total CO_2 emitted in the U.S. while housing 2.4% of the population, but it is still a comparatively large amount of the world's GHG emissions. Massachusetts' emissions are likely lower than other states per capita due to relatively cleaner energy sources and to there being a high proportion of people living in the inner core area in and around Boston, where population densities are high, work and other destinations are close by, and transit alternatives are available. Overall, Massachusetts ranks 25th in total state CO_2 emissions.

FIGURE 2
Massachusetts CO_2 Emissions by Sector (2003)[8]

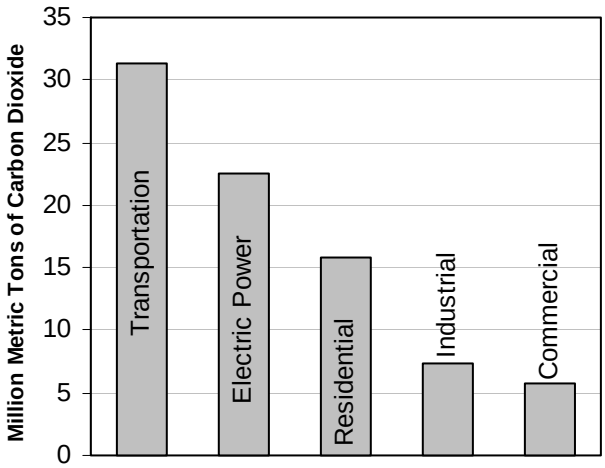
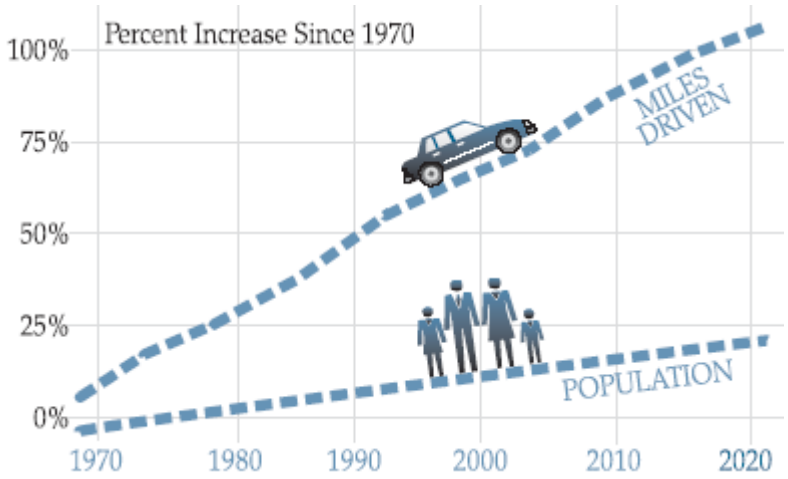


Figure 2 shows that CO_2 emissions are higher for the transportation sector than for any other sector in Massachusetts. Between 1990 and 1998, annual vehicle miles traveled (VMT) in Massachusetts rose 13%, from 45 billion miles to 51 billion miles. Figure 3 shows how VMT is outpacing population growth in the Commonwealth.

FIGURE 3
Miles Driven and Population Growth in Massachusetts[9]



Massachusetts anticipates a 33% overall increase in CO_2 from the transportation sector between 1990 and 2020.[10] This is due in part to increasing VMT, but is even more attributable to increasing sales of less efficient vehicles, which include light trucks and sport utility vehicles.[11] Additionally, diesel fuel, the predominant fuel for freight, is a major source of GHG emissions in Massachusetts. National projections in 2004 showed diesel fuel consumption growing 14% from 1997 to 2010, which represents an increase of more than 40% above 1990 levels.[12] Although modest efficiency gains in all forms of freight transportation are expected over the next decade, they will be offset by increased freight travel as more goods are produced and consumed for a growing national population. Vehicle miles traveled by heavy-duty trucks are expected to

increase by nearly 24% from 1998 to 2010, according to projections from the U.S. Energy Information Administration.[13]

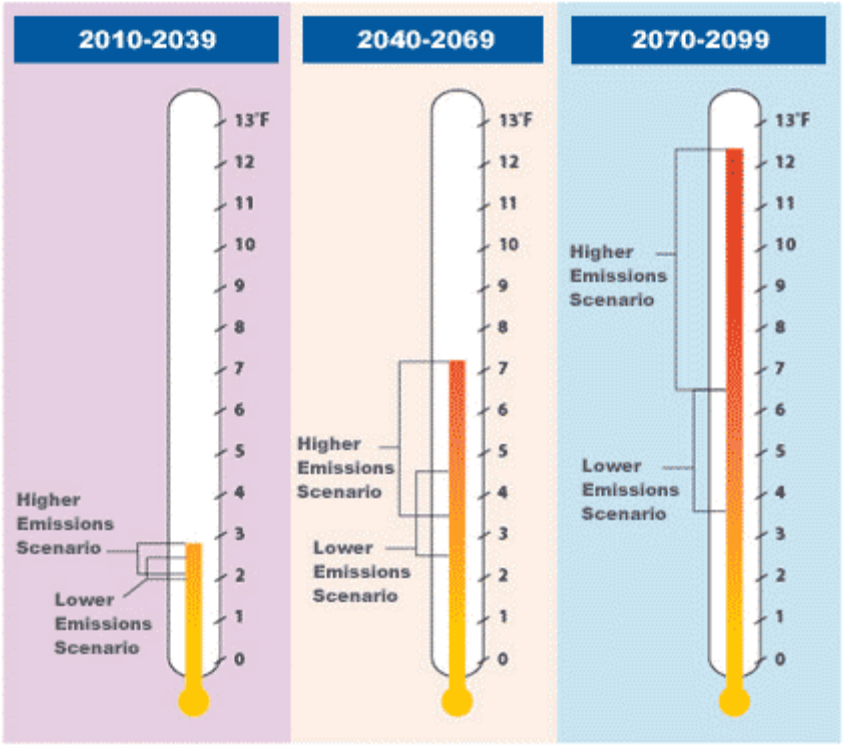
Impacts

Historically, sea level rose 11" along the coast of Massachusetts in the last century.[14] Over the same time period, precipitation increased 16.8% and temperatures increased 1.7°F in coastal areas of New England.[15] For parts of New England, wintertime warming has been nearly three times the summertime warming.[16]

Temperature Increases

The Union of Concerned Scientists recently developed two GHG emissions scenarios and examined their impacts on temperature increases for the Northeast (which includes New England, New York, New Jersey, and Pennsylvania) and Massachusetts. The higher emissions scenario represents a continued heavy reliance on fossils fuels, causing heat-trapping emissions to rise significantly over the century. The lower-emissions scenario represents a shift away from fossil fuels in favor of clean energy technologies, causing heat-trapping emissions to decline by mid-century. Both scenarios assume a world with high economic growth and a global population that peaks mid-century and then declines. Based on these scenarios, temperatures in New England could increase on average by 3.5° F to 12° F by 2100 (Figure 4).[17]

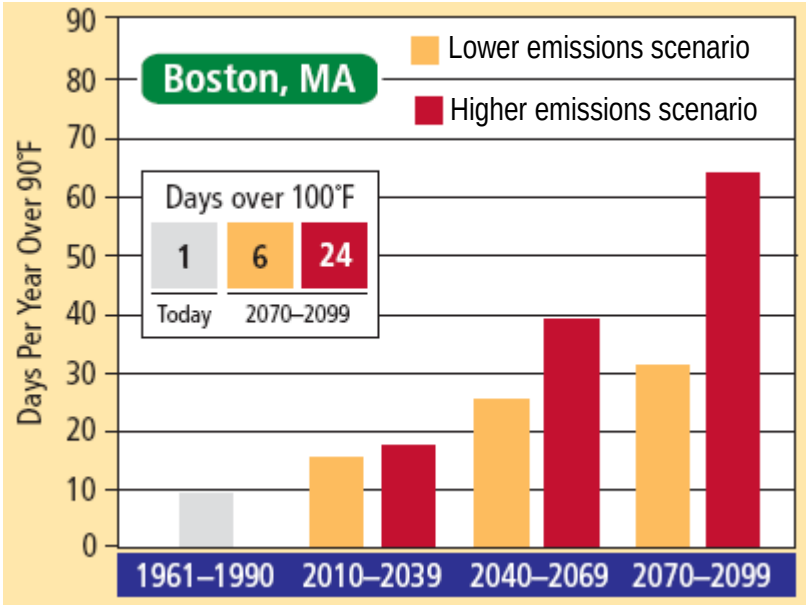
FIGURE 4:
Changes in Average Annual Temperature in New England[18]



Under these scenarios, this study determined that Boston, which previously experienced an average of 10 days per year with temperatures exceeding 90°F, would have up to 63 such days by 2100 with 24 days over 100°F (Figure 5).[19] Such increases in extremely hot days may result in an appreciable increase in high-energy consumption days and the need for requisite peaking units, which are ancillary electricity-producing facilities.[20]

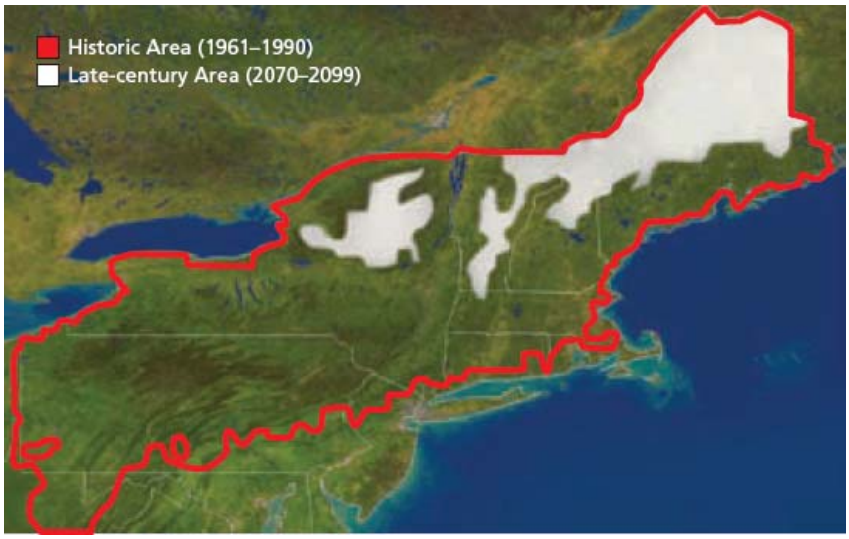
Hotter weather with more frequent and severe heat waves also pose multiple health risks that include a rise in heat-related illness, more frequent periods of harmful outdoor air quality, and the spread of certain diseases.[21] Those most at risk from high and continuous heat include the elderly, young children, and people who already suffer from certain illnesses, particularly heart disease.[22] In Boston, elevated heat-stress mortality rates occur in certain lower-income and immigrant neighborhoods, suggesting that these communities are more socially vulnerable to heat than others.[23]

FIGURE 5:
Extreme Heat in Boston[24]



Higher temperatures and a changing climate translate into less snow for the Northeast. Figure 6 shows that far less of the Northeast will experience a typical snow season toward the end of the century under the higher emissions scenario. The red line in the map shows the area of the northeastern United States that had at least a dusting of snow on the ground for at least 30 days in the average year. The white area shows the projected retreat of this snow cover by the end of this century.

FIGURE 6
The Changing Face of Winter[25]



Air Quality

Hotter summers could set the stage for an increase in the number of days that fail to meet federal air-quality standards.[26] In the absence of more stringent controls on ozone-forming pollutants, the number of days with poor air quality is projected to quadruple in Boston under the higher-emissions scenario.[27] Such days could increase by half under the lower-emissions scenario.[28] Deteriorating air quality would exacerbate the risk of respiratory, cardiovascular, and other ailments in Massachusetts, which already has the highest rate of adult asthma in the United States.[29] In Boston, eight-hour maximum ground-level ozone concentrations are projected to increase 13 to 21 percent under the higher-emissions scenario and zero to five percent under the lower-emissions scenario.[30]

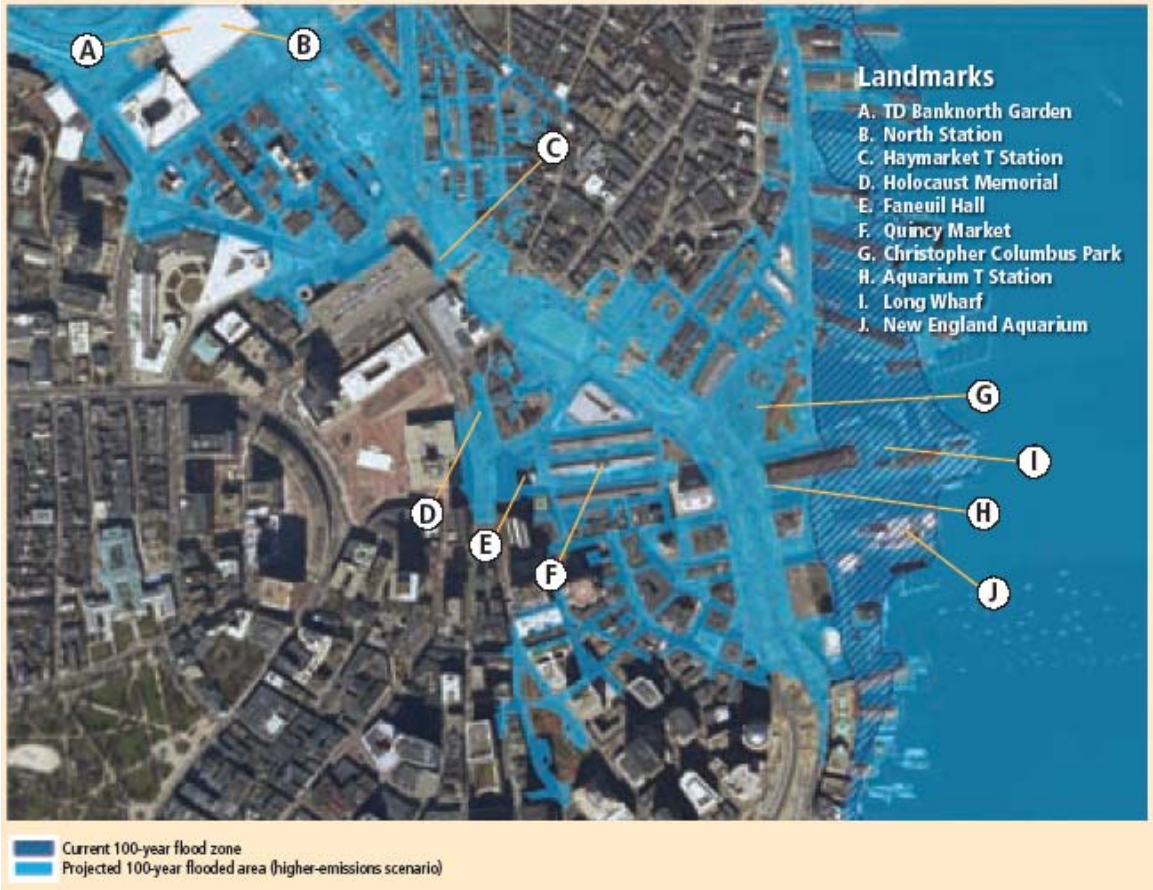
Sea Level Rise and Flooding

Massachusetts and all coastal states will lose beachfront in the coming years as climate change causes rising sea levels and stronger coastal storms.[31] By the end of the century, sea levels are expected to rise four to 21 inches under the lower-emissions scenario and eight to 33 inches under the higher-emissions scenario, with the potential for additional increases due to more rapid melting of major polar ice sheets.[32] Regardless of scenario, Boston can expect a coastal flood equivalent to today's 100-year flood every two to four years on average by mid-century and almost annually by the end of the century.[33]

As today's 100-year maximum flood height of 9.7 feet becomes a more common occurrence in Boston, the new 100-year maximum flood height is projected to rise to more than 12 feet under the higher-emissions scenario by the end of this century.[34] This means that many more existing buildings and properties as well as associated transportation and other infrastructure will be at risk of flooding. Figure 7 shows the current Federal Emergency Management Agency 100-year flood zone (hatched darker blue) as well as the extent of the projected 100-year flood zone in 2100 (lighter blue) under the higher-emissions scenario for the waterfront/Government Center

area of Boston.[35] Under this scenario, important Boston landmarks (such as Faneuil Hall) and transportation infrastructure currently not at great risk of flooding could witness repeated flooding in the future unless they are protected from such events beforehand.[36] Flood elevations under the lower-emissions scenario are roughly half a foot lower than the flooding depicted in this figure (but are still two feet higher than the current 100-year flood).[37]

FIGURE 7
Potential Flooding in Downtown Boston[38]



The Commonwealth has a very high risk of coastal and river flooding because of its long coastline, numerous rivers and streams, and concentrated development in combination with high exposure to heavy rainstorms, hurricanes, and nor'easters. One study estimates that property damage and emergency services due to rises in sea level over the next 100 years could range from $20 billion to $94 billion if there are no adaptive responses except rebuilding after floods.[39] For more information on the impact of sea level rise and flooding in the Boston region, please see Appendix B.

Transportation Impacts

The principal way in which climate change will affect the transportation system is through extreme climate events, in particular events that produce significant flooding or snowfall. Sea level rise impacts will become evident during extreme events when storm tides will be higher,

increasing the frequency and severity of coastal flooding. In economic terms, the impacts of extreme weather events on the transportation system are of two types.

The first is the damage inflicted upon infrastructure, such as flood damage to road, rail, and bridges. According to the Union of Concerned Scientists report, "In 1996, heavy rains raised the level of Boston's Muddy River, flooding a tunnel entrance to the 'T,' the city's subway system. The damage from this flooding closed a busy subway line for several weeks and cost… roughly $75 million. While the main reason for this damage and disruption is simple—the tunnel entrance was not flood-proof—it also underscores the broader vulnerability of Boston's transportation infrastructure: its subway system—the country's oldest—was not built with certain conditions in mind, including significantly higher sea levels and storm surges."[40]

The second is the economic cost of interruptions in the operation of the transportation systems, which prevent, for example, employees from going to work, shoppers from getting to stores, and goods from being delivered. One study estimates that traffic delay due to flood events over the course of the 21st century in the Boston region may increase by about 80% and lost trips over the same period may increase by 82% over delay and lost trips that would be expected in the absence of climate change.[41]

Social, Economic, and Natural Impacts

New England and Massachusetts may be affected by climate change in several other ways. These impacts are attributable, at least in part, to temperature increases and sea level rise. All of these impacts have economic implications since important Massachusetts industries such as tourism and agriculture rely on the state's climate and natural resources.[42] These impacts include more frequent and damaging weather events, water shortages, and adverse changes in the state's ecosystems, native species, and commercial fish stocks.[43]

PART II: CURRENT MPO POLICY AND ACTION

As stated in JOURNEY TO 2030, the MPO's current long-range transportation plan, the MPO will continue to support projects and programs to reduce emissions of CO_2 in the region. Several of the policies and visions that the MPO created to guide the development of JOURNEY TO 2030 and to steer decision-making for transportation in the region may lead to MPO actions that may reduce GHG emissions over time. Primarily, these policies can be found under the Environment, Land Use and Economic Development, and Mobility topics in the plan. A few of the policies under the System Preservation, Modernization, and Efficiency; Safety and Security; and Public Participation topics may also lead to ways the MPO can reduce GHG emissions in the region. Appendix C lists the policies that may lead to a reduction of GHG emissions over time.

There are three basic ways the MPO and its partners currently work to reduce GHG emissions. First, the MPO funds projects that provide people with transportation options other than single-occupancy vehicles (SOVs) to travel to work, school, and other destinations. Alternative modes to SOVs include transit, bicycling, walking, and carpooling. Second, MPO investments, such as the reconstruction of intersections, reduce VMT and roadway congestion, therefore cutting back

emissions. Third, the MPO funds the use of alternative fuels, which release less GHG emissions than traditional fossil fuels. This third method is discussed within the context of the other two methods as described below.

Alternative Modes

Transit

One American person using mass transit for an entire year, instead of driving to work, can keep an average of over 5,000 pounds of CO_2 from being discharged into the air, and one full, 40-foot bus takes 58 cars off the road.[44] A 10 percent nationwide increase in transit ridership would save 135 million gallons of gasoline a year and prevent 2.7 billion pounds of CO_2 being added to the atmosphere (one gallon of gasoline creates 20 pounds of CO_2).[45, 46]

The Massachusetts Bay Transportation Authority (MBTA) is a significant part of the region's transportation system, both by providing people with an alternative to SOVs and by running buses, subways, trains, and maintenance and operations vehicles throughout the region. The Massachusetts Bay Transportation Authority's (MBTA) 2003 long-range capital planning document, the Program for Mass Transportation (PMT), contained information for each project's projected percentage reduction in CO_2 emissions on weekdays regionwide and on the ratio between the capital cost of the project and the anticipated reduction in CO_2 emissions on weekdays regionwide. The 2008 PMT will consider how the MBTA's CO_2 emissions reduction goals fit into state and other CO_2 emissions reduction goals.

In line with the PMT and JOURNEY TO 2030, the MPO allocates millions of dollars of funding to transit projects annually. This funding is used to maintain, improve, and expand the existing transit system. Near-term transit upgrade projects include the Blue Line modernization, Fairmount Line improvements, the redevelopment of Ashmont Station, station accessibility improvements, and the procurement of new buses. Despite these expenditures, many un-met transit needs still persist in the region.

The MPO also allocates Congestion Mitigation and Air Quality (CMAQ) and transit funds for cleaner transit vehicles. In recent and coming years, these projects include: undertaking bus diesel retrofit programs, purchasing hybrid locomotive switches, monitoring and controlling bus emissions, and procuring emission control diesel buses.

Bicycle and Pedestrian Projects

Non-motorized (bicycle and pedestrian) transportation produces no emissions. According to the Regional Bicycle Plan, 66% of our trips, by any mode of transportation, are less than five miles; 68% of us live within two miles of a transit station; and 31% of us live within one mile of a shared-use path.[47] Despite these relatively short distances, bicycling remains a marginal transportation choice for work and errands, comprising less than 1% of trips in our region.[48] The Metropolitan Area Planning Council conducted a survey on bicycle issues in the region that identified reasons more people do not bicycle to work, to shop, or to visit friends. The survey

found that approximately 45% of respondents would bicycle more often if the route were safer for bicycling.[49]

The MPO allocates funding for bicycle and pedestrian projects in the region to make the use of these modes of transportation safer, more attractive, and more viable as a mode choice. Over $23.7 million of the funding in the MPO's Federal Fiscal Years 2007-2009 Transportation Improvement Program (TIP) is programmed for bicycle and pedestrian projects using CMAQ funds. These projects mainly include multi-use paved paths. Recent projects include the Peabody Bikeway, the Upper Charles Trail in Milford, and a portion of the reconstruction of Somerville Avenue in Somerville. The MPO also funds a bicycle parking program and conducts studies and workshops to improve bicycling and walking conditions throughout the region in an effort to get more people to use these modes for traveling to work and running errands.

Massachusetts is one of three states that requires state agencies to accommodate bicycles and pedestrians into the design and construction of every project. This requirement is reflected in the Massachusetts Highway Department's *Project Development & Design Guide* (2006). The design guide provides for the accommodation of pedestrians and bicyclists in line with Chapter 87 of the Acts of 1996. By integrating these guidelines into their design, new roadway projects will accommodate both bicyclists and pedestrians.

Reduction of VMT and Roadway Congestion

Congestion Mitigation and Air Quality Improvement Program

The MPO programs funds for projects that help improve air quality and reduce traffic congestion as part of its CMAQ program. Projects eligible for funding under this program include public transportation improvements, traffic flow improvements (usually through intersections and interchanges), travel demand management, bicycle and pedestrian projects, alternative fuel projects, inspection and maintenance programs, intermodal freight transportation, public education and outreach, idle reduction technology, and intelligent transportation systems. Recent projects using CMAQ funds include the signalization and improvements on Route 28 in Reading, the bus diesel retrofit program, the suburban mobility program, and the region's bicycle parking program. In recent years, the MPO's target for spending CMAQ funds has been approximately $13 million a year.

Freight Projects

Freight transportation accounts for 6.3% of total CO_2 emissions in the United States.[50] Much of New England's freight is transported by truck, contributing to CO_2 emissions and congestion in the region. Among other reasons, the perishability and short-haul distances of many of the commodities transported in the region necessitates truck freight transportation. The MPO helps to decrease truck CO_2 emissions and improve freight mobility by funding projects that rehabilitate weight-restricted bridges and reduce congestion. For example, weight-restricted bridges in the region require detours of truck traffic that could take up to one and a half hours, thereby increasing traffic and CO_2 emissions.

Moving a larger percentage of freight by rail has the potential to reduce GHG emissions since trains are three times more fuel-efficient than trucks on a ton per mile basis. According to the American Society of Mechanical Engineers, if 10% of intercity freight now moving by highway were shifted to rail, 2.5 million fewer tons of CO_2 would be emitted into the air annually nationwide.[51] An increase in the movement of rail freight via more frequent service in the Boston region would have to be coordinated with passenger rail operations so as not to diminish passenger service that may use the same tracks. Additional infrastructure would also be necessary to accommodate more frequent rail freight in the region.

One way of increasing the movement of rail freight without increasing the frequency of trains in the region is to double-stack rail cars. Double stack rail cars, which have two containers stacked on one another, move freight more efficiently than single stack cars. Since one rail car can carry as much as 3.5 truckloads, one double stack car can carry approximately seven truckloads. Since many bridges over rails in the Boston region are too low to accommodate double-stack rail cars – there are approximately 56 railroad bridges in the region with a vertical clearance of less than 21 feet, which is the threshold for double stack cars – it is Massachusetts policy that new bridges over rail lines, and bridges over rail lines that are scheduled for reconstruction, are built with a vertical clearance of 21 feet in order to accommodate double-stack rail cars.

PART III: FUTURE MPO ACTIVITIES

Because transportation is a significant source of CO_2 emissions in Massachusetts, slowing the growth of emissions in the transportation sector is important. While the MPO and its partners should continue the work that reduces CO_2 emissions as described above, there are several additional actions that can be taken to reduce GHG emissions in the region within the purview of the MPO. Some actions can be taken exclusively by the MPO, and other actions can be led or carried out by the MPO in partnership with other agencies and organizations.

While these actions can effect a reduction in the transportation sector's CO_2 emissions, some important considerations and trade-offs must be faced to have a significant effect. Improving mobility for alternative mode users, particularly transit, may result in reduced mobility for motorists. For example, shifts in investments to increase transit mode split may reduce funding for highway projects. These kinds of decisions over time could impact our current lifestyle through prohibiting or discouraging the continuance of our current travel behavior.

Other MPO Actions

Other MPOs are becoming increasingly involved in climate change issues and reducing CO_2 emissions. Since 2002, the New York State Department of Transportation has required that New York MPOs include estimates of energy use and GHG-related emissions in their TIPs and transportation plans with an analysis showing no-build versus build conditions.

The Board of Directors of the Metropolitan Washington Council of Governments in Washington, DC, recently adopted a regional initiative designed to address global climate change by controlling harmful emissions locally. The Board created a new Climate Change Steering

Committee to make recommendations for reducing the region's GHG emissions. In addition to establishing a reduction goal for the region, the committee will consider several other action items, including:

- Measuring local GHG emissions and their impact on the region;
- Preparing a catalogue of activities currently underway in local jurisdictions;
- Identifying best practices for local governments; and
- Recommending climate change policy and potential advocacy positions on federal, state, and local climate change proposals.

During the update to its regional plan, the Puget Sound Regional Council (PSRC) in Seattle, Washington, received numerous comments urging the updated plan to address climate change. To integrate climate change into its planning process, PSRC drafted several goals and policies under its environment policy area that called for decreasing per-capita CO_2 emissions and energy use, increasing alternatives to driving alone, and preparing for climate change impacts. PSRC also models CO_2 emissions to compare alternative development scenarios as part of its long-range transportation planning process.

Goals

Lowering the transportation sector's GHG emissions in the Boston region requires:

- Creating a more efficient transportation system through supporting alternative modes and reducing congestion and VMT,
- Using more fuel-efficient and cleaner vehicles, and
- Making investments that support land uses that will reduce VMT.

Ways to achieve these goals are listed below.

Consistent with its policies, the MPO can adopt these goals and take steps to lead them. The MPO can add these goals to the list of policies under the Environment topic to integrate them into the MPO's current planning process.

The possible actions below are based on actions and ideas from the Massachusetts Climate Protection Plan, other MPOs, MPO staff, and other sources. Each possible action is broadly categorized as something that can be accomplished in the short-term, mid-term, long-term, or a combination thereof.

A Transportation System that Emits Less GHG Emissions

If desired, the Boston Region MPO can create a transportation system that curtails the anticipated growth of GHG emissions and reduces current emissions. Spending decisions would be based on reducing transportation-related CO_2 emissions in the region by encouraging people to travel in more climate friendly ways, such as taking transit, ride-sharing, bicycling, and walking; alleviating congestion; and ultimately reducing VMT. To attain this goal, the MPO can take some of or all of the following actions.

Possible MPO Actions:

- *Short-Term* – Model CO_2 emissions with the region's transportation model. With the appropriate programming, the region's transportation model can provide the MPO with information on the CO_2 emissions of existing and/or future transportation networks. This information can be reported alongside other emissions that MPO staff routinely models and compared to see the relative benefits of some investments.
- *Short-Term* – Enhance transportation planning and decision-making criteria.
  - Add CO_2 emissions as criteria in transportation decisions. By adopting criteria that estimates a project's CO_2 emissions for Plan and TIP projects, the MPO can be informed on what projects' CO_2 emissions will be and can make decisions accordingly.
  - Use Plan and TIP criteria to support GHG-reducing programs and projects. Give greater emphasis to Plan and TIP criteria and projects that support sustainable land use and transit-oriented development; that promote transit, ridesharing, and TDM coordination; and that include bicycle and pedestrian improvements that will generate significant use of these modes.
- *Short- to Long-Term* – Fund pedestrian and bicycling programs and facilities that are likely to result in auto trips being replaced by non-motorized trips. Planning and infrastructure investments can improve and increase non-motorized transportation.
- *Short-Term* – Create a CMAQ-funded program in the TIP to implement minor and simple pedestrian, bicycle, and congestion-relieving intersection improvements recommended in MPO studies.
- *Short- to Mid-Term* – Conduct an inventory of successful transportation-related climate change-curbing activities that agencies and municipalities in the region are undertaking. Develop best practices for agencies and municipalities in the region based on this inventory and relevant national best practices.
- *Mid-Term* – Continue to support transit agencies in their efforts to increase parking at train stations to encourage greater use of public transit. Increased parking spaces at crowded train stations would encourage more people to drive to transit, thereby shortening their overall auto trip. These studies would also consider train capacity since trains would need to have enough available capacity to accommodate any additional riders.
- *Mid- to Long-Term* – Favor transit investments near commercial or residential development. Providing transit stations near commercial or residential development can increase transit mode share and reduce VMT.

Possible MPO Interest/Partnership Opportunities:

- *Short- to Long-Term* – Maintain and upgrade public transit service and improve the efficiency of transit vehicle operations. Funding projects that improve facilities and services and that enhance the capacity of the region's transit system can increase the number of transit riders and decrease the number of cars on the region's roads.
- *Mid- to Long-Term* – Support the expansion of ride-sharing and carpool programs and high-occupancy vehicle (HOV) lanes in the region to promote efficient travel. More visibility and encouragement to use existing ride-share lots, and the creation of more ride-share lots, can lead to more carpooling in the region. More HOV lanes in the region would provide an additional incentive for people to carpool.

Promote Fuel-Efficiency and Cleaner Vehicles

Possible MPO Actions:

- *Short- to Long-Term* – Continue to fund transit vehicle retrofits and the purchasing of cleaner motor vehicles and train engines in public transit fleets. Cleaner transit by purchasing more efficient vehicles can curb global warming emissions by 10 to 15 percent compared with conventional buses.[52] Cleaner train engine technology can also help to reduce diesel soot and particulates.[53]
- *Short- to Long-Term* – Upgrade bridges to lift weight restrictions for freight and accelerate the double-stacked bridge program. There are two rail bridges in the region that are limited to 263,000 pounds per train carload, which limits the movement of freight within and across the region. Weight-restricted roadway bridges could also be upgraded to prevent long detours. In addition to these upgrades, increasing the clearance of bridges to allow for the passage of double-stacked railcars would create more efficient freight movement in the Boston region.

Possible MPO Interest/Partnership Opportunities:

- *Short- to Long-Term* – Support the acquisition of clean and fuel-efficient vehicles for public fleets. State and regional agencies and municipalities should buy more efficient cars and trucks and increase the use of lower-carbon fuels. By doing this, agencies and municipalities will assemble a cleaner fleet and save money on energy.
- *Short- to Long-Term* – Promote the use of cleaner diesel equipment on state-funded construction projects.
- *Short- to Mid-Term* – Support initiatives to eliminate unnecessary idling. The Massachusetts anti-idling regulation prohibits idling the engine of any motor vehicle while the vehicle is stopped in excess of five minutes (with exceptions for activities such as maintenance and operating auxiliary equipment such as delivery lifts). With technology that is now available, buses can be automatically switched off if left idling for over five minutes.

Coordinate with Land Use Decisions

Many GHG-reducing initiatives can be advanced by changes in land use, particularly when coordinated with changes in transportation services. While land use decisions are not made by the MPO, the MPO should continue consulting with municipal, regional, and state agencies to ensure that transportation investments are coordinated with land use changes and plans. Through this process the MPO can make and support investments that promote alternative mode choices in development areas.

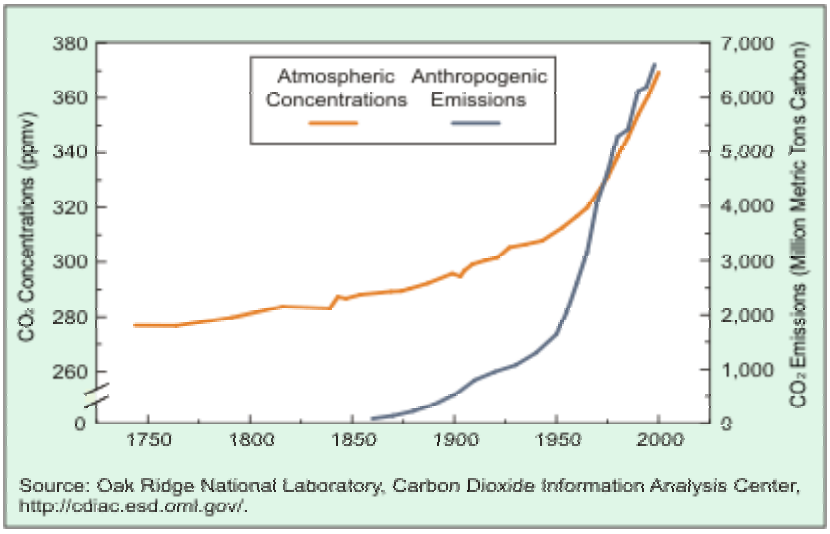
Possible MPO Interest/Partnership Opportunities:

- *Short- to Long-Term* – Support the sustainable redevelopment of urban areas that enables residents to live near their work or live near transit. Providing people with the option to live nearer to their work or closer to public transit reduces the need for long trips to and from work.
- *Short- to Long-Term* – Continue to support compact development and discourage sprawl. Through revised zoning laws, many towns are returning to a more compact, traditional New England style of development that relies less on the automobile and can allow people to complete more of their daily tasks via transit, by bicycle, or on foot. This support can include activities such as funding the design and construction of roadways that control traffic speeds and allow pedestrians to cross safely and prioritizing and funding projects that encourage the redevelopment of existing urban areas instead of funding projects that may encourage new, auto-dependent development in the suburbs.

Appendix A: International Trends and Impacts

Globally, more CO_2 is emitted than any other GHG. Human contributions to CO_2 began with the industrial revolution when we began burning wood and fossil fuels in engines and generators and have increased sharply over the last half-century. Atmospheric concentrations of CO_2 are the highest they have been in 140,000 years, with concentrations growing from 290 parts per million (ppm) in 1870 to 373 ppm today. Figure 1 shows how this increase corresponds with an increase in human-caused, or anthropogenic, emissions.

FIGURE 1
Trends in Atmospheric Concentrations and Anthropogenic Emissions of CO_2



The third warmest year on record was 2003, following 2002, while 1998 remains the warmest year. The International Panel for Climate Change, a group sponsored by the United Nations and the World Meteorological Organization, representing more than 2,000 leading climate scientists, predicts an average temperature increase of 5 to 9°F by 2100, with a wider range of outcomes possible. To put this number in perspective, only about 9°F separates the world at the beginning of the twenty-first century from the world at the end of the last Ice Age, more than 10,000 years ago.

Current global impacts of climate change include:[54]

- The number of Category 4 and 5 hurricanes has almost doubled in the last 30 years.
- Malaria has spread to higher altitudes in places like the Colombian Andes, 7,000 feet above sea level.
- The flow of ice from glaciers in Greenland has more than doubled over the past decade.
- At least 279 species of plants and animals are already responding to global warming, moving closer to the poles.

Scientists predict more severe global impacts in the future:[55]

- Deaths from global warming will double in 25 years to 300,000 people a year.

- Global sea levels could rise by more than 20 feet with the loss of shelf ice in Greenland and Antarctica, devastating coastal areas and cities worldwide. As much as one-tenth of the world's population (630 million people) live in coastal areas that are within 33 feet of elevation from sea level.
- Heat waves will be more frequent and more intense.
- Droughts and wildfires will occur more often.
- More than a million species worldwide could be driven to extinction by 2050.

Appendix B: Sea Level Rise and Flooding in the Boston Region

Sea level rise in the coastal zone will lead to more severe flooding events, and a decrease in the average recurrence interval of design floods such as the current 100-year storm.[56] An increase in mean sea level will add to the base elevation of any storm surge, giving it more power to overtop both natural and constructed protection. A continuation of today's sea level rise rates would give the 10-year storm the intensity of the current 100-year storm before the end of this century and the 100-year storm the intensity of a 500-year storm.[57]

With a worst case scenario of a one-meter (39.4 inches) increase in sea level rise, the expected area at risk to permanent inundation makes up 1.2 percent of the total land area of the Boston region, with some towns expected to experience up to a six percent loss. Specifically, while most municipalities are expected to lose less than one percent of their total land area, the Towns of Nahant and Hull are exceptions: in both municipalities, considerable amounts of residential area would be lost as a result of a rise in sea level of one meter.[58]

Flooding can seriously damage the built environment, paralyze transportation, interrupt energy distribution, and impair wastewater plants, posing threats to the economy of the region and the health of its inhabitants. The areas vulnerable to the most extreme river flood events have a disproportionately high representation of low value houses that are likely to be uninsured.[59] If the frequency of very severe events increases as expected under climate change, households with relatively poor ability to cope will become more vulnerable. Table 1 shows the number of properties and estimated damage climate change could cause in riverside areas. A localized case study found that with increased flood discharges in rivers, bridge foundation scour could become a problem.[60]

TABLE 1
Properties Damaged by River Flood under Baseline (No Climate Change) and Climate Change Scenarios – Cumulative to 2100, maximum of 3 events per year[61]

	Residential		Commercial		Industrial	
Scenario	**Units**	**Cost ($ mil)**	**Hectares**	**Cost ($ mil)**	**Hectares**	**Cost ($ mil)**
No climate change	334,979	6,226	8,834	22,741	30,321	1,789
Climate change	604,491	12,121	16,161	41,096	54,795	3,964
Increase	*80%*	*95%*	*83%*	*81%*	*81%*	*122%*

Appendix C: Policies that Will Likely Result in the Reduction of Carbon Dioxide Emissions

Environment

- Give priority to projects that maintain and improve public transportation facilities and services so as to increase public transportation mode share and reduce reliance on automobiles.
- Give priority to projects that reduce congestion or manage transportation demand to improve air quality.
- Promote the use of low-polluting or alternative fuels, efficient engine technology, and other new, viable technologies that protect resources.
- Consider environmental issues during project selection; in particular, air quality and the reduction of pollutants (CO, NOx, VOCs, particulates, and CO_2), the protection of water resources (soil and water contamination, stormwater management, and wetlands impacts), greenfields and open space, and wildlife and ecosystem preservation; and value those projects that reduce negative impacts.
- Consult with environmental and cultural resource agencies and entities on environmental effects, particularly through the existing NEPA/MEPA processes.
- Encourage, through planning and programming, transportation choices that promote a healthy lifestyle such as walking and bicycling.

Land Use and Economic Development

- Make transportation investments where existing or planned development will encourage public transportation use, walking, and bicycling.
- Give priority to projects in areas identified in local and regional plans as being suitable for concentrated development and/or redevelopment, including brownfield redevelopment; support initiatives that increase sustainability.
- Consider both existing development and densities in transportation decision-making and give priority to projects that support them.

Mobility

- Support projects and programs that improve public transportation service by making it faster, more reliable, and more affordable.
- Fund projects that expand the existing transportation system's ability to move people and goods in areas identified in the Boston Region Mobility Management System, the MBTA Program for Mass Transportation, the MPO's Regional Equity Program, and MPO and EOT freight studies, and through public comment. This includes encouraging options that manage demand. Adding highway capacity by building general-purpose lanes should

be considered only when no better solution can be found and should be accompanied by proponent commitments, developed in the environmental review process, to implement transportation demand management (TDM) measures.

- Assist agencies and communities in planning and implementing projects that provide bicycle and pedestrian routes, networks, and facilities.
- Support programs that meet public transportation needs in suburban communities, including improving access to existing public transportation and partnering with others to initiate new intra-suburban services linking important destinations.

Safety and Security

- Support designs and fund projects and programs that address safety problems and enhance safe travel for all system users. This includes designs and projects that encourage motorists, public transportation riders, bicyclists, and pedestrians to share the transportation network safely.

System Preservation, Modernization, and Efficiency

- Make investments that maximize the efficiency, effectiveness, reliability, and flexibility of the existing transportation system.

Public Participation

- Use the MPO's criteria, based on MPO policies, in decision-making and project selection.
- Solicit the input of environmental, cultural resource, community, business, economic development, and other appropriate agencies on MPO activities, to promote the integration of these interests with transportation planning and programming.

NOTES

[1] New England Regional Assessment Group. *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. New England Regional Overview*, U.S. Global Change Research Program, University of New Hampshire. 2001: 96 pp.
[2] U.S. Department of Energy, Energy Information Administration, "Greenhouse Gases, Climate Change, and Energy." http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html. Date accessed: Apr. 25, 2007.
[3] A cap-and-trade program is a flexible, market-based approach to achieving real emissions reductions at the lowest possible cost. The design of RGGI, like any other cap-and-trade program, includes the following basic components: First, the states determine the emissions sources to be covered by the cap. Second, the states establish the total amount of emissions to be allowed from all of the sources, commonly referred to as the "emissions cap." Third, each state issues one allowance for each ton of emissions, up to the amount of the cap, and those allowances are distributed to the generators and the market. Lastly, every covered source is required to have enough allowances to cover its emissions at the end of each compliance period. Sources that do not have enough allowances to cover their projected emissions can either reduce their emissions, buy allowances on the market, or generate credits through an emissions offset project. Sources that reduce their emissions and have excess allowances may either bank those allowances or sell them to other sources. Emissions trading guarantees that the most cost-effective reductions are implemented at the plants
[4] Corbin, R. *An Inconvenient Truth in the Classroom.* 2006: 59 pp.
[5] Energy Information Administration, "Emissions of Greenhouse Gases in the United States 2005." http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html. Date accessed: Apr. 27, 2007.
[6] This increase is antithetical to the Kyoto Treaty, an international agreement signed by 169 countries, which calls for a 55% global reduction of carbon dioxide based on 1990 levels. As one of the original signatories of the Kyoto treaty in the early 1990s, the United States agreed to reduce emissions by 6% from its 1990 levels. The United States has not ratified the treaty.
[7] U.S. Environmental Protection Agency, "Energy CO2 Emissions by State." http://www.epa.gov/climatechange/emissions/state_energyco2inv.html. Date accessed: Apr. 27, 2007.
[8] U.S. Environmental Protection Agency, "Energy CO2 Emissions by State." http://www.epa.gov/climatechange/emissions/state_energyco2inv.html. Date accessed: Apr. 27, 2007.
[9] Office for Commonwealth Development. *Massachusetts Climate Protection Plan.* The Commonwealth of Massachusetts. 2004: 51 pp.
[10] *Ibid.*
[11] *Ibid.*
[12] *Ibid.*
[13] *Ibid.*
[14] *Ibid.*
[15] New England Regional Assessment Group. *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. New England Regional Overview*, U.S. Global Change Research Program, University of New Hampshire. 2001: 96 pp.
[16] *Ibid.*
[17] Union of Concerned Scientists. "Climate Change in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment." Oct. 2006; 35 pp.
[18] *Ibid.*
[19] *Ibid.*
[20] Kirshen, P., et al. *Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area*, also known as *Climate's Long-term Impacts on Metro Boston (CLIMB).* Civil and Environmental Engineering Department, Tufts University; School of Public Policy, University of Maryland; Center for Transportation Studies, Boston University; and Metropolitan Area Planning Council. EPA Grant Number: R.827450-01. 2004: 164 pp.
[21] Office for Commonwealth Development. *Massachusetts Climate Protection Plan.* The Commonwealth of Massachusetts. 2004: 51 pp.
[22] Union of Concerned Scientists. "Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions." July 2007; 146 pp.
[23] *Ibid.*

[24] Union of Concerned Scientists. "Climate Change in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment." Oct. 2006; 35 pp.
[25] *Ibid.*
[26] Union of Concerned Scientists. "Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions." July 2007; 146 pp.
[27] *Ibid.*
[28] *Ibid.*
[29] *Ibid.*
[30] *Ibid.*
[31] Sea level rise has two components, both related to temperature increases. The first is thermal expansion of seawater as it warms, and the second is an increase in the amount of water in the ocean basins resulting from the addition of fresh water as continental ice sheets and glaciers melt.
[32] Union of Concerned Scientists. "Climate Change in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment." Oct. 2006; 35 pp.
[33] Union of Concerned Scientists. "Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions." July 2007; 146 pp.
[34] *Ibid.*
[35] *Ibid.*
[36] *Ibid.*
[37] *Ibid.*
[38] *Ibid.*
[39] Kirshen, P., et al. *Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area,* also known as *Climate's Long-term Impacts on Metro Boston (CLIMB).* Civil and Environmental Engineering Department, Tufts University; School of Public Policy, University of Maryland; Center for Transportation Studies, Boston University; and Metropolitan Area Planning Council. EPA Grant Number: R.827450-01. 2004: 164 pp.
[40] Union of Concerned Scientists. "Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions." July 2007; 146 pp.
[41] Kirshen, P., et al. *Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area,* also known as *Climate's Long-term Impacts on Metro Boston (CLIMB).* Civil and Environmental Engineering Department, Tufts University; School of Public Policy, University of Maryland; Center for Transportation Studies, Boston University; and Metropolitan Area Planning Council. EPA Grant Number: R.827450-01. 2004: 164 pp.
[42] *Ibid.*
[43] Office for Commonwealth Development. *Massachusetts Climate Protection Plan.* The Commonwealth of Massachusetts. 2004: 51 pp.
[44] National Safety Council, "Auto Emissions Fact Sheet." http://www.nsc.org/ehc/mobile/mse_fs.htm. Date accessed: Apr. 16, 2007.
[45] *Ibid.*
[46] United States Department of Energy and the U.S. Environmental Protection Agency. "How can a gallon of gasoline produce 20 pounds of carbon dioxide?" http://www.fueleconomy.gov/feg/co2.shtml. Accessed Apr. 2007.
[47] Metropolitan Area Planning Council and the Boston Region MPO. "Regional Bicycle Plan." Mar. 2007: 90 pps.
[48] *Ibid.*
[49] *Ibid.*
[50] Scott, J. and H. Sinnamon. *Smokestacks on Rails: Getting Clean Air Solutions for Locomotives on Track.* Environmental Defense. 2006: 39 pps.
[51] American Association of State Highway and Transportation Officials. *Transportation – Invest in America: Freigh-Rail Bottom Line Report.* 2003: 123 pp.
[52] Dutzik, T., et al. *Shifting Gears: 20 Tools for Reducing Global Warming Pollution from New England's Transportation System.* MASSPIRG Education Fund, Clean Water Fund, and Massachusetts Climate Action Network. 2006: 61 pp.
[53] In addition to CO_2 emissions, scientists have recently identified black carbon (soot) as having a large and fast-warming impact on the atmosphere.
[54] Corbin, R. *An Inconvenient Truth in the Classroom.* 2006: 59 pp.
[55] *Ibid.*

[56] A design flood is a hypothetical flood representing a specific likelihood of occurrence.
[57] Kirshen, P., et al. *Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area*, also known as *Climate's Long-term Impacts on Metro Boston (CLIMB).* Civil and Environmental Engineering Department, Tufts University; School of Public Policy, University of Maryland; Center for Transportation Studies, Boston University; and Metropolitan Area Planning Council. EPA Grant Number: R.827450-01. 2004: 164 pp.
[58] *Ibid.*
[59] *Ibid.*
[60] *Ibid.*
[61] *Ibid.*