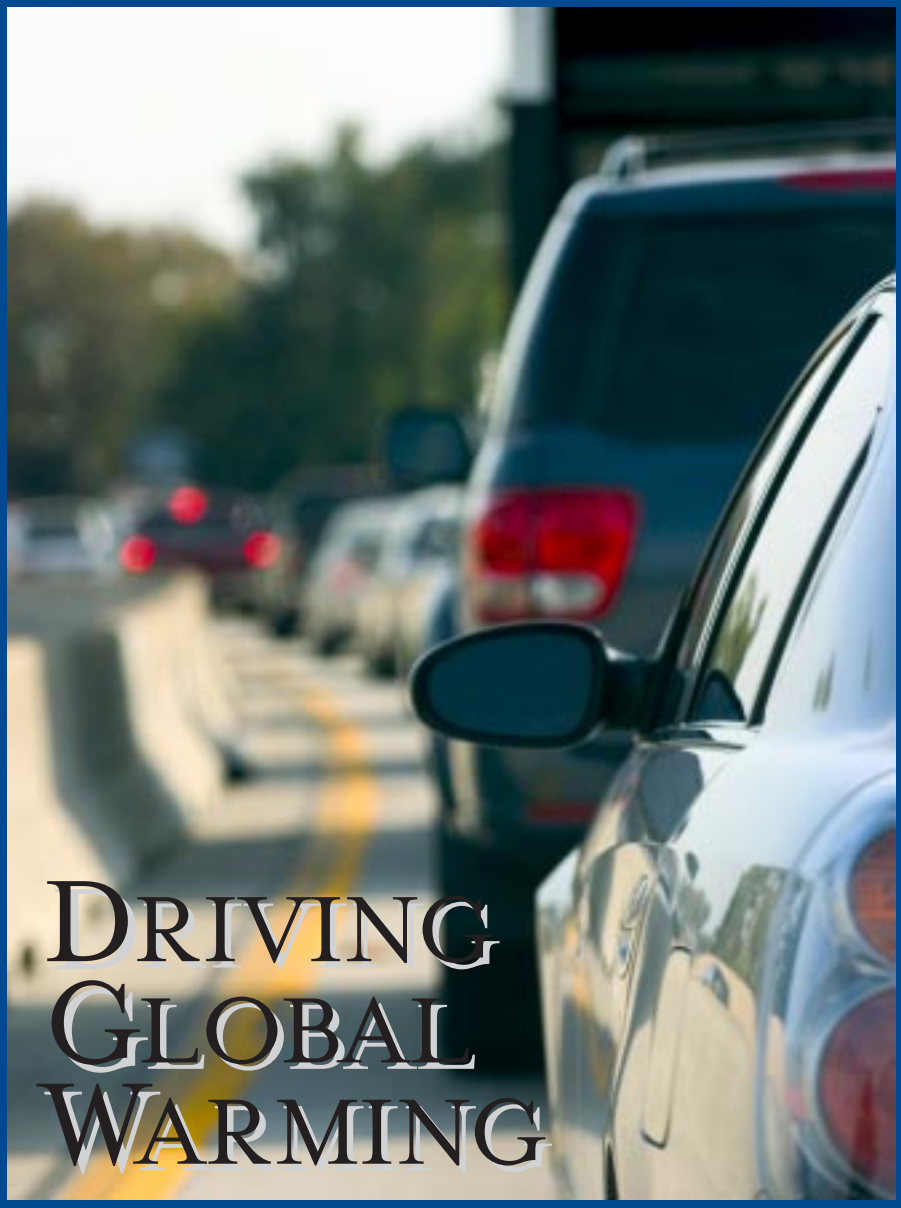

Driving Global Warming

Commuting in Massachusetts and its Contribution to Global Warming

MASSPIRG EDUCATION FUND

CLEAN WATER FUND

January 2006

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With contributions from the New England Climate Coalition steering committee

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Table of Contents

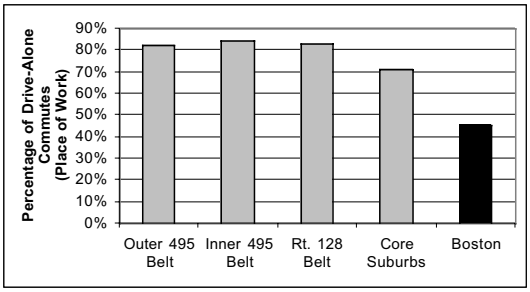
Executive Summary

Transportation is the leading source of global warming emissions in Massachusetts. The state's cars, trucks and other transportation vehicles emit more carbon dioxide – the leading global warming gas – than the entire economies of more than 140 other nations, including Peru, Croatia and Lebanon.

The trips Massachusetts residents make to and from work are major contributors to the problem. Commuting is directly responsible for 5 to 8 percent of the state's carbon dioxide emissions and the decisions that influence commuting – such as where to live and where to work – influence the trips people make for other purposes as well. To reduce global warming emissions from cars and trucks – and to meet the state's climate protection goals – Massachusetts must find ways to reduce the global warming impact of commuting.

In order to find the right policy options for confronting global warming emissions from commuting, it is necessary to know who is commuting where and by what mode of transportation. A review of data collected by the U.S. Census Bureau identifies which towns in the commonwealth are responsible for the greatest amount of commuting-related emissions of carbon dioxide (the leading cause of global warming) and suggests ways that the state can effectively reduce emissions.

Fig. ES-1. Percentage of Drive-Alone Commutes by Place of Work



The growth of suburban employment and the explosion of "exurban" residential development in formerly rural areas of the state pose major challenges to the state's efforts to reduce global warming emissions.

- Many of Massachusetts' fastest-growing communities are located on the extreme fringes of the state's metropolitan areas, where per-worker emissions are very high. These "exurbs" often serve as bedroom communities for two or more cities, making the delivery of high-quality transit service very difficult.

- Long-distance commutes are responsible for an increasingly large share of global warming emissions from driving. The 2 percent of Massachusetts commuters who travel more than 30 miles to work were responsible for about 11 percent of the state's commuting-related carbon dioxide emissions.

- While a large percentage of commuters traveling to Boston use transit and other low-emission transportation alternatives, the majority of commuters traveling to towns just outside the city – many of which have substantial transit infrastructure – drive to work alone. (See Fig. ES-1.) Promoting transit connections in these "core suburbs" could significantly reduce commuting emissions.

The average commuter living in parts of the South Shore and in north-central Massachusetts produces three to four times more carbon dioxide from his or her daily commute than the average commuter living in Boston.

- Among towns with significant commuting-related carbon dioxide emissions, Plymouth ranks first for annual carbon dioxide emissions per commuter, with several other South Shore towns just behind. Cambridge, Brookline, Somerville and Boston commuters produce the lowest average emissions, with the average Cambridge commuter emitting one-sixth the amount of carbon dioxide as the average Plymouth commuter. (See Fig. ES-2.)

Commuters traveling to workplaces in the Interstate 495 belt produce significantly more emissions than those traveling to workplaces in Boston and nearby towns.

- Commuters traveling to Marlborough, Westborough, Littleton and Andover – all of which are located along Interstate 495 – produce the highest amounts of per-commuter emissions by place of work. By contrast, workers traveling to communities in and around Boston produce significantly lower amounts of emissions. (See Figure ES-3.)

Increasing residential population density, shifting more commuting trips to transit, and encouraging workers to live near their place of work can reduce carbon dioxide emissions from transportation.

- Regardless of their location within the state, towns with higher residential population density, high rates of transit use, and short average commute lengths tend to have lower average per-worker emissions of carbon dioxide.

Massachusetts should take a series of immediate and long-term actions to reduce global warming emissions from commuting. Among other actions, the state should:

Reduce Vehicle Emissions

- Implement vehicle global warming emission standards and adopt other measures to encourage the purchase of vehicles that produce less carbon dioxide per mile driven.

Fig. ES-2. Annual Per-Worker Carbon Dioxide Emissions
(By Place of Residence)

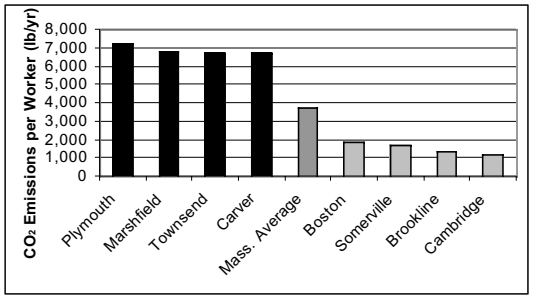
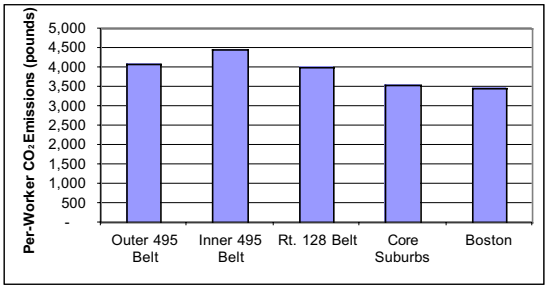


Fig. ES-3. Annual Per-Worker Carbon Dioxide Emissions by Place of Work



Promote Transit and Transportation Alternatives

- Invest in the core MBTA transit system and other regional transit systems to maintain high service quality and keep fares low.

- Improve transit connections to allow suburban commuters to more easily reach jobs in a variety of towns near Boston, improve transit service to suburban "edge cities" that increasingly serve as centers of employment, and improve transit service in other areas of the state to reduce the number of single-passenger automobile commutes.

- Hold suburban workplaces accountable for the carbon dioxide emissions they generate by strengthening requirements that employers implement commute-trip reduction programs and providing greater programmatic support.

- Extend the regional transit network to promote connections with residential and work locations in neighboring states.

- Develop programs to encourage residents to live near their workplaces and to encourage employers to implement telecommuting.

Promote More Efficient Land Use

- Put the brakes on exurban development in rural areas by encouraging urban redevelopment, the creation of affordable housing, and mixed-use planning.

- Encourage transit-oriented development.

Introduction

The New England states have been leaders in the effort to reduce the threat of global warming. Beginning with the adoption of the New England/Eastern Canada Climate Change Action Plan in 2001, and continuing through the adoption of state climate plans and the Regional Greenhouse Gas Initiative process, the region has taken unprecedented steps forward, inspiring other states around the country to consider similar actions.

One of the most promising series of developments has been with regard to transportation. Five of the six New England states, including Massachusetts, have moved to adopt the clean cars program, which will require the production of advanced-technology vehicles and set global warming emission standards for all cars and light trucks. The impact of these initiatives will be substantial: by 2020, states adopting the full clean cars program can expect emissions from light-duty cars and trucks to roughly stabilize at today's levels.

But stability is not enough – transportation-sector carbon dioxide emissions increased by 12 percent New England-wide between 1990 and 2001 and now represent the largest source of emissions in the region. Achieving the region's global warming emission reduction targets will require the New England states to find ways to *reduce* global warming emissions from cars and trucks. And the most promising way to achieve that goal is by reducing the rate of growth in vehicle travel – particularly single-passenger travel in automobiles and light trucks.

A thoughtful approach to reducing vehicle travel must begin from a detailed assessment of who is driving, how much they are driving, why and where. The U.S. Census Bureau collects detailed survey data that enable us to come up with a detailed portrait of one important source of vehicle travel: the journey to and from work.

The analysis that follows suggests that wise land-use and transportation policies can reduce carbon dioxide emissions from the daily commute and can have ripple effects on other sources of vehicle travel. Mustering the political will to implement these policies may be challenging, but if the region is serious about addressing global climate change – and reducing the threats it poses to New England – the time to do so is now.

Commuting and Global Warming

The daily commutes of Massachusetts workers have a large impact on the state's contribution to global warming. Reducing these emissions can have positive ripple effects both on other transportation-related emissions and on other aspects of quality of life in the Bay State.

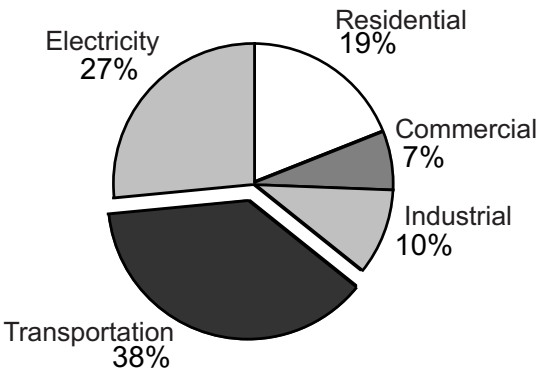
The Role of Transportation in Global Warming

Transportation is the number one source of global warming emissions in Massachusetts. In 2001, transportation-sector emissions represented 38 percent of Massachusetts' emissions of carbon dioxide – the leading global warming gas.[1] And emissions are rising; Massachusetts' transportation-sector emissions of carbon dioxide jumped by 9 percent between 1990 and 2001.[2]

Massachusetts' emissions of global warming gases from transportation are significant on a global scale. In 2000, the state's transportation system was responsible for more carbon dioxide emissions than the entire economies of 144 nations, including Peru, Croatia and Lebanon.[3]

Given recent trends in vehicle fuel economy and vehicle travel, carbon dioxide emissions from transportation can be expected to increase over the next two decades – possibly by as much as 41 percent.[4]

Fig. 1. Massachusetts Carbon Dioxide Emissions from Fossil Fuel Consumption, 2001[5]



Reining in carbon dioxide emissions from the transportation sector is a key part of the state's efforts to achieve the global warming emission reductions adopted by the New England states in 2001 and by the Romney administration in Massachusetts' 2004 Climate Protection Plan.[6] These goals call for overall reductions in greenhouse gas emissions to 1990 levels by 2010, to 10 percent below 1990 levels by 2020 and eventually by the 75 to 85 percent scientists believe will be necessary to stabilize the concentration of global warming gases in the atmosphere.

Reducing global warming emissions from commuting can play a key role in lowering overall transportation sector emissions. It can also lead to changes in development patterns, modes of travel and personal decisions that can bring reductions in non-work related transportation emissions and bring about other benefits for the state – such as reduced air pollution, improved energy security and reduced highway expenditures.

Why Commuting Matters

Massachusetts' transportation system is designed with many goals in mind, but one of the foremost among them is enabling people to travel conveniently to and from work. The effectiveness of the transportation system is largely judged by its ability to carry traffic at peak periods during the day, which tend to be those periods during which most people are driving to or from work.

Transportation decisions have changed the state's landscape dramatically over the past several decades. The construction of Interstate highways in the 1950s and 1960s, among other public policies, enabled workers who had long lived in urban areas to construct homes in distant suburbs. At the same time, those highways facilitated the movement of jobs and industry away from the urban core.

The result of these decisions has been more and longer commutes. Nationally, the average commute is 12 miles in length, compared with 8.55 miles in 1983.[7] And while commuting makes up a smaller proportion of vehicle travel than it has in the past (28 per-

Cars and Global Warming: A Primer

Global warming is caused by the release of pollution that traps the sun's radiation near the earth's surface. Over the past 250 years – and particularly since World War II – the concentrations of these heat-trapping gases in the atmosphere have increased dramatically, and the earth's surface temperatures have begun to rise.

Scientists believe that continued releases of global warming gases – the most significant of which is carbon dioxide – will lead to increasing global average temperatures in the decades to come. Among the potential impacts of global warming are rising sea levels, more severe storms, changes in precipitation, and effects on wildlife, ecosystems and public health.

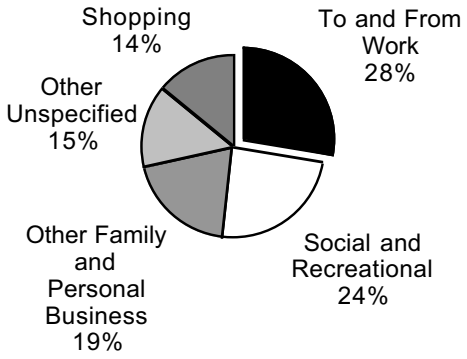
Carbon dioxide is released to the atmosphere mainly through the burning of fossil fuels, such as the gasoline consumed in cars and light trucks. Unlike other automobile pollutants, which can be captured or otherwise eliminated through the use of emission-control devices, carbon dioxide is a natural product of fossil fuel combustion. As a result, there are three main ways to reduce carbon dioxide emissions from vehicles:

1) drive fewer miles
2) switch to low-carbon fuels
3) improve vehicle fuel efficiency.

Cars and trucks also release small amounts of other chemicals that contribute to global warming, such as methane and nitrous oxide, and fluorocarbons from vehicle air conditioning systems. Enhanced emission control systems and the substitution of coolants with less impact on the climate can reduce these types of emissions.

cent in 2001 versus one-third in 1969), it is still the leading source of vehicle travel.[8] (See Fig. 2.)

Fig. 2. Vehicle-Miles Traveled by Trip Purpose, U.S., 2001



In Massachusetts, commuting is responsible for approximately 5 to 8 percent of the state's global warming emissions, or about as much as the direct use of fossil fuels in all of the state's commercial buildings.[9] But the personal decisions that determine commuting behavior – such as where to live, where to work, and how to travel between home and work – also impact other aspects of vehicle travel. Individuals who choose to live in densely populated neighborhoods are more likely to walk or bicycle to engage in shopping, recreation or other activities.[10] Conversely, residents of low-density suburbs likely have little choice but to drive their automobiles longer distances to conduct their daily non-work activities.

An individual's choice of travel mode for commuting (driving alone, carpooling, transit, etc.) could be expected to have an impact on other transportation behaviors as well. Transportation experts have noted the importance of "trip chaining" – the stringing together of trips for work, shopping, educational and other purposes. A typical trip chain might involve a worker who leaves home in the morning with his or her children, drops them off at school, stops by the dry cleaner, and picks up a cup of coffee before arriving at work. Again, a person living and working in a large city might be able to conduct this mix of activities by transit or on foot (or with a combination of driving and transit), while a suburban worker might conduct all of them by car.

The need to conduct chained trips can also influence a worker's choice of transportation mode. A worker who must pick up children at day care on the way home from work, for example, might be unable to conform his or her schedule to public transit timetables – even when transit would be a more efficient and effective way to get to and from work.

The links among the various factors that influence commuting behavior – and the links between commuting choices and choices for non-work travel – are complex. It is clear, however, that commuting and commuting-related choices play a large role in transportation global warming emissions in Massachusetts, and that policies that reduce carbon dioxide emissions from commuting may result in additional emission reduction benefits from other travel.

Other Impacts of Commuting

While this report examines the global warming impact of commuting, work-related trips – especially single-passenger automobile commutes – have a series of other important impacts on the environment and society.

- **Air pollution** – Automobiles are major contributors to health-threatening air pollution in Massachusetts. In 1999, cars and light trucks were responsible for about 24 percent of Massachusetts' emissions of nitrogen oxides (NOx), and about 28 percent of emissions of volatile organic compounds (VOCs) – the two chemical components of ozone smog.[11] Vehicles also emit other health-threatening pollutants – such as particulate matter and toxic chemicals – in their exhaust.

- **Congestion** – Single-passenger automobile commutes are key contributors to congestion, particularly at peak travel periods. In the Boston metropolitan area in 2004, the average rush-hour driver spent 54 hours – more than two full days – per year in traffic. Boston-area congestion resulted in the consumption of 130 million excess gallons of gasoline and cost the region about $1.4 billion in wasted time and wasted fuel.[12] Policies and practices that encourage single-passenger automobile commutes add to this congestion.

- **Highway expenditures** – Chronic congestion often brings calls for new or expanded highway capacity – both major highways and local roads and streets. Expansion of road capacity imposes large costs on state and local governments, both for highway construction and for ongoing maintenance. In 1999, for example, approximately $5 billion were spent by all levels of government on construction, operation and maintenance of Massachusetts highways.[13]

Policies that reduce global warming emissions from commuting can reduce many of these other costs as well.

Global Warming Emissions from Commuting in Massachusetts

About the Study

In this report, we use data collected by the U.S. Census Bureau during the 2000 decennial census to estimate the carbon dioxide emissions produced by commuters traveling to and from various locations in Massachusetts and neighboring states. This analysis, which uses a simple methodology, produces rough estimates of total and per-commuter emissions from commuting trips that are useful in evaluating how various factors influence commuting-related emissions.

However, the methodology has several limitations:

1) We use average carbon dioxide emission factors that are applied to all cars and transit vehicles in the state. As a result, this study does not take into account local variations in the amount of carbon dioxide produced per mile by vehicles – for example, the propensity of residents of one town to own less-efficient vehicles than those in another, or variations in ridership among commuter rail or bus lines.

2) To preserve individual privacy, the Census Bureau does not disclose information for trips that are taken by a small number of people. These low-frequency trips are not included in the analysis.

3) We use town-level geographic data to estimate the length of each trip. In effect, we assume that all trips are from the center of one town to the center of the other, and that trips within a town average the length of the radius of the town. The use of more detailed geographic data (for example, at the census tract level), might produce more robust results.

4) The Census Bureau survey also allows only one choice for commuting mode and asks respondents to choose the mode used most frequently and for the greatest distance. As a result, for example, individuals who drive to a commuter rail line will generally list their mode of travel as "train." The automobile portion of this commute does not appear in the data and will not be reflected in this analysis.

For a more detailed description of the methodology, see Appendix A. See Appendix A also for suggestions for further research to deepen and broaden the analysis presented here.

Commuting Emissions by Place of Residence

Commuters residing in Massachusetts were responsible for about 4.6 million metric tons of carbon dioxide emissions in 2000.[14] About one-quarter of these emissions came from residents of 20 cities and towns. (See Table 1 and the map on page A of the color insert at the center of this report.)

Table 1. Top 20 Cities and Towns for Highest Commuting-Related Carbon Dioxide Emissions by Place of Residence (Metric Tons)

City or Town	Total CO_2 Emissions (metric tons)
Boston	234,490
Worcester	116,777
Plymouth	80,361
Lowell	73,454
Brockton	69,642
Springfield	65,817
Fall River	64,893
New Bedford	62,236
Taunton	61,428
Haverhill	61,295
Framingham	57,913
Quincy	52,019
Lynn	51,435
Newton	49,923
Barnstable	41,700
Weymouth	41,578
Attleboro	41,080
Leominster	40,918
Methuen	38,079
Waltham	37,224

The state's largest cities and towns dominate the list for total carbon dioxide emissions, but there are exceptions. Residents of Plymouth, with a population of about 50,000, were responsible for more carbon dioxide emissions than residents of Lowell and Springfield, which have more than double the population.

On a per-commuter basis, there is wide variation in carbon dioxide emissions among residents of the state's cities and towns. (See map on page B of the color insert.) The highest per-worker emission levels are among residents of southeastern Massachusetts, some communities in north-central Massachusetts, and belts in western and central Massachusetts.

Many of the communities with the highest per-worker carbon dioxide emissions from commuting are in rural areas, where there are few residents and, as a result, limited overall impact on statewide emissions. Among the 154 communities with total emissions of greater than 10,000 metric tons per year, the top 10 towns for per-worker emissions are predominantly located in two regions – the South Shore and north-central Massachusetts. (See Table 2.)

By contrast, the towns with the lowest levels of per-worker emissions (among those with 10,000 metric tons of annual emissions or greater) are generally those in the Metro Boston urban core. (See Table 3.)

The degree of variation among residents of the state's towns is significant. According to these estimates, the average worker living Plymouth emits ***six times*** the level of global warming pollution annually from his or her daily commute as the average worker living in Cambridge.

A Closer Look: The Boston Metro Area

Residents living in towns within 25 miles of Boston's city limits were responsible for about three-fifths (61 percent) of commuting-related carbon dioxide emissions in the state in 2000. As noted above, residents living near Boston's urban core produce very low levels of carbon dioxide emissions from their daily commutes. A detailed look at the Boston metro region suggests that emissions increase dramatically as one travels from the core toward outer suburbia.

Table 2. Top 10 Towns for Highest Per-Worker Carbon Dioxide Emissions by Place of Residence
(Towns Greater than 10,000 Metric Tons Annual Emissions)

City or Town	CO_2 Emissions per Commuter (lb/yr)	Total CO_2 Emissions (metric tons)
Plymouth	7,215	80,361
Marshfield	6,820	36,938
Townsend	6,741	12,977
Carver	6,695	15,308
Wareham	6,547	26,249
Duxbury	6,242	17,009
Bourne	6,204	23,111
Winchendon	5,960	10,539
Sandwich	5,791	23,626
Pepperell	5,762	13,749

To illustrate this, we compared total and per-worker emissions from Boston proper and four concentric belts around the city, which we term the Core Suburbs (communities within five miles of Boston city

Table 3. Bottom 10 Towns for Per-Worker Carbon Dioxide Emissions by Place of Residence
(Towns Greater than 10,000 Metric Tons Annual Emissions)

City or Town	CO_2 Emissions per Commuter (lb/yr)	Total CO_2 Emissions (metric tons)
Cambridge	1,171	28,593
Brookline	1,400	19,890
Somerville	1,672	33,480
Boston	1,869	234,490
Everett	2,102	16,425
Belmont	2,162	11,915
Malden	2,186	28,172
Watertown	2,199	18,069
Medford	2,256	28,279
Amherst	2,279	17,563

limits); the Route 128 belt (within 10 miles); the Inner I-495 belt (within 15 miles); and the Outer I-495 belt (within 25 miles). (See Fig. 3.)[15]

Fig. 3. Towns Included in Various "Belts" Around Boston

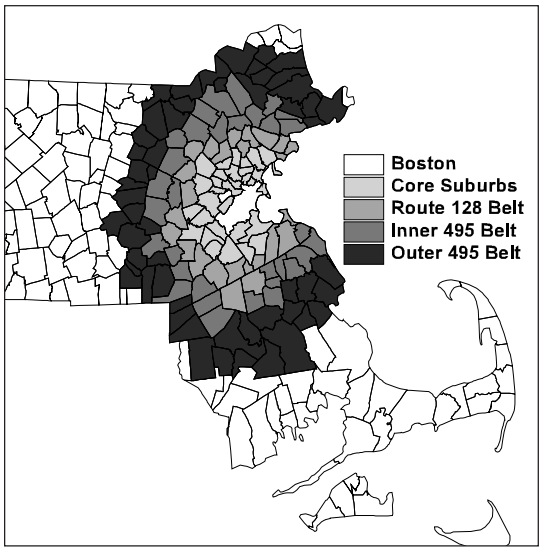


Fig. 4. Total Carbon Dioxide Emissions by Place of Residence

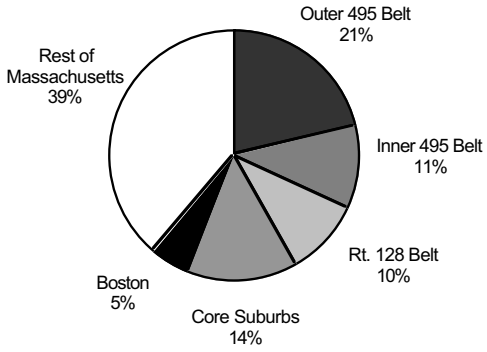
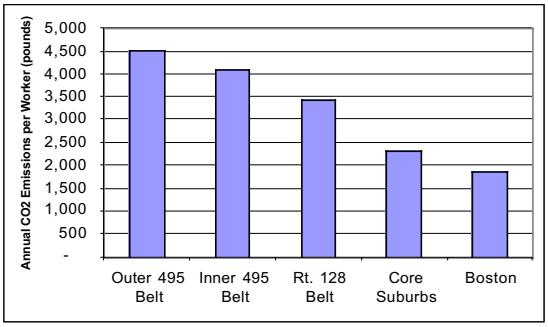


Fig. 5. Average Per-Worker Carbon Dioxide Emissions by Place of Residence



As shown in Figs. 4 and 5 below, the half-million commuters living in the Outer 495 Belt were responsible for about one-fifth of Massachusetts' commuting-related carbon dioxide emissions – producing more than twice as much carbon dioxide annually from their journeys to work, on average, as residents of Boston or the core suburbs surrounding the city.

Out-of-State Commuters

In addition to Massachusetts-based commuters, a large number of commuters travel from residences outside the state to workplaces in Massachusetts. These trips are significant sources of emissions, responsible for about 0.5 metric tons of carbon dioxide emissions each year – or about one-ninth of the total emissions created by Massachusetts residents.

In terms of total emissions, the greatest amount of carbon dioxide comes from commuters from towns in New Hampshire and Rhode Island – particularly those in close proximity to major highways such as I-93, I-95 and Route 3. (See Table 4.)

Unsurprisingly, commuters traveling to Massachusetts for work produce substantially more emissions than commuters within the state – an average of more than 9,100 pounds of carbon dioxide per worker per year (compared to the in-state average of about 3,700 pounds). Among the 21 towns generating greater than 5,000 metric tons of emissions per year, the highest level of per-capita emissions are in New Hampshire communities on the Seacoast (Portsmouth, Hampton)

Table 4. Carbon Dioxide Emissions from Out-of-State Commuters, Total by Town

City or Town	Total CO_2 Emissions (metric tons)
Nashua, NH	46,633
Derry, NH	26,803
Providence, RI	21,757
Salem, NH	21,426
Manchester, NH	21,385
Pawtucket, RI	18,630
Woonsocket, RI	16,265
Londonderry, NH	16,123
Hudson, NH	14,161
Cumberland, RI	10,701

Table 5. Top 10 Out-of-State Towns for Carbon Dioxide Emissions per Worker
(Towns with Greater than 5,000 Metric Tons Total Emissions)

City or Town	CO_2 Emissions per Worker (lb/yr)
Portsmouth, NH	16,018
Manchester, NH	15,501
Hampton, NH	12,419
Londonderry, NH	12,003
Merrimack, NH	11,707
Warwick, RI	10,777
Derry, NH	10,711
Cranston, RI	10,617
Nashua, NH	9,318
Windham, NH	8,744

or farther up I-93 or Route 3 (Manchester, Merrimack, Londonderry, Derry).

A major source of emissions from many of these communities is commutes to and from Boston. About one-third of emissions from residents of Portsmouth, NH commuting to Massachusetts locations are from commutes to Boston, with commutes to Cambridge and Andover running second and third.

Commuting Emissions by Place of Work

Carbon dioxide emissions from workers traveling to Massachusetts businesses totaled approximately 5.0 million metric tons in 2000. Commuters heading to Boston were responsible for about 16 percent of the state total. (See Table 6 and the map on page C of the color insert.)

The list of top 20 cities and towns for inbound commuting emissions is a mix of larger, established cities (Boston, Worcester, Cambridge and Springfield) with suburban "edge cities" (Waltham, Framingham, Marlborough).

The suburban "edge cities" are by far the leaders in per-commuter inbound emissions, with communities in the Interstate 495 belt west and northwest of Boston generating the greatest emissions. (See map on page D of the insert.) Among towns with total inbound commuting emissions of 10,000 metric tons or more, the leading communities for emissions per worker are suburban locations – most of them on the outer edges of the Boston metro area and in close proximity to major highways. (Table 7.)

Table 6. Top 20 Towns for Total Carbon Dioxide Emissions by Place of Work

City or Town	Total CO_2 Emissions (metric tons)
Boston	814,933
Worcester	166,498
Cambridge	148,620
Waltham	112,931
Framingham	102,011
Springfield	99,447
Marlborough	88,551
Andover	87,992
Quincy	87,742
Burlington	78,629
Newton	75,671
Woburn	68,136
Lowell	58,922
Brockton	58,603
Westborough	55,562
Billerica	54,252
Fall River	53,884
Braintree	52,688
Norwood	49,701
Bedford	48,725

Table 7. Top 10 Towns for Inbound Carbon Dioxide Emissions per Worker
(Total Emissions Over 10,000 Metric Tons)

City or Town	CO_2 Emissions per Worker (lb/yr)
Marlborough	6,125
Westborough	5,880
Littleton	5,504
Andover	5,503
Westwood	5,500
Canton	5,445
Bedford	5,362
Burlington	5,297
Billerica	5,292
Hopkinton	5,242

Interestingly, the list of towns with the lowest per-capita inbound emissions does not include Boston, but is rather dominated by smaller urban and suburban areas. (See Table 8.)

Boston Metro Area

Commutes to business locations in the Boston area (including towns within 25 miles of Boston's city limits) generate about three-quarters of the state's commuting-related carbon dioxide emissions. Commutes to Boston itself account for only about 22 percent of emissions from commutes to the metro region – indeed, more commuters travel daily to Boston's Core Suburbs than to the city itself and even more commuters travel to the suburban rings farther out from the city. (See Fig. 6.)

Fig. 6. Carbon Dioxide Emissions by Place of Work

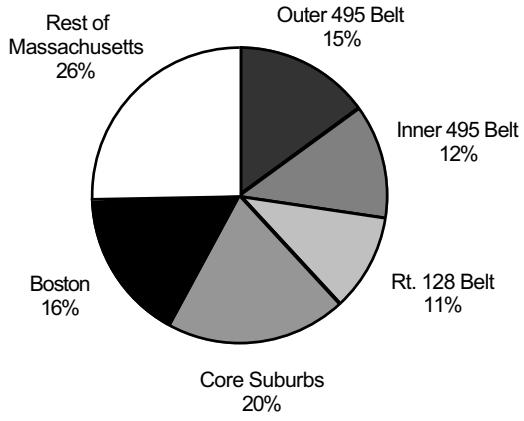


Fig. 7. Average Annual Carbon Dioxide Emissions per Worker by Place of Work

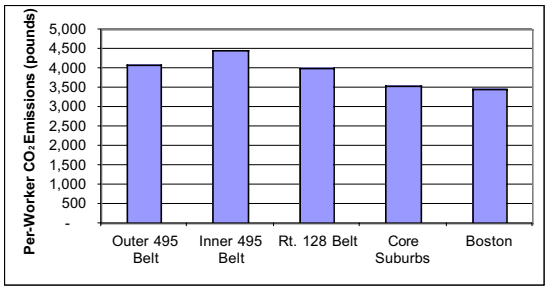


Table 8. Bottom 10 Towns for Inbound Carbon Dioxide Emissions per Worker
(Total Emissions Over 10,000 Metric Tons)

City or Town	CO_2 Emissions per Worker (lb/yr)
Brookline	2,209
Malden	2,403
Agawam	2,437
Chicopee	2,467
Somerville	2,485
Salem	2,536
Amherst	2,546
Chelsea	2,607
Holyoke	2,619
Medford	2,663

The difference in commuting emissions among various work locations is not as great as it is by residential location. In the case of Boston and the Core Suburbs, while more commuters traveling to those communities take transit, the average commute to those communities is longer. (See Fig. 7.) The average length of the commute to Boston, for example, is 11 miles, compared to just over 9 miles statewide.

Table 9. Top Out-of-State Cities for Carbon Dioxide Emissions by Massachusetts Residents

City or Town	Total CO_2 Emissions (metric tons)
Providence, RI	27,993
Hartford, CT	15,233
Nashua, NH	13,413
Manhattan, NY	11,438
Windsor, CT	10,392
Enfield, CT	8,088
Salem, NH	6,742
East Providence, RI	5,833
Manchester, NH	5,135
Newport, RI	5,125

Commutes to Out-of-State Locations

Just as some commuters travel from outside the state to work in Massachusetts, so too do some Massachusetts residents travel to workplaces in neighboring states. These commutes were responsible for about 0.2 million metric tons of carbon dioxide, or about half the emissions from out-of-state commuters headed to Massachusetts. The Hartford and Providence areas are the leading attractions for Massachusetts residents, although Manhattan Borough in New York City is also a draw. (See Table 9.)

Factors Influencing Commuting Emissions

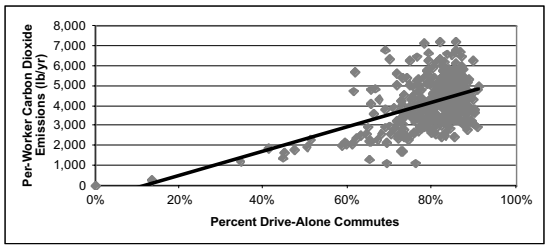
The variation among Massachusetts towns in global warming emissions from commuting can be explained by several factors, specifically: the use of transit service and other transportation alternatives; development patterns (especially the growth of "exurban" bedroom communities and suburban centers of employment); and the degree to which commuters live near their work.

Use of Transit and Other Transportation Alternatives

Global warming emissions from commuting are directly correlated with the degree to which commuters drive to work in single-passenger automobiles. The use of transit and other transportation alternatives (such as carpools and vanpools, walking and biking, and telecommuting) can significantly reduce global warming emissions.

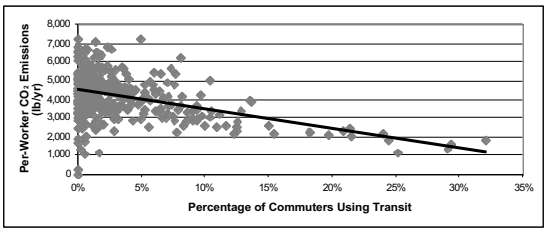
Across the commonwealth's 351 cities and towns, there is a strong correlation between single-passenger commuting and per-worker carbon dioxide emissions. (See Fig. 8.)

Fig. 8. Percentage of Drive-Alone Trips versus Carbon Dioxide Emissions per Worker by Place of Residence



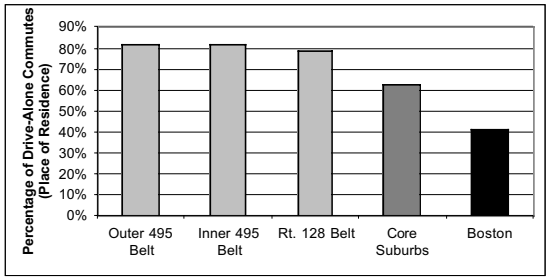
Looking more specifically at transit use, emissions of carbon dioxide per commuter decline as the percentage of workers taking any form of transit (bus, commuter rail, subway or other) increases. (See Fig. 9.)

Fig. 9. Percentage of Transit Users versus Carbon Dioxide Emissions per Worker by Place of Residence



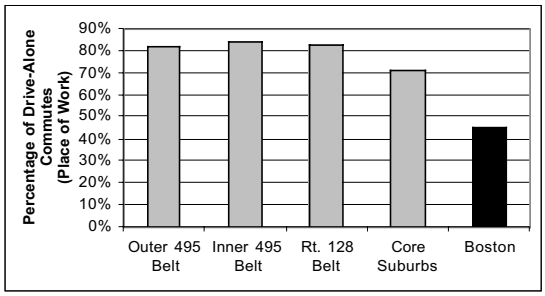
Nowhere is the impact of transit greater than in the metropolitan Boston area. Only about 40 percent of all commuters living in Boston drive to work alone, while just over 60 percent of residents of Boston's Core Suburbs drive alone. (See Fig. 10.) These percentages are far below the state average of 73 percent. In some Core Suburbs – such as Cambridge (35 percent drive-alone), Brookline (45 percent) and Somerville (45 percent) – the percentage of drive-alone commuters is similar to that of Boston itself. It is little surprise that these communities have among the lowest levels of per-worker emissions in the commonwealth by place of residence.

Fig. 10. Percentage of Drive-Alone Commutes by Place of Residence: Boston Metropolitan Area



The same is true when looking at emissions by place of work. Again, the percentage of commuters traveling alone by car to Boston is dramatically lower than the percentage driving alone to other locations in the metropolitan area. (See Fig. 11.)

Fig. 11. Percentage of Drive-Alone Commuters by Place of Work: Boston Metropolitan Area



It is interesting to note that, while 63 percent of commuters *living in* Core Suburbs drive alone to their jobs, 71 percent of commuters *traveling to* Core Suburbs drive alone. This suggests that transit service and other transportation alternatives are significantly more effective in getting commuters out of these cities and towns than they are in servicing commuters who work there. We will return to this issue in our discussion of "Edge Cities" below.

Transit and transportation alternatives also play an important role beyond the Boston metropolitan area. The Pioneer Valley and Berkshires in western Massachusetts have relatively low levels of per-worker emissions by place of residence, and the propensity of residents of those areas to use transportation alternatives is a major contributing factor.

The college towns of western Massachusetts – particularly Amherst (51 percent drive-alone commuters), Williamstown (59 percent), and Northampton (69 percent) – have among the lowest rates of drive-alone commuting outside of the Boston metropolitan area.

Transit is a significant factor in some of these communities. In both Amherst and Springfield, for example, transit accounts for more than 5 percent of commuting trips – a level higher than in many Boston-area suburbs. But other transportation alternatives play an important role as well. South Hadley residents, for example, are very likely to carpool (8 percent of commutes), walk (12 percent of commutes) or work at home (4 percent of commutes).

Transit, particularly in the form of rail, also plays a key role in reducing emissions from long-distance commutes from out-of-state locations to Boston. Providence, RI, for example, sends approximately 1,100 commuters the 38 miles to Boston every day, but nearly half of these commuters travel to Boston by rail and only about a quarter drive to Boston alone. By contrast, about half of commuters from Portsmouth, NH – which is not directly served by rail – drive to Boston alone, while about a fifth carpool. (Note: The Census survey was conducted before the extension of Amtrak "Downeaster" service to several towns in southeastern New Hampshire.)

In summary, the metropolitan Boston-area transit network plays an important role in reducing global warming emissions in the region – without it, emissions would likely be dramatically higher than they are today. Transit also plays a significant role in other parts of the commonwealth, as do transportation alternatives such as carpooling. But there are several important weaknesses in the region's transit network – particularly the ability of the system to deliver workers to Boston's Core Suburbs and to reduce commuting emissions from long-distance commuters from the rapidly-growing suburban areas of New Hampshire and Rhode Island.

Land Use: Exurbia and Edge Cities

Suburban development patterns have played a major role in increasing automobile travel over the past several decades and, by extension, increasing global warming emissions. In recent years, two related developments – the expansion of employment in suburban "edge cities" and the growth of formerly rural, residential "exurbs" – have threatened to further exacerbate global warming emissions from commuting.

Edge Cities: Suburbia Squared

"Edge cities" are newly constructed suburban mini-hubs – often located at junctions of major highways – that are centers of employment and commercial activity in their own right.[16] The term "edge cities" was coined in a 1991 book of the same name by *Washington Post* reporter Joel Garreau. At the time of publication, Garreau identified 10 existing or emerging edge cities in the Boston metropolitan area:

- Kendall Square-MIT area
- Alewife T station area
- Quincy-Braintree
- Mass. Turnpike-Rt. 128 area
- Burlington Mall area
- Peabody-Danvers
- Southern New Hampshire
- Mass. Turnpike-I-495 area
- Framingham area
- Foxboro[17]

Garreau's definition of "edge city" excludes concentrations that were cities prior to the advent of the automobile. In Massachusetts, there are many of these old-model regional hubs including Fitchburg, Lowell, Lawrence and Brockton.

A listing of the top communities for per-worker emissions by inbound commuters is a virtual "who's who" of Massachusetts edge cities – with Marlborough, Westborough, Andover and Littleton at the top for communities with greater than 10,000 metric tons of emissions annually.

In terms of total emissions, commutes to workplaces in the Route 128/I-495 belts generate more global warming pollution than commutes to Boston and the core suburbs. And the vast bulk of these emissions come from "suburb-to-suburb" commutes. For workplaces in the I-495 belt, for example, about two-thirds of commuting related emissions come from commuters living within or outside of the 495 belt. (See Table 10.)

The challenge of providing transportation alternatives to commuters heading to suburban workplaces is formidable, but there are opportunities to do so. Many Boston-area suburbs – and particularly Core Suburbs and those in the Rt. 128 Belt – have some amount of transit infrastructure in the form of commuter rail service, bus routes, or even direct connections to the MBTA subway system. Yet, the existence of this infrastructure often does little to reduce the number of single-passenger automobile commutes to edge city locations.

The case of commuters residing in Plymouth is a prime example. Plymouth has the highest rate of per-worker carbon dioxide emissions among towns with more than 10,000 metric tons of annual emissions. It has also been served by commuter rail since the mid-1990s, when service was restored on the Old Colony rail lines.

The availability of transit has made a significant impact for commuters to and from Boston – in 2000, more than one-quarter of commutes from Plymouth to Boston were via commuter rail and only a little more than half of Boston-bound commuters drove alone. But while Boston-bound commuters were responsible for the largest share of Plymouth's carbon dioxide emissions, commuters to other destinations – such as Quincy, Brockton and Braintree – were also important sources of emissions.

Table 10. Emissions from Commutes to Inner and Outer 495 Belts

	Total CO_2 Emissions	Percent of Total Emissions	CO_2 Emissions/ Worker (lb/yr)
All Trips to Inner and Outer 495 Belts	1,367,807		
From Boston	51,149	4%	8,202
From Core Suburbs	165,386	12%	6,884
From Rt. 128 Belt	104,056	8%	4,700
From Inner 495 Belt	149,980	11%	2,456
From Outer 495 Belt	385,538	28%	2,778
From Outside Outer 495 Belt	511,698	37%	7,355

Table 11. Top Five Destinations for Total Carbon Dioxide Emissions from Plymouth Commuters

	Total CO_2 Emissions (metric tons)	Percent of Total
Total Emissions	80,361	
Boston	13,951	17%
Plymouth	9,868	12%
Quincy	4,780	6%
Brockton	3,165	4%
Braintree	2,480	3%

The Plymouth commuter rail line stops in both Braintree and Quincy Center, but the level of commuting rail travel to these destinations is very low. A similar pattern exists in other South Shore communities such as Duxbury and Marshfield, where over 10 percent of commuting-related emissions are from trips to Braintree and Quincy. Levels of rail travel from these communities, which are not directly served by commuter rail, are significantly lower.

The edge city phenomenon is also in evidence on the North Shore. Amesbury, for example, is part of a belt of high per-worker emission communities in the Merrimack Valley. Amesbury (like communities such as Duxbury and Marshfield) is not directly served by commuter rail, but residents do have access to rail at stations in nearby Newburyport and Haverhill. While Boston-bound commuters are the leading contributors of carbon dioxide emissions, significant emissions result from commutes to suburban mini-hubs such as Danvers and Andover, as well as older, established regional hubs such as Newburyport and Lawrence.

Table 12. Top Five Destinations for Total Carbon Dioxide Emissions from Amesbury Commuters

	Total CO_2 Emissions (metric tons)	Percent of Total
Total Emissions	19,732	
Boston	2,151	11%
Danvers	1,363	7%
Andover	1,187	6%
Newburyport	965	5%
Lynn	809	4%

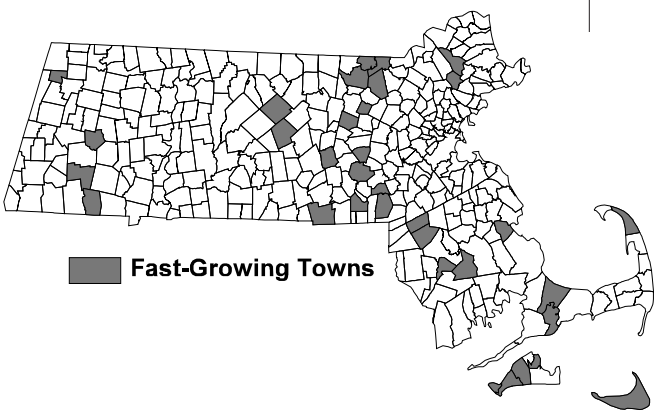
Reducing global warming emissions from commuting will require effective strategies for addressing suburb-to-suburb commutes. The commonwealth should begin by taking better advantage of its existing transit infrastructure. A large part of the problem is that transit stations in suburban locations are often not located in close proximity to centers of employment. Transit stations may be remote and isolated by large parking lots – making walking to or from the station difficult – or workplaces may be located in isolated office parks that are difficult to reach on foot. Several transit agencies in other states have instituted shuttle bus services that connect suburban office parks with neighboring transit stations. Encouraging transit-oriented development near existing stations could also help. Finally, improving the connectivity of the central MBTA system could allow commuters to use the system more effectively to reach jobs around Boston, and not just those in the center city.

Exurbs: The New Bedroom Communities

The growth of suburban edge cities also spurs the development of residential areas even farther from central cities. This trend is exacerbated by the extremely high cost of housing in Massachusetts, particularly in the Boston metro area, where "drive until you qualify" has become a mantra for potential homebuyers looking for an affordable place to live.

Over the past decade, Massachusetts has seen the explosive growth of formerly rural "exurbs." Massachusetts' fastest-growing towns are in the exurban belt surrounding I-495, as well as on the Cape and Islands and in portions of western Massachusetts. (See Fig. 12.) With the exception of the Cape and Islands, these are all relatively high-emitting portions of the state.

Fig. 12. Towns with Greater than 25 Percent Population Growth: 1990-2000[18]



Exurban development poses several problems from a global warming perspective. First, many exurban developments are distant from centers of employment and transit infrastructure, with the result that residents have longer commutes that are less likely to occur via transit. The trend toward longer commutes is not

just a Massachusetts phenomenon: nationally, the number of workers making "stretch commutes" (those of 50 miles or more) has swelled to more than 3 million. The vast majority of these commutes – about 96 percent – are by personal vehicle.[19]

Second, many Massachusetts exurbs serve as bedroom communities for several cities at the same time. These "multi-polar" bedroom communities are not easily served by transit or other transportation alternatives. Two examples of these communities are in the north-central portion of the state: the towns of Winchendon and Hubbardston. Both communities rank very high for per-worker carbon dioxide emissions – with Hubbardston ranking 20th among the commonwealth's 351 cities and towns (average emissions: 6,098 pounds per commuter per year) and Winchendon ranking 22nd (5,960 pounds per commuter per year).

In both of these communities, large shares of commuting-related global warming emissions come from trips to regional centers – such as Worcester, Leominster and Fitchburg. (See Table 13.)

What is interesting about Winchendon and Hubbardston is that neither community is all that close to the cities for which it serves as a bedroom community. Winchendon lies 18 miles from Leominster, 14 miles from Fitchburg and 30 miles from Worcester. The destination that ranks sixth for emissions from the town – Cambridge – lies 52 miles away. Similarly, Hubbardston is 17 miles from Worcester and 32 miles away from Framingham, but provides significant numbers of commuters to both communities. Both towns have experienced significant population growth in the past decade, with the population of Hubbardston increasing by 40 percent and the population of Winchendon increasing by 9 percent between 1990 and 2000.[20]

The concept of the multi-polar bedroom community reaches its apex in a series of small towns in southern and western Massachusetts that are rapidly transform-

Table 13. Top Five Destinations for Total Carbon Dioxide Emissions from Winchendon Commuters

	Total CO_2 Emissions (metric tons)	Percent of Total
Total Emissions	10,539	
Leominster	1,159	11%
Fitchburg	1,115	11%
Worcester	919	9%
Gardner	789	7%
Winchendon	684	6%

Table 14. Top Five Destinations for Total Carbon Dioxide Emissions from Hubbardston Commuters

	Total CO_2 Emissions (metric tons)	Percent of Total
Total Emissions	4,864	
Worcester	970	20%
Leominster	427	9%
Gardner	391	8%
Fitchburg	305	6%
Framingham	271	6%

Table 15. Top Five Destinations for Total Carbon Dioxide Emissions from Holland Commuters

	Total CO_2 Emissions (metric tons)	Percent of Total
Total Emissions	3,575	
Worcester	645	18%
Westborough	218	6%
Springfield	217	6%
Auburn	176	5%
Southbridge	170	5%

Table 16. Top Five Destinations for Total Carbon Dioxide Emissions from Tolland Commuters

	Total CO_2 Emissions (metric tons)	Percent of Total
Total Emissions	432	
Springfield	118	27%
W. Springfield	65	15%
W. Hartford, Ct.	57	13%
Simsbury, Ct.	38	9%
Hartford, Ct.	36	8%

ing into exurbs. The town of Holland, for example, had less than 2,500 residents in 2000, but ranked number one in the entire state for per-worker carbon dioxide emissions from commuting (7,216 pounds per commuter per year), due largely to its proximity to Interstate 84, which connects the town to the Massachusetts Turnpike. Neighboring small towns such as Wales (12th, with 6,487 pounds per worker per year) ranked high as well.

Holland is a relatively long way from Worcester (24 miles), Westborough (32 miles), Springfield (20 miles), and Hartford, Conn. (34 miles), but sent significant numbers of commuters to all four communities – in essence, serving as a bedroom community for cities to the east, west and south, all at the same time.

A similar pattern emerges in the even-smaller town of Tolland in western Massachusetts, which ranked fourth for per-worker emissions among all Massachusetts towns (6,843 pounds per worker per year). Tolland sends commuters to Springfield (24 miles to the east) and Hartford (28 miles to the southeast) as well as to communities just outside those two cities.

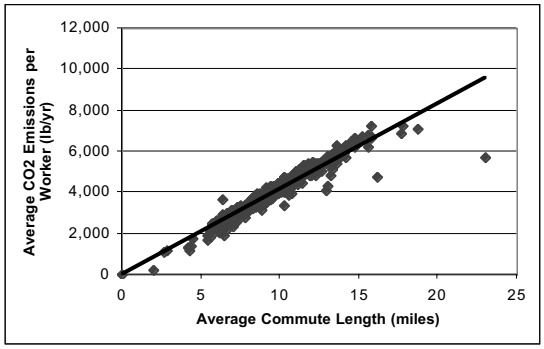
As sources of total emissions, these small towns barely register on the map. But they are sentinels of a broader movement toward exurban development in rural regions of the state – a trend with significant potential impacts on carbon dioxide emissions in the future.

Continued exurban development poses a significant challenge to Massachusetts' ability to control carbon dioxide emissions generated from commutes. Because of their distance from major metropolitan and regional centers, as well as the fact that many exurbs supply workers to several of these centers, it is unlikely that conventional transit service or other alternatives will succeed in replacing single-passenger commutes from these communities. Curbing exurban development itself, and promoting compact development patterns and a mix of land uses in areas targeted for new development are potentially important steps the state could take to deal with this trend.

Population Density and Living Near Work

One simple, but often overlooked, way to reduce global warming emissions from commuting is to encourage commuters to live closer to their place of work. In fact, average commute trip length appears to have the strongest relationship of any factor with carbon dioxide emissions by place of residence and by place of work. (See Fig. 13.)

Fig. 13. Average Commute Distance versus Carbon Dioxide Emissions per Worker by Place of Residence

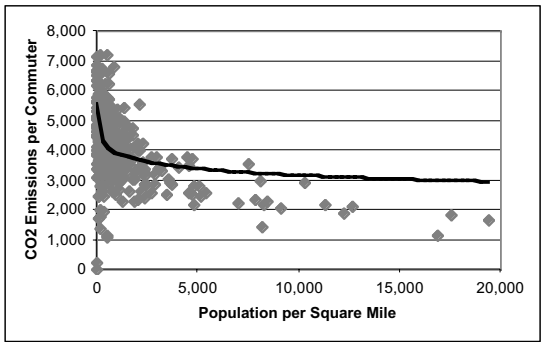


The importance of living near work is exemplified by the belts of low emission towns and cities in the Pioneer Valley and in the Berkshires. Commuters from the Berkshires town of Lenox, for example, emit an average of less than 2,600 pounds of carbon dioxide per year, about 25 percent below the state average. The major reason for the low per-worker emissions is the fact that the majority of Lenox commuters drive to nearby towns for work; nearly three-quarters of all commuting trips are to three towns: Pittsfield (6 miles away), Great Barrington (11 miles away) and Lenox itself. Similar patterns exist in towns such as Dalton, as well as the older cities of Pittsfield and North Adams – all of which have low levels of per-worker emissions.

Thus, one of the most powerful steps Massachusetts could take to reduce global warming emissions from commuting would be to encourage workers to live nearer their places of work. Traditional New England town design encourages this by placing residences close to town centers and by mixing residential and com-

mercial development. Indeed, per-worker carbon dioxide emissions are also correlated with the population density of the towns in which workers live. (See Fig. 14.)

Fig. 14. Population Density versus Carbon Dioxide Emissions per Worker by Place of Residence



However, living near one's work is not an option for commuters who cannot afford the cost of housing. Resolving the state's affordable housing crisis would reduce the pressure toward exurban development and make it possible once again for many workers to choose to live near their place of employment. In addition, creating a balanced mix of residential and commercial development, increasing residential population density, and designing incentives to promote living near work could all contribute to reducing carbon dioxide emissions from commuting.

The data presented in this report point the way to several conclusions regarding how Massachusetts can reduce carbon dioxide emissions resulting from journeys to work.

Strategies to Promote Transit and Transportation Alternatives

Invest in Success

Metro Boston's transit network is a key factor in reducing carbon dioxide emissions from commuting. The fact that just over 40 percent of Boston residents and just over 60 percent of Core Suburb residents drive alone to work is a testament to the role of the MBTA transit system in reducing carbon dioxide emissions. In addition, the MBTA's commuter rail network plays a strong role in reducing emissions from Boston-bound commuters living in distant cities and towns such as Providence.

But the continued success of the MBTA system as a global warming-fighting tool depends on the maintenance of high standards of service quality and affordable fares – which in turn depends on the provision of adequate operating funding to the T. Reductions in service quality or increases in fares that discourage transit use could set the state backward in its quest to reduce transportation-sector global warming emissions and must be avoided.

In addition, the parking crunch at commuter rail and MBTA stations discourages many commuters from using rail. Additional parking may be needed in some cases, but the MBTA should emphasize creative solutions – such as community shuttle buses that bring local residents to train stations – that have worked well in other states. Finally, planning for commuter rail lines should be integrated with land-use planning to ensure that new commuter rail expansions do not lead to additional sprawling development.

Outside the Boston area, several regional transit authorities play an important role in reducing single-passenger automobile commutes. State officials should investigate ways to build upon the success of these systems.

Promote Transit Connectivity

A clear area for potential improvement in the MBTA system and regional transit agencies is the improvement of connectivity, which would make it easier for suburban commuters to reach a variety of destinations in Boston and its Core Suburbs. As noted earlier, while many commuters take advantage of the MBTA to travel to central Boston, fewer use transit to reach jobs in the Core Suburbs – despite the presence of substantial transit infrastructure in many of these communities.

Infrastructure investments are part of the solution. Projects such as a well-designed "Urban Ring" transit link around Boston, the Red-Blue Line Connector, subway extensions on the Green and Blue lines and, eventually, a North-South commuter rail link can improve connectivity across Boston's core urban transit system and allow commuters from more communities to more easily reach more jobs in more locations.

Encourage Transit-Oriented Development and Improve Service to "Edge Cities"

Massachusetts could make better use of its existing transit infrastructure by encouraging development in and around transit stations. The creation of new commercial and residential opportunities within walking distance of transit would reduce the need to use automobiles to "trip chain" and would create mini-hubs that would be primarily served by transit, not the automobile. The Romney administration's efforts to promote transit-oriented development represent a promising step, but care should be taken to ensure that residents currently living near transit stops are not uprooted in the process.

Suburban development has already created many automobile-oriented mini-hubs. But many of these hubs (for example, Braintree and Quincy) also have some transit infrastructure. For many reasons (which may include inconvenient access, poor timing of service, or the lack of emergency back-up transportation options), even commuters in towns served by commuter

rail lines that pass through these mini-hubs are reluctant to use transit to get to and from their work in edge cities. The state and private employers should engage in efforts to find ways to encourage the use of transit, carpooling and other alternatives for workers commuting to edge city locations. New Jersey and other states have pioneered jitney and shuttle bus services to and from commuter rail stations in suburban locations. Massachusetts should consider similar pilot programs to better tie suburban residences and workplaces into the Boston region's expansive transit network.

Hold Suburban Workplaces Accountable for the Emissions They Generate

As noted above, suburban workplaces – particularly those in the fast-growing I-495 Belt – generate greater levels of carbon dioxide emissions per commuter than workplaces in the Boston metropolitan core. Employers who choose to build in these areas are often required, as part of the local planning process, to mitigate the impact of their development on local residents, the environment, or the transportation system. They should also be required to mitigate the impact they have on Massachusetts' emissions of global warming pollution.

One way to do this is to require that employers with a certain number of employees implement commute-trip reduction plans aimed at reducing the number of single-passenger automobile commuters. Smaller employers in a given area could be required or encouraged to join together to support joint commute-trip reduction efforts, and large employers could offer transit subsidies – indeed, some businesses already engage in such efforts. Employers in more remote areas could provide carpooling, guaranteed ride home programs, and financial incentives for living near work, among other programs.

Massachusetts' existing ridesharing regulation could serve as the basis for such a program. The rule currently requires very large employers (with 250 employees or more at a particular facility) to develop plans designed to reduce single-passenger commutes by 25 percent. The state could expand the program to include smaller employers (as is the case in Washington state, where employers with more than 100 employees must comply) or improve its effectiveness.

Extend the Regional Transit Network

Exurban development is not limited to Massachusetts. Commuters come to the state every day from southern New Hampshire, southern Maine, Rhode Island and beyond. These interstate commutes, while low in number, produce large amounts of carbon dioxide per worker – up to 10 times the amount produced by the average commuter living in Boston.

Massachusetts and neighboring states should consider further expansions of the MBTA commuter rail network in New Hampshire and Rhode Island, as well as encouraging the completion of commuter rail links to Fall River, New Bedford and Greenbush. The significant number of western Massachusetts commuters heading to Connecticut could benefit from extension of that state's commuter rail network from New Haven to Hartford and eventually Springfield, Mass. Finally, Massachusetts, New Hampshire and Maine should ensure continued service on Amtrak's "Downeaster" line and find ways to encourage commuters to use the service. Any expansion of commuter rail service should be designed in such a way as to minimize its contribution to additional suburban sprawl.

Strategies to Promote More Efficient Land Use

Put the Brakes on Exurban Development

The growth of "exurbs" – formerly rural areas that are now being converted to low-density sprawling development – is one of the most ominous trends for Massachusetts' efforts to reduce global warming emissions from transportation. As noted earlier, exurban development is growing in areas that are centrally located to several cities or regional mini-hubs. By definition, these areas are unlikely ever to have the population density or mixed-use development that can make alternatives to driving possible. They are likely to remain permanently automobile dependent.

Slowing the growth of exurbs requires both carrots and sticks. It is no secret that one of the great pressures driving individuals to consider exurban residences is the high cost of housing in and around the

Boston metro region. "Drive until you qualify" has become a common phrase for workers seeking housing in the region's overheated housing market. By increasing the supply of affordable housing in the metropolitan core, these pressures would be much reduced.

Among the sticks that can be used to slow exurban development are policies that require sprawling developments to pay their own way. State dollars should not be used to support transportation and infrastructure improvements that will facilitate further sprawl, but should rather be targeted toward areas in which growth is desirable. The Romney administration's efforts to align state investment decisions with "smart growth" principles are promising. The state should also investigate how to adapt tools developed in other states – such as priority funding areas, urban growth boundaries, and municipal service boundaries – to fit within Massachusetts' strongly held tradition of home rule.

Encourage Mixed-Use Development, Live-Near-Work, and Telecommuting

As the data presented above on non-vehicular commutes shows – and the experience of communities in the Pioneer Valley and Berkshires demonstrates – living near work can dramatically reduce carbon dioxide emissions from commuting.

Pedestrian commutes are often disregarded in transportation planning, but from a global warming perspective they are very important. However, pedestrian commutes are only possible when workplaces and residences are in close proximity and where pedestrian infrastructure (such as sidewalks and safe crossing points) exists. Massachusetts' traditional town centers provide a model for how to mix uses in a way that is beneficial to a community's character and its environment. The state and its towns should encourage mixed-use development in town centers and adopt practices – such as traffic calming techniques – that are friendly to pedestrian commuters.

These practices would be bolstered by efforts to encourage greater density in suburban development and to encourage the redevelopment of urban areas. New suburban developments should be designed so that the automobile is not the sole means of transportation. Existing suburbs should be encouraged to promote "infill" development. And state investment should be directed to encouraging the redevelopment of existing properties in urban areas that could be sites for affordable housing or new commercial development.

At the same time, transportation planning should be conducted in concert with land-use planning. One tool is the use of corridor planning, which allows for the evaluation of a variety of transportation options, along with land-use changes, to address the future transportation needs of a given area.

The commonwealth, towns and employers should explore novel ways to encourage commuters to live near their work or near transit. The "Take the T Home" mortgage program – which allows residents living near transit to purchase homes with no money down – is an example of one such program. Commuters who live near their place of work not only reduce global warming emissions, but also reduce the strain on the commonwealth's transportation infrastructure. They should be rewarded for their choices.

Telecommuting also holds promise to reduce the number and length of commuting trips made daily. Employers – particularly those in remote or suburban locations – should be encouraged to develop telecommuting alternatives for their employees.

Strategies to Reduce Vehicle Global Warming Emissions

No matter where commuters live and work within the commonwealth, their emissions of global warming pollution could be much reduced if they were to use cleaner vehicles and avoid unnecessary single-passenger driving. There are several policy tools that Massachusetts could use to encourage reductions in per-mile vehicle emissions and unnecessary single-passenger driving.

Massachusetts has already taken an important first step by adopting the Clean Cars Program, which will re-

quire new cars sold by 2016 to produce about 34 percent less global warming pollution and new light trucks to produce about 25 less pollution than vehicles sold today.[21] The state can also require the sale of fuel-saving tires, provide incentives for the purchase of more fuel-efficient vehicles, and work to reduce global warming emissions from transit fleets.

The commonwealth should also consider ways to discourage unnecessary single-passenger driving. Reallocating the cost of driving away from fixed charges and toward per-mile charges – as would be accomplished by calculating auto insurance rates by the mile – are among the options that should be considered, as should surcharges on motor fuels or vehicle travel that can be used to promote the purchase of more efficient vehicles or low-emission transportation alternatives.

Appendix A: Methodology

Calculation of Carbon Dioxide Emissions

This analysis is based on journey-to-work data collected by the U.S. Census Bureau during the 2000 decennial Census. Massachusetts data for county subdivisions was downloaded from the Census Bureau on January 10, 2005.

Distance between towns was calculated based on latitude and longitude coordinates for each county subdivision downloaded from the Census Bureau on January 11, 2005. Distance in miles was calculated by applying the Haversine formula to the latitude and longitude coordinates in radians. The formula is as follows:

```
3956*(2*ASIN(MIN(1,SQRT(SIN((latwkrad-
latresrad)/2)^2 + COS(latwkrad)*
COS(latresrad)*(SIN((longwkrad-longresrad)/
2))^2))))

Where:
latwkrad = The latitude of the work location in
    radians
longwkrad = The longitude of the work location
    in radians
latresrad = The latitude of the residential location
    in radians
longresrad = The longitude of the residential
    location in radians
```

For commutes within a town, we assumed that the average trip length equaled SQRT(areares/3.14), where "areares" equals the land surface area of the town. This method could result in higher-than-warranted emission estimates for towns with a very large surface area and lower-than-warranted estimates for very small towns.

Pounds-per-mile carbon dioxide emission factors for each transportation mode were calculated as follows:

- **Drive-alone commutes**: Per-mile emissions were based on the assumption that a gallon of gasoline results in emissions of 19.6 pounds of carbon dioxide, per carbon coefficients and heat content data from U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B. Average, on-road fuel economy for cars and light trucks was based on year 2001 data obtained from U.S. Energy Information Administration, *Annual Energy Outlook 2004.* Emission factors for both cars and light trucks were estimated by multiplying carbon dioxide emissions per gallon of gasoline by the inverse of on-road MPG. These values were then weighted by the ratio of registered cars to light trucks in Massachusetts per Federal Highway Administration, *Highway Statistics 2003*.

- **Carpooling**: Emissions from carpools were obtained by dividing the emission factor for drive-alone commuters, calculated above, by the number of people in the carpool. For carpools of 4-5 commuters, 4.5-person carpools were assumed; for carpools of 6-7 commuters, 6.5; and for carpools of 7 and more, 7-person carpools were assumed.

- **Transit**: Emission factors for each transit mode were based on fuel consumption and passenger-miles data from the Federal Transit Administration, National Transit Database 2003. Data for Massachusetts transit agencies reporting energy use data to the data base were aggregated by mode, with the sum of energy use divided by passenger-miles for each mode to arrive at energy consumption per passenger-mile of travel. Carbon dioxide emissions were estimated by multiplying energy consumption by carbon coefficients from U.S. Department of Energy, Energy Information Administration, *Fuel and Energy Source Codes and Emission Coefficients* downloaded from www.eia.doe.gov/oiaf/1605/factors.html, 17 January 2005. Emissions from transit modes consuming electricity were based on the average electric-sector carbon dioxide emissions per kilowatt-hour derived from U.S. Energy Information Administration, *State Electricity Profiles 2002*. For transit modes in which Massachusetts transit agencies did not report energy use data, New England averages were used, calculated according to a similar methodology as described above.

- **Taxis and motorcycles**: Per-mile emissions from taxis were assumed to be the same as the per-mile

emissions from cars and light-duty trucks derived above. Emission factors for motorcycles were based on an average fuel economy for motorcycles of 50 miles per gallon, per U.S. Environmental Protection Agency, *Updating Fuel Economy Estimates in MOBILE 6.3*, draft report, August 2002.

- **Non-motorized commutes and other**: Bicycling, walking and work-at-home commutes were assumed to produce zero emissions of carbon dioxide, as were commutes listed under the "other" category.

Other Notes

Emissions "per commuter" or "per worker" are based on total emissions from a place of residence or place of work, divided by the number of commuters driving to or from that town.

The definitions of the various "belts" around Boston were based on GIS mapping using ArcView 3.x. Towns included in each ring are those identified by ArcView as within 5, 10, 15 or 25 miles of Boston city limits.

Limitations and Suggestions for Further Research

As noted in the text, the simplified methodology used in this report appears to be sufficient to show general trends, but suffers from several limitations. We suggest several areas future researchers may wish to explore to add detail and depth to this analysis:

- Integrating vehicle registration data into the analysis to factor in variations in fuel economy among the vehicles used by residents of various towns.

- Accounting for regional differences in transit energy consumption and ridership to more accurately reflect emissions from transit modes.

- Using more detailed geographic analysis comparing transit use based on proximity to commuter rail lines and other sources of transit infrastructure.

- Integrating more recent population and transportation data to update this analysis prior to the next decennial census.

Appendix B: Emissions and Commuting Data by Town of Residence

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Abington town	83%	3,554	246	11,688	141
Acton town	81%	4,422	150	20,974	65
Acushnet town	86%	3,597	238	7,971	187
Adams town	83%	3,580	241	6,102	208
Agawam city	90%	3,292	272	21,189	62
Alford town	66%	4,090	189	275	344
Amesbury town	82%	5,457	45	19,732	72
Amherst town	51%	2,279	331	17,563	82
Andover town	81%	4,350	162	28,116	39
Aquinnah town	66%	3,623	236	244	345
Arlington town	67%	2,289	330	23,933	54
Ashburnham town	87%	5,973	21	6,896	199
Ashby town	87%	5,442	47	3,154	257
Ashfield town	74%	5,456	46	2,262	276
Ashland town	85%	4,051	193	13,956	113
Athol town	75%	5,074	78	10,609	149
Attleboro city	80%	4,407	152	41,080	17
Auburn town	88%	3,720	227	12,656	130
Avon town	82%	3,015	294	2,536	273
Ayer town	84%	4,561	135	7,039	197
Barnstable Town city	80%	4,315	168	41,700	15
Barre town	79%	5,751	30	5,594	212
Becket town	83%	6,161	19	2,097	281
Bedford town	84%	3,385	262	9,048	169
Belchertown town	84%	4,637	126	14,057	111
Bellingham town	85%	5,072	79	17,650	81
Belmont town	69%	2,162	335	11,915	136
Berkley town	87%	5,801	27	7,159	194
Berlin town	83%	3,441	255	1,658	293
Bernardston town	87%	3,660	234	1,680	291
Beverly city	78%	3,258	276	29,257	35
Billerica town	87%	3,851	214	34,712	24
Blackstone town	85%	4,593	130	8,372	179
Blandford town	82%	6,321	14	1,551	298
Bolton town	83%	5,111	74	4,228	239
Boston city	41%	1,869	340	234,490	1
Bourne town	81%	6,204	18	23,111	56
Boxborough town	82%	4,856	99	5,176	224
Boxford town	83%	5,739	34	8,766	172
Boylston town	88%	3,514	249	2,555	272
Braintree town	78%	2,883	303	21,141	63
Brewster town	83%	3,910	211	7,750	190
Bridgewater town	81%	4,796	104	25,373	48
Brimfield town	81%	5,418	51	3,423	250
Brockton city	73%	3,766	221	69,642	5
Brookfield town	84%	5,135	71	3,127	259
Brookline town	45%	1,400	345	19,890	70
Buckland town	84%	3,967	205	1,632	295
Burlington town	87%	3,177	279	16,903	85
Cambridge city	34%	1,171	347	28,593	36
Canton town	76%	3,402	259	15,102	99
Carlisle town	74%	3,679	230	3,252	253
Carver town	86%	6,695	7	15,308	97
Charlemont town	73%	5,415	52	1,521	300

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Charlton town	86%	5,482	43	13,070	123
Chatham town	77%	2,736	309	3,227	254
Chelmsford town	88%	4,413	151	34,713	23
Chelsea city	47%	1,827	341	9,965	156
Cheshire town	86%	3,540	247	2,598	268
Chester town	79%	6,680	8	1,709	290
Chesterfield town	88%	5,425	49	1,462	304
Chicopee city	82%	2,417	326	27,203	40
Chilmark town	73%	2,460	325	464	340
Clarksburg town	85%	3,097	287	1,115	316
Clinton town	82%	4,202	180	11,853	139
Cohasset town	73%	4,239	176	5,877	210
Colrain town	81%	4,651	122	1,768	288
Concord town	77%	3,506	251	10,830	148
Conway town	77%	4,727	114	2,033	285
Cummington town	75%	6,286	15	1,023	320
Dalton town	86%	2,462	324	3,497	249
Danvers town	86%	3,342	267	18,675	75
Dartmouth town	85%	4,259	174	25,818	47
Dedham town	79%	2,869	305	14,333	105
Deerfield town	85%	4,210	179	4,420	236
Dennis town	82%	4,125	186	12,123	134
Dighton town	87%	4,322	167	5,461	214
Douglas town	88%	5,868	25	8,681	174
Dover town	77%	3,463	252	3,597	246
Dracut town	88%	4,094	188	26,860	41
Dudley town	86%	5,093	75	10,834	147
Dunstable town	86%	5,335	59	3,310	251
Duxbury town	79%	6,242	17	17,009	84
East Bridgewater town	84%	4,248	175	11,856	138
East Brookfield town	88%	4,922	92	2,049	284
East Longmeadow town	91%	2,892	301	8,564	176
Eastham town	83%	4,829	101	4,708	232
Easthampton city	84%	3,080	289	11,775	140
Easton town	81%	4,396	155	22,688	58
Edgartown town	73%	1,748	342	1,470	303
Egremont town	67%	4,302	171	1,216	313
Erving town	83%	4,188	181	1,218	312
Essex town	79%	3,390	261	2,219	277
Everett city	60%	2,102	336	16,425	87
Fairhaven town	88%	4,155	184	13,769	116
Fall River city	79%	3,763	222	64,893	7
Falmouth town	82%	4,795	106	30,187	33
Fitchburg city	77%	4,082	190	30,210	32
Florida town	88%	3,911	210	521	336
Foxborough town	82%	4,449	146	15,855	92
Framingham town	77%	3,747	224	57,913	11
Franklin city	81%	4,952	89	31,498	29
Freetown town	87%	5,331	60	10,493	152
Gardner city	80%	4,564	134	18,517	76
Georgetown town	87%	5,741	33	9,121	168
Gill town	84%	3,360	264	1,058	317
Gloucester city	78%	4,048	194	26,858	42
Goshen town	89%	5,370	57	1,116	315
Gosnold town	13%	244	350	3	350
Grafton town	86%	4,565	133	15,055	100
Granby town	88%	3,277	274	4,640	233
Granville town	85%	5,339	58	1,662	292

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Great Barrington town	75%	4,396	154	6,664	204
Greenfield town	77%	3,572	242	13,589	120
Groton town	83%	5,143	69	9,947	157
Groveland town	85%	4,651	123	5,676	211
Hadley town	89%	2,802	308	2,770	264
Halifax town	82%	5,018	82	7,835	189
Hamilton town	80%	3,666	232	5,424	218
Hampden town	90%	3,668	231	3,910	244
Hancock town	85%	3,561	245	497	338
Hanover town	86%	4,385	158	12,628	131
Hanson town	86%	4,646	124	9,726	160
Hardwick town	80%	5,896	23	2,667	266
Harvard town	83%	5,751	31	5,908	209
Harwich town	87%	4,211	178	9,408	165
Hatfield town	89%	3,327	270	2,556	271
Haverhill city	82%	4,733	113	61,295	10
Hawley town	76%	5,308	61	215	346
Heath town	66%	4,865	97	796	329
Hingham town	76%	3,981	202	16,068	89
Hinsdale town	87%	3,305	271	1,352	306
Holbrook town	79%	3,330	269	7,037	198
Holden town	90%	4,282	173	14,307	106
Holland town	86%	7,216	1	3,575	247
Holliston town	85%	4,756	111	13,997	112
Holyoke city	75%	2,297	329	14,720	103
Hopedale town	86%	4,002	198	4,475	235
Hopkinton town	84%	5,269	63	13,879	114
Hubbardston town	86%	6,098	20	4,864	228
Hudson town	85%	3,802	217	16,004	90
Hull town	75%	3,714	228	8,847	171
Huntington town	84%	5,846	26	2,811	262
Ipswich town	81%	4,523	139	12,942	126
Kingston town	82%	5,425	50	12,920	127
Lakeville town	86%	5,707	35	11,427	143
Lancaster town	78%	4,166	183	5,047	227
Lanesborough town	83%	2,482	323	1,557	297
Lawrence city	65%	2,908	300	31,732	28
Lee town	80%	3,122	285	4,165	241
Leicester town	84%	3,582	240	8,084	184
Lenox town	81%	2,603	314	2,592	269
Leominster city	84%	4,690	117	40,918	18
Leverett town	79%	3,917	209	1,524	299
Lexington town	78%	3,015	295	18,959	73
Leyden town	87%	4,313	169	745	331
Lincoln town	77%	2,918	297	4,549	234
Littleton town	86%	4,679	119	8,007	186
Longmeadow town	90%	3,030	292	9,449	164
Lowell city	74%	3,529	248	73,454	4
Ludlow town	88%	3,021	293	12,964	125
Lunenburg town	88%	4,604	129	9,647	162
Lynn city	70%	2,999	296	51,435	13
Lynnfield town	81%	3,567	244	8,139	183
Malden city	60%	2,186	334	28,172	38
Manchester-by-the-Sea town	75%	4,310	170	4,349	238
Mansfield town	77%	5,092	77	24,347	53
Marblehead town	76%	3,450	254	15,439	95
Marion town	79%	5,241	64	5,062	226
Marlborough city	82%	4,031	196	34,707	25

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Marshfield town	86%	6,820	5	36,938	21
Mashpee town	83%	4,823	102	11,883	137
Mattapoisett town	89%	4,464	143	5,357	219
Maynard town	82%	3,972	204	9,886	158
Medfield town	79%	4,167	182	9,879	159
Medford city	65%	2,256	332	28,279	37
Medway town	83%	4,296	172	11,580	142
Melrose city	70%	2,593	316	16,391	88
Mendon town	90%	4,643	125	5,297	223
Merrimac town	86%	4,936	91	6,383	206
Methuen city	85%	4,236	177	38,079	19
Middleborough town	84%	5,581	39	24,353	52
Middlefield town	70%	6,337	13	634	334
Middleton town	87%	3,957	206	5,073	225
Milford town	86%	4,542	137	26,683	43
Millbury town	84%	3,624	235	10,163	153
Millis town	86%	4,057	192	6,749	202
Millville town	91%	4,777	107	2,410	274
Milton town	72%	2,344	327	12,870	128
Monroe town	NA	0	351	0	351
Monson town	89%	4,699	115	7,935	188
Montague town	80%	3,569	243	6,108	207
Monterey town	61%	4,756	110	906	327
Montgomery town	89%	4,572	132	592	335
Mount Washington town	62%	5,680	37	142	349
Nahant town	78%	2,911	299	2,157	279
Nantucket town	65%	1,344	346	3,222	255
Natick town	79%	3,427	258	26,597	44
Needham town	74%	2,607	313	15,394	96
New Ashford town	82%	3,379	263	177	348
New Bedford city	74%	3,728	226	62,236	8
New Braintree town	81%	5,148	68	938	326
New Marlborough town	81%	4,609	128	1,343	307
New Salem town	79%	5,142	70	958	324
Newbury town	84%	4,901	95	6,683	203
Newburyport city	79%	5,543	40	21,606	61
Newton city	68%	2,545	318	49,923	14
Norfolk town	78%	4,147	185	7,153	196
North Adams city	76%	2,646	312	7,619	192
North Andover town	83%	4,384	159	24,811	50
North Attleborough town	87%	4,875	96	30,510	31
North Brookfield town	81%	4,467	142	4,030	242
North Reading town	83%	4,372	160	13,562	121
Northampton city	69%	2,916	298	20,224	68
Northborough town	89%	4,621	127	14,229	108
Northbridge town	88%	5,177	67	13,461	122
Northfield town	80%	4,328	165	2,892	261
Norton town	82%	5,116	73	18,720	74
Norwell town	77%	4,795	105	9,569	163
Norwood town	76%	3,214	277	20,317	67
Oak Bluffs town	76%	1,089	349	834	328
Oakham town	90%	6,257	16	2,073	282
Orange town	75%	3,799	218	5,431	216
Orleans town	81%	3,357	266	3,533	248
Otis town	83%	6,624	9	1,638	294
Oxford town	87%	4,768	108	13,838	115
Palmer town	83%	4,102	187	10,860	146
Paxton town	83%	3,153	281	2,587	270

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Peabody city	86%	3,359	265	35,551	22
Pelham town	82%	3,286	273	1,049	318
Pembroke town	83%	5,437	48	20,563	66
Pepperell town	86%	5,762	29	13,749	117
Peru town	80%	4,459	144	736	332
Petersham town	66%	4,808	103	1,027	319
Phillipston town	87%	5,476	44	1,762	289
Pittsfield city	80%	2,663	310	24,770	51
Plainfield town	72%	5,621	38	480	339
Plainville town	86%	4,989	84	8,051	185
Plymouth town	82%	7,215	2	80,361	3
Plympton town	83%	5,380	55	3,179	256
Princeton town	87%	5,871	24	4,003	243
Provincetown town	50%	1,936	339	1,276	309
Quincy city	63%	2,483	322	52,019	12
Randolph town	73%	3,429	257	23,029	57
Raynham town	84%	4,859	98	12,557	132
Reading town	83%	3,393	260	18,031	80
Rehoboth town	86%	4,441	148	10,537	151
Revere city	62%	2,337	328	21,119	64
Richmond town	82%	3,435	256	1,246	310
Rochester town	85%	5,520	42	5,307	222
Rockland town	83%	3,732	225	14,800	101
Rockport town	73%	4,494	140	7,159	193
Rowe town	72%	5,092	76	213	347
Rowley town	82%	4,683	118	5,342	220
Royalston town	79%	5,749	32	1,176	314
Russell town	87%	4,342	163	1,506	301
Rutland town	87%	5,119	72	6,631	205
Salem city	71%	2,817	306	26,454	45
Salisbury town	83%	5,704	36	9,244	167
Sandisfield town	78%	7,131	3	982	323
Sandwich town	85%	5,791	28	23,626	55
Saugus town	81%	3,133	283	18,106	78
Savoy town	91%	5,043	81	646	333
Scituate town	78%	5,395	53	20,134	69
Seekonk town	89%	3,181	278	8,957	170
Sharon town	71%	3,923	208	14,576	104
Sheffield town	81%	3,908	212	2,620	267
Shelburne town	73%	3,121	286	1,227	311
Sherborn town	79%	3,996	201	2,742	265
Shirley town	86%	5,053	80	5,512	213
Shrewsbury town	87%	4,757	109	31,926	27
Shutesbury town	77%	4,400	153	1,884	287
Somerset town	87%	3,597	239	13,620	119
Somerville city	45%	1,672	344	33,480	26
South Hadley town	75%	2,510	320	9,722	161
Southampton town	90%	3,754	223	4,727	231
Southborough town	86%	4,849	100	7,736	191
Southbridge town	81%	4,444	147	14,089	110
Southwick town	86%	4,558	136	8,599	175
Spencer town	88%	4,671	120	12,049	135
Springfield city	73%	2,499	321	65,817	6
Sterling town	89%	5,198	66	8,282	180
Stockbridge town	75%	3,999	199	2,063	283
Stoneham town	81%	2,876	304	14,095	109
Stoughton town	77%	3,510	250	21,652	60
Stow town	83%	4,355	161	5,325	221

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Sturbridge town	84%	5,525	41	8,250	181
Sudbury town	84%	4,488	141	15,189	98
Sunderland town	80%	3,661	233	3,270	252
Sutton town	86%	4,324	166	7,154	195
Swampscott town	74%	2,802	307	8,764	173
Swansea town	87%	4,045	195	14,277	107
Taunton city	82%	5,017	83	61,428	9
Templeton town	85%	4,334	164	5,447	215
Tewksbury town	87%	4,387	157	29,346	34
Tisbury town	70%	1,147	348	941	325
Tolland town	69%	6,843	4	432	341
Topsfield town	83%	4,388	156	4,817	229
Townsend town	87%	6,741	6	12,977	124
Truro town	77%	5,391	54	2,115	280
Tyngsborough town	89%	4,575	131	10,971	145
Tyringham town	73%	4,020	197	345	342
Upton town	84%	4,743	112	4,807	230
Uxbridge town	85%	5,285	62	12,407	133
Wakefield town	78%	3,032	291	17,342	83
Wales town	87%	6,487	12	2,217	278
Walpole town	85%	4,069	191	19,783	71
Waltham city	73%	2,578	317	37,224	20
Ware town	85%	4,656	121	9,397	166
Wareham town	85%	6,547	10	26,249	46
Warren town	83%	5,224	65	4,227	240
Warwick town	69%	3,828	216	506	337
Washington town	72%	3,084	288	339	343
Watertown city	66%	2,199	333	18,069	79
Wayland town	80%	3,777	219	10,061	154
Webster town	82%	4,971	87	15,783	93
Wellesley town	64%	2,594	315	13,717	118
Wellfleet town	76%	4,956	88	2,771	263
Wendell town	76%	4,533	138	987	322
Wenham town	72%	3,174	280	1,998	286
West Boylston town	88%	3,122	284	3,683	245
West Bridgewater town	85%	3,998	200	5,425	217
West Brookfield town	83%	4,921	93	3,009	260
West Newbury town	84%	5,378	56	4,351	237
West Springfield town	83%	2,651	311	15,603	94
West Stockbridge town	80%	4,979	85	1,485	302
West Tisbury town	73%	1,737	343	1,022	321
Westborough town	85%	4,454	145	15,863	91
Westfield city	85%	3,608	237	30,695	30
Westford town	88%	4,902	94	22,280	59
Westhampton town	90%	3,838	215	1,328	308
Westminster town	86%	4,973	86	6,837	201
Weston town	72%	3,276	275	6,858	200
Westport town	86%	4,948	90	14,754	102
Westwood town	78%	3,051	290	8,461	177
Weymouth town	79%	3,333	268	41,578	16
Whately town	89%	3,938	207	1,441	305
Whitman town	80%	3,976	203	12,686	129
Wilbraham town	90%	3,137	282	8,183	182
Williamsburg town	83%	3,906	213	2,362	275
Williamstown town	59%	2,019	338	3,129	258
Wilmington town	86%	3,711	229	18,335	77
Winchendon town	83%	5,960	22	10,539	150
Winchester town	72%	2,526	319	11,079	144

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Windsor town	81%	4,433	149	768	330
Winthrop town	61%	2,059	337	8,400	178
Woburn city	85%	2,885	302	25,365	49
Worcester city	73%	3,458	253	116,777	2
Worthington town	76%	6,488	11	1,581	296
Wrentham town	84%	4,696	116	9,968	155
Yarmouth town	82%	3,766	220	16,759	86

Appendix C: Emissions and Commuting Data by Town of Work

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Abington town	81%	2,542	223	4,299	170
Acton town	84%	5,024	21	24,890	52
Acushnet town	74%	2,083	280	1,681	230
Adams town	81%	2,982	163	3,429	186
Agawam city	81%	2,437	242	10,798	100
Alford town	0%	0	351	0	351
Amesbury town	79%	2,745	194	5,788	146
Amherst town	59%	2,546	221	23,988	55
Andover town	87%	5,503	7	87,992	8
Aquinnah town	64%	1,083	327	54	325
Arlington town	68%	1,933	283	6,868	130
Ashburnham town	73%	3,226	136	1,232	246
Ashby town	63%	1,093	325	129	309
Ashfield town	51%	2,365	253	486	280
Ashland town	80%	3,171	144	5,752	147
Athol town	75%	3,544	99	6,183	136
Attleboro city	84%	3,474	107	31,973	36
Auburn town	85%	3,622	89	15,856	77
Avon town	87%	4,958	23	13,973	87
Ayer town	83%	4,352	41	8,724	117
Barnstable Town city	85%	3,601	92	40,550	28
Barre town	76%	3,477	106	2,118	215
Becket town	62%	2,453	240	210	297
Bedford town	89%	5,362	11	48,725	20
Belchertown town	80%	2,850	182	2,850	195
Bellingham town	80%	2,994	161	6,090	137
Belmont town	69%	2,087	278	5,654	151
Berkley town	59%	1,609	302	322	291
Berlin town	68%	2,084	279	554	275
Bernardston town	78%	2,335	259	348	289
Beverly city	83%	3,240	134	28,487	44
Billerica town	88%	5,292	13	54,252	16
Blackstone town	83%	1,694	298	731	265
Blandford town	51%	2,678	204	114	312
Bolton town	74%	3,969	61	2,824	197
Boston city	45%	3,478	105	814,933	1
Bourne town	79%	3,577	95	9,122	112
Boxborough town	83%	4,493	38	4,258	172
Boxford town	60%	1,808	293	797	262
Boylston town	77%	2,632	209	975	253
Braintree town	84%	4,449	39	52,688	18
Brewster town	79%	3,264	133	5,260	156
Bridgewater town	80%	3,842	72	14,181	86
Brimfield town	61%	2,348	258	496	279
Brockton city	82%	3,873	68	58,603	14
Brookfield town	77%	3,450	110	703	266
Brookline town	55%	2,209	270	19,076	68
Buckland town	76%	2,909	173	760	263
Burlington town	90%	5,297	12	78,629	10
Cambridge city	50%	2,921	171	148,620	3
Canton town	86%	5,445	10	47,931	21
Carlisle town	44%	1,322	316	394	287

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Carver town	76%	2,830	185	1,602	232
Charlemont town	13%	453	340	12	338
Charlton town	83%	3,318	128	3,920	176
Chatham town	80%	3,289	129	5,576	153
Chelmsford town	84%	4,646	31	45,833	23
Chelsea city	70%	2,607	215	14,741	82
Cheshire town	69%	2,184	273	534	276
Chester town	40%	2,653	207	101	314
Chesterfield town	44%	739	332	18	333
Chicopee city	82%	2,467	236	23,122	57
Chilmark town	69%	2,290	264	453	283
Clarksburg town	73%	1,340	315	133	306
Clinton town	80%	3,481	104	6,922	129
Cohasset town	80%	2,419	245	2,463	207
Colrain town	47%	1,125	322	92	317
Concord town	84%	5,072	18	31,811	37
Conway town	19%	673	333	47	327
Cummington town	38%	661	334	34	331
Dalton town	85%	2,719	198	3,055	191
Danvers town	86%	3,697	83	32,211	35
Dartmouth town	81%	3,433	117	19,029	69
Dedham town	85%	4,436	40	25,818	47
Deerfield town	86%	4,136	46	5,646	152
Dennis town	84%	2,623	212	5,806	145
Dighton town	79%	2,898	176	1,811	223
Douglas town	74%	2,390	250	869	260
Dover town	67%	1,776	296	666	268
Dracut town	78%	2,573	217	5,911	142
Dudley town	77%	2,428	244	2,415	209
Dunstable town	50%	1,347	314	171	304
Duxbury town	80%	2,846	183	3,765	181
East Bridgewater town	83%	2,771	192	3,659	182
East Brookfield town	78%	2,250	267	281	293
East Longmeadow town	84%	2,566	218	9,541	107
Eastham town	71%	3,880	67	2,037	218
Easthampton city	76%	2,355	256	4,851	161
Easton town	77%	3,916	64	14,337	85
Edgartown town	77%	1,835	292	1,560	235
Egremont town	52%	2,128	277	281	294
Erving town	77%	2,686	202	398	286
Essex town	74%	2,471	235	1,511	237
Everett city	69%	2,951	167	17,272	74
Fairhaven town	85%	2,941	169	9,444	108
Fall River city	82%	2,967	165	53,884	17
Falmouth town	83%	3,183	142	20,416	63
Fitchburg city	82%	3,711	81	26,997	46
Florida town	48%	1,056	329	14	337
Foxborough town	88%	4,600	33	15,504	78
Framingham town	85%	5,200	15	102,011	5
Franklin city	85%	4,574	36	32,478	34
Freetown town	76%	3,055	156	2,638	203
Gardner city	81%	3,515	101	14,431	83

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Georgetown town	78%	2,486	232	1,695	229
Gill town	72%	1,598	304	166	305
Gloucester city	79%	3,142	148	18,708	70
Goshen town	73%	2,302	263	115	311
Gosnold town	13%	244	348	3	345
Grafton town	79%	2,865	181	4,297	171
Granby town	77%	1,799	294	665	269
Granville town	61%	3,774	76	472	281
Great Barrington town	81%	3,923	63	8,580	118
Greenfield town	81%	3,158	145	15,255	80
Groton town	76%	2,955	166	3,284	188
Groveland town	73%	1,875	287	575	274
Hadley town	75%	3,239	135	7,676	124
Halifax town	81%	2,516	227	915	256
Hamilton town	80%	2,356	255	1,762	224
Hampden town	85%	2,626	211	1,133	251
Hancock town	77%	3,400	122	509	278
Hanover town	89%	3,886	66	12,594	93
Hanson town	78%	2,511	228	2,283	212
Hardwick town	66%	1,639	300	133	307
Harvard town	81%	3,637	88	2,670	201
Harwich town	81%	3,069	154	4,526	163
Hatfield town	79%	4,936	24	5,656	150
Haverhill city	81%	3,520	100	31,159	39
Hawley town	45%	1,782	295	47	328
Heath town	38%	541	335	16	335
Hingham town	85%	3,868	70	19,359	65
Hinsdale town	62%	1,445	312	68	321
Holbrook town	76%	2,509	229	1,984	220
Holden town	84%	3,335	126	5,291	155
Holland town	63%	1,094	324	67	322
Holliston town	80%	3,900	65	9,084	114
Holyoke city	80%	2,619	213	25,566	48
Hopedale town	83%	2,446	241	1,572	233
Hopkinton town	85%	5,242	14	17,510	73
Hubbardston town	63%	2,496	231	590	272
Hudson town	83%	4,022	57	13,877	88
Hull town	69%	1,851	290	1,195	247
Huntington town	65%	3,187	140	420	284
Ipswich town	80%	3,186	141	6,059	139
Kingston town	85%	3,818	74	9,311	111
Lakeville town	85%	4,590	34	8,148	119
Lancaster town	70%	2,548	220	1,974	221
Lanesborough town	78%	2,683	203	1,668	231
Lawrence city	76%	3,041	160	30,120	41
Lee town	80%	3,373	123	4,862	160
Leicester town	80%	2,430	243	2,053	217
Lenox town	79%	3,083	153	5,740	148
Leominster city	81%	3,562	97	28,183	45
Leverett town	46%	1,622	301	184	303
Lexington town	84%	4,693	28	43,148	26
Leyden town	57%	1,255	318	40	329
Lincoln town	67%	2,922	170	2,212	213
Littleton town	86%	5,504	6	15,345	79
Longmeadow town	74%	1,871	289	2,832	196
Lowell city	80%	3,580	94	58,922	13
Ludlow town	83%	2,744	195	6,378	134
Lunenburg town	78%	2,348	257	2,492	206
Lynn city	78%	2,752	193	31,024	40

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Lynnfield town	77%	2,837	184	4,656	162
Malden city	68%	2,403	249	18,274	71
Manchester-by-the-Sea town	71%	2,417	246	1,753	226
Mansfield town	84%	4,863	25	21,972	61
Marblehead town	69%	1,706	297	4,876	159
Marion town	82%	3,118	150	2,905	193
Marlborough city	88%	6,125	3	88,551	7
Marshfield town	81%	3,580	93	7,861	122
Mashpee town	84%	4,084	54	9,422	109
Mattapoisett town	86%	2,702	200	1,707	227
Maynard town	83%	5,080	17	9,871	104
Medfield town	79%	3,340	125	5,473	154
Medford city	70%	2,663	205	22,723	59
Medway town	73%	2,455	239	2,852	194
Melrose city	74%	2,543	222	8,859	115
Mendon town	74%	1,872	288	932	255
Merrimac town	74%	2,029	281	904	257
Methuen city	81%	3,281	132	18,072	72
Middleborough town	81%	4,120	48	11,144	99
Middlefield town	0%	75	350	1	350
Middleton town	84%	3,412	118	4,389	168
Milford town	87%	3,993	59	22,973	58
Millbury town	79%	2,614	214	4,258	173
Millis town	79%	2,225	269	1,704	228
Millville town	74%	5,481	9	959	254
Milton town	75%	2,813	186	7,743	123
Monroe town	88%	6,217	2	122	310
Monson town	84%	3,041	159	2,571	205
Montague town	77%	2,574	216	3,092	190
Monterey town	47%	2,229	268	202	298
Montgomery town	68%	4,308	44	292	292
Mount Washington town	27%	334	344	2	347
Nahant town	61%	369	343	39	330
Nantucket town	65%	1,590	305	3,880	177
Natick town	85%	4,602	32	41,717	27
Needham town	83%	4,588	35	35,266	32
New Ashford town	27%	266	346	2	349
New Bedford city	80%	2,774	191	47,062	22
New Braintree town	57%	2,303	262	110	313
New Marlborough town	71%	3,447	112	514	277
New Salem town	58%	2,158	275	201	299
Newbury town	66%	2,367	252	1,340	244
Newburyport city	82%	3,467	109	16,656	75
Newton city	72%	3,738	80	75,671	11
Norfolk town	82%	3,560	98	3,414	187
North Adams city	76%	2,506	230	7,284	127
North Andover town	84%	4,084	55	31,366	38
North Attleborough town	83%	3,501	103	16,065	76
North Brookfield town	70%	2,323	260	1,161	249
North Reading town	80%	4,319	43	12,701	92
Northampton city	76%	3,213	137	28,546	43
Northborough town	83%	4,111	51	10,642	102
Northbridge town	80%	2,555	219	4,018	175
Northfield town	84%	3,766	78	2,016	219
Norton town	81%	3,772	77	9,705	106
Norwell town	86%	4,087	53	13,106	91
Norwood town	87%	5,043	20	49,701	19
Oak Bluffs town	73%	1,138	321	895	258
Oakham town	40%	538	336	12	339

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Orange town	72%	1,919	284	1,853	222
Orleans town	86%	3,662	85	5,842	144
Otis town	47%	1,066	328	55	324
Oxford town	80%	2,795	188	3,771	180
Palmer town	81%	2,905	175	6,196	135
Paxton town	61%	2,318	261	752	264
Peabody city	85%	3,618	90	38,046	30
Pelham town	52%	1,207	319	92	316
Pembroke town	85%	3,445	113	6,036	140
Pepperell town	73%	2,417	247	1,566	234
Peru town	56%	873	331	18	334
Petersham town	38%	1,649	299	187	302
Phillipston town	62%	1,450	310	69	320
Pittsfield city	83%	3,179	143	37,642	31
Plainfield town	30%	416	342	9	343
Plainville town	81%	3,100	152	3,488	184
Plymouth town	84%	4,662	30	39,672	29
Plympton town	58%	1,886	286	214	296
Princeton town	75%	2,942	168	649	271
Provincetown town	62%	3,849	71	3,857	179
Quincy city	78%	4,232	45	87,742	9
Randolph town	79%	3,571	96	13,586	89
Raynham town	82%	3,935	62	11,421	97
Reading town	80%	2,783	190	8,007	121
Rehoboth town	72%	2,628	210	2,061	216
Revere city	68%	1,943	282	6,770	131
Richmond town	45%	1,195	320	89	318
Rochester town	79%	3,785	75	1,488	238
Rockland town	83%	3,684	84	12,374	94
Rockport town	61%	1,605	303	1,168	248
Rowe town	27%	538	337	11	341
Rowley town	78%	2,521	226	1,553	236
Royalston town	29%	494	338	16	336
Russell town	70%	1,529	307	69	319
Rutland town	82%	3,331	127	1,428	241
Salem city	78%	2,536	224	20,566	62
Salisbury town	83%	2,886	178	2,158	214
Sandisfield town	50%	1,088	326	49	326
Sandwich town	82%	3,282	131	9,376	110
Saugus town	80%	2,383	251	9,737	105
Savoy town	84%	6,654	1	191	300
Scituate town	75%	2,739	196	4,489	164
Seekonk town	84%	3,653	86	11,997	96
Sharon town	77%	3,440	114	6,591	132
Sheffield town	75%	3,838	73	2,320	210
Shelburne town	73%	2,193	271	670	267
Sherborn town	65%	1,894	285	418	285
Shirley town	81%	3,195	139	1,474	239
Shrewsbury town	85%	4,057	56	23,199	56
Shutesbury town	30%	480	339	32	332
Somerset town	82%	2,260	265	5,111	158
Somerville city	61%	2,485	233	24,549	53
South Hadley town	69%	2,191	272	6,457	133
Southampton town	76%	3,103	151	1,440	240
Southborough town	88%	5,065	19	12,220	95
Southbridge town	80%	2,994	162	8,042	120
Southwick town	80%	2,656	206	2,662	202
Spencer town	82%	3,403	121	6,063	138

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Springfield city	82%	2,896	177	99,447	6
Sterling town	78%	3,438	115	2,319	211
Stockbridge town	68%	2,809	187	1,136	250
Stoneham town	77%	2,915	172	10,315	103
Stoughton town	84%	4,095	52	22,048	60
Stow town	80%	3,344	124	2,926	192
Sturbridge town	83%	3,705	82	7,138	128
Sudbury town	83%	4,111	50	13,165	90
Sunderland town	73%	2,703	199	652	270
Sutton town	76%	2,472	234	1,241	245
Swampscott town	74%	1,585	306	2,442	208
Swansea town	85%	2,907	174	5,874	143
Taunton city	85%	4,320	42	43,873	25
Templeton town	79%	3,154	146	2,751	198
Tewksbury town	85%	4,507	37	29,126	42
Tisbury town	73%	1,389	313	1,386	242
Tolland town	60%	906	330	10	342
Topsfield town	84%	3,061	155	2,727	200
Townsend town	79%	3,435	116	3,621	183
Truro town	27%	1,314	317	99	315
Tyngsborough town	82%	3,212	138	4,416	167
Tyringham town	11%	133	349	2	348
Upton town	69%	2,169	274	872	259
Uxbridge town	78%	2,467	237	2,636	204
Wakefield town	85%	3,742	79	19,234	67
Wales town	27%	330	345	8	344
Walpole town	85%	4,123	47	15,039	81
Waltham city	83%	4,813	26	112,931	4
Ware town	87%	2,794	189	3,481	185
Wareham town	84%	3,987	60	11,309	98
Warren town	65%	1,837	291	388	288
Warwick town	31%	2,253	266	67	323
Washington town	16%	263	347	3	346
Watertown city	71%	2,886	179	19,242	66
Wayland town	78%	3,447	111	5,977	141
Webster town	82%	3,284	130	9,097	113
Wellesley town	77%	4,004	58	34,782	33
Wellfleet town	78%	5,766	5	4,088	174
Wendell town	63%	2,636	208	224	295
Wenham town	79%	3,123	149	1,753	225
West Boylston town	85%	3,618	91	5,681	149
West Bridgewater town	82%	4,117	49	10,723	101
West Brookfield town	72%	2,151	276	802	261
West Newbury town	76%	1,528	308	469	282
West Springfield town	84%	2,734	197	19,670	64
West Stockbridge town	52%	1,507	309	130	308
West Tisbury town	64%	1,446	311	575	273
Westborough town	88%	5,880	4	55,562	15
Westfield city	83%	3,050	157	24,507	54
Westford town	84%	5,006	22	25,031	51
Westhampton town	76%	2,359	254	338	290
Westminster town	82%	3,507	102	4,464	166
Weston town	70%	2,975	164	5,124	157
Westport town	80%	2,866	180	4,371	169
Westwood town	85%	5,500	8	25,210	49
Weymouth town	80%	3,407	120	25,132	50
Whately town	89%	4,722	27	3,861	178
Whitman town	79%	2,686	201	3,113	189

City or Town	Pct. Drive Alone Commutes	Annual CO_2 Emissions per Worker (lbs./yr.)	Per-Worker Rank	Annual Total CO_2 Emissions (metric tons)	Total Emissions Rank
Wilbraham town	83%	2,527	225	4,484	165
Williamsburg town	60%	3,146	147	1,128	252
Williamstown town	71%	3,410	119	8,755	116
Wilmington town	88%	5,199	16	45,721	24
Winchendon town	78%	3,048	158	2,735	199
Winchester town	77%	2,412	248	7,329	125
Windsor town	27%	431	341	11	340
Winthrop town	63%	1,113	323	1,381	243
Woburn city	86%	4,665	29	68,136	12
Worcester city	80%	3,871	69	166,498	2
Worthington town	62%	2,464	238	190	301
Wrentham town	82%	3,641	87	7,306	126
Yarmouth town	84%	3,467	108	14,358	84

Notes

1. Based on data from the U.S. Department of Energy, Energy Information Administration, *State Energy Data Consumption Tables, 2001,* compiled for New England Climate Coalition, *Getting on Track: New England's Rising Global Warming Emissions and How to Reverse the Trend*, February 2005. See www.newenglandclimate.org for a copy of the report.

2. Ibid.

3. Comparison of data from New England Climate Coalition, *Getting on Track: New England's Rising Global Warming Emissions and How to Reverse the Trend*, February 2005, with ranking from Greg Marland, Tom Boden, Bob Andres, Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, *National Fossil Fuel CO_2 Emissions*, downloaded from cdiac.esd.ornl.gov/trends/emis/top2000.tot, 17 February 2005.

4. MASSPIRG Education Fund, Clean Water Fund, *A Blueprint for Action: Policy Options to Reduce Massachusetts' Contribution to Global Warming*, Spring 2004.

5. See note 1.

6. Conference of New England Governors and Eastern Canadian Premiers, *Climate Change Action Plan 2001*, August 2001; Commonwealth of Massachusetts, *Massachusetts Climate Protection Plan*, Spring 2004.

7. U.S. Department of Transportation, Federal Highway Administration, *Summary of Travel Trends: National Household Transportation Survey 2001*, December 2004.

8. Ibid.

9. This wide range of estimates reflects uncertainty about the total contribution made by commuting to global warming. The 5 percent figure is based on a comparison of the emission figures cited below for Massachusetts with total carbon dioxide emissions for Massachusetts based on data compiled for New England Climate Coalition, *Getting on Track: New England's Rising Global Warming Emissions and How to Reverse the Trend*, February 2005. This estimate likely understates the contribution of commuting since it excludes certain low-frequency trips and calculates trip distances "as the crow flies." The 8 percent estimate is based on assuming that commuting is responsible for 29 percent of light-duty vehicle gasoline consumption in Massachusetts, again from *Getting on Track*. This estimate also excludes some commuting-related emissions from transit vehicles and other sources.

10. See Jayanthi Rajamani, Chandra Bhat, et al, *Assessing the Impact of Urban Form Measures in Nonwork Trip Mode Choice After Controlling for Demographic and Level-of-Service Effects*, presented at 2003 Annual Meeting of Transportation Research Board, 15 January 2003 and similar studies.

11. Based on data from U.S. Environmental Protection Agency, *AirData – Emissions by Category Report – Criteria Air Pollutants for Massachusetts*, downloaded from www.epa.gov/air/data/reports.html, 4 March 2005.

12. Data from Texas Transportation Institute, *The 2004 Urban Mobility Study*, downloaded from mobility.tamu.edu/ums/congestion_data/east_map.stm, 17 February 2005.

13. Federal Highway Administration, *2000 State Highway Briefing Sheet for Massachusetts*, downloaded from www.fhwa.dot.gov/ohim/hbs/ma.htm, 4 March 2005.

14. This figure includes emissions from residents of Massachusetts commuting to workplaces in other states. See "Methodology" for more details.

15. These definitions are a matter of convenience and do not necessarily correspond to the towns located along each highway.

16. Garreau defines an edge city as one that: 1) has 5 million square feet or more of leasable office space; 2) has 600,000 square feet or more of leasable retail space; 3) has more jobs than bedrooms; 4) is perceived by the population as one place; 5) was nothing like a "city" as recently as 30 years ago (early 1960s at time of publication). No effort has been made to compare the towns cited as "edge cities" here to these criteria, although the list suggests that many would fit Garreau's definition. Definition from online text of Joel Garreau, *Edge City: Life on the New Frontier*, downloaded from www.garreau.com/edge_city.html, 17 February 2005.

17. Joel Garreau, *Edge City: Life on the New Frontier*, downloaded from www.garreau.com/edge_city.html, 17 February 2005.

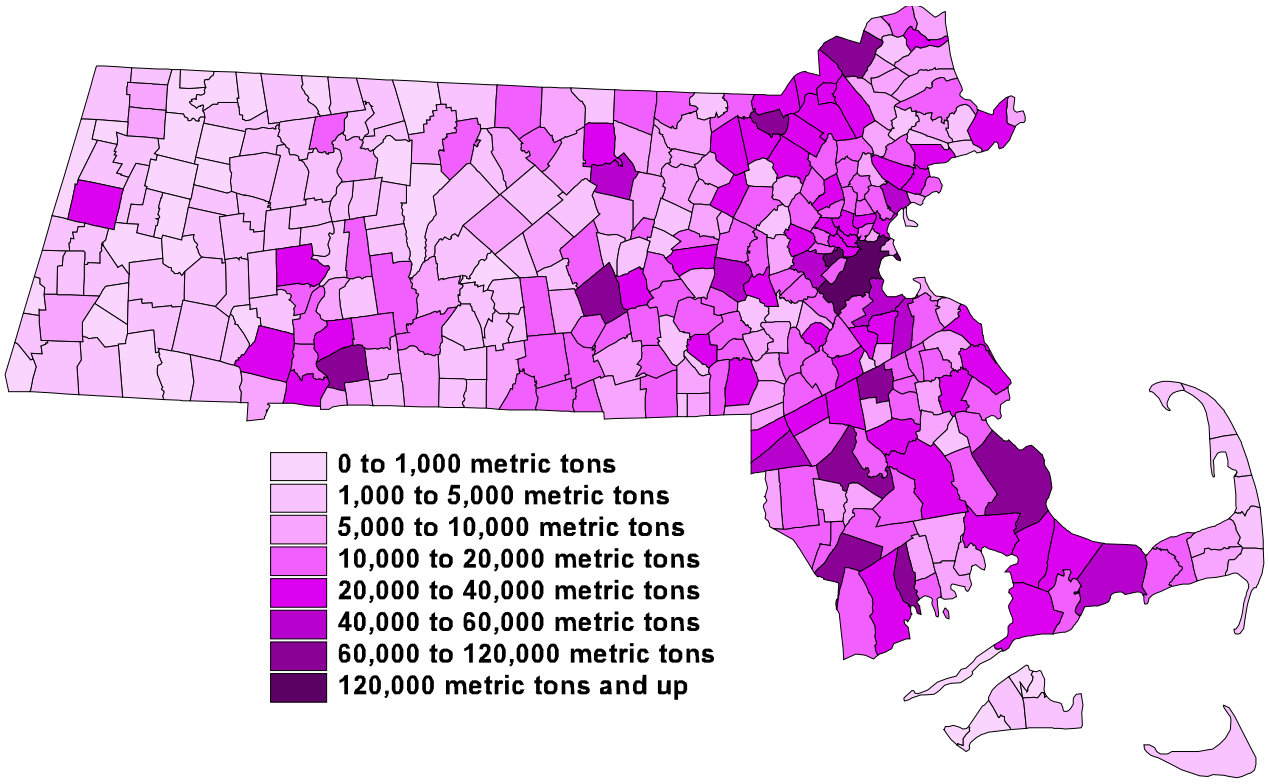
18. Massachusetts Department of Revenue, Division of Local Services, "Population Trends in Massachusetts," *City and Town*, June 2001.

19. U.S. Department of Transportation, *BTS Reports That 3.3 Million Americans Are "Stretch Commuters" Traveling at Least 50 Miles One-Way to Work*, press release, 12 May 2004.

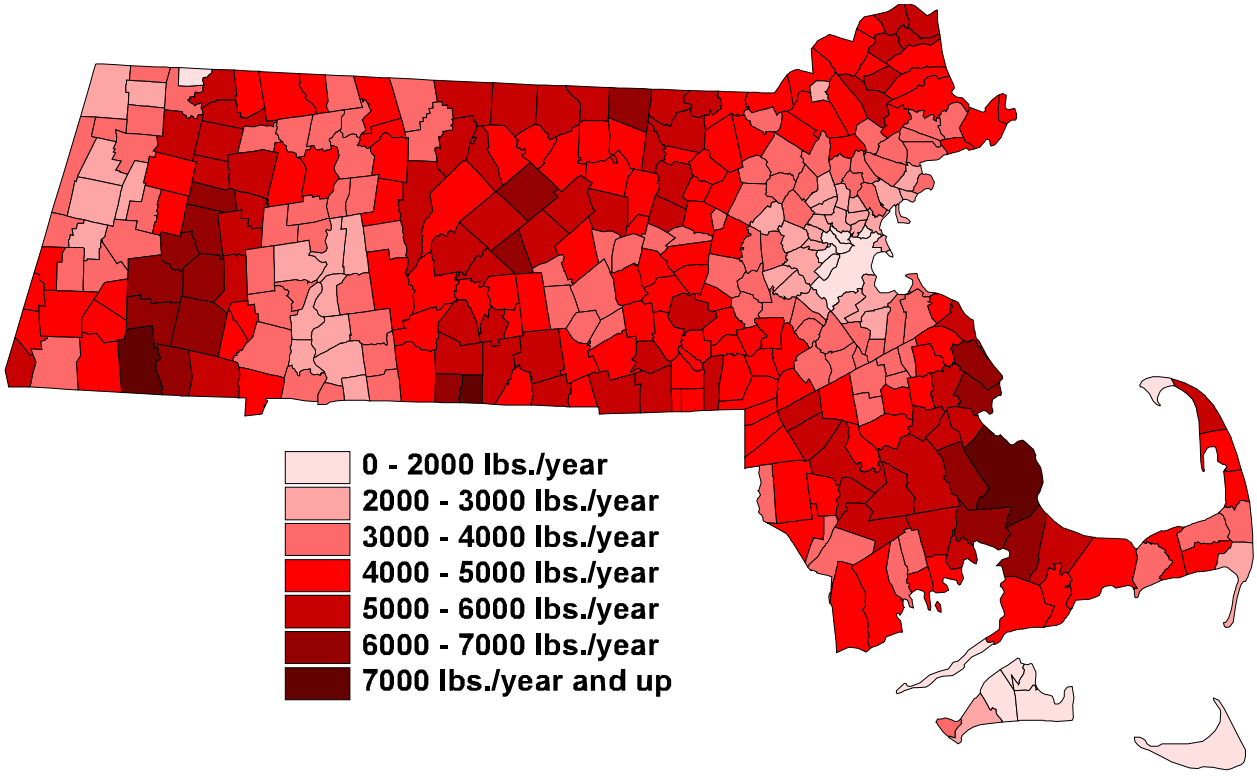
20. See note 18.

21. California Environmental Protection Agency, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 6 August 2004.

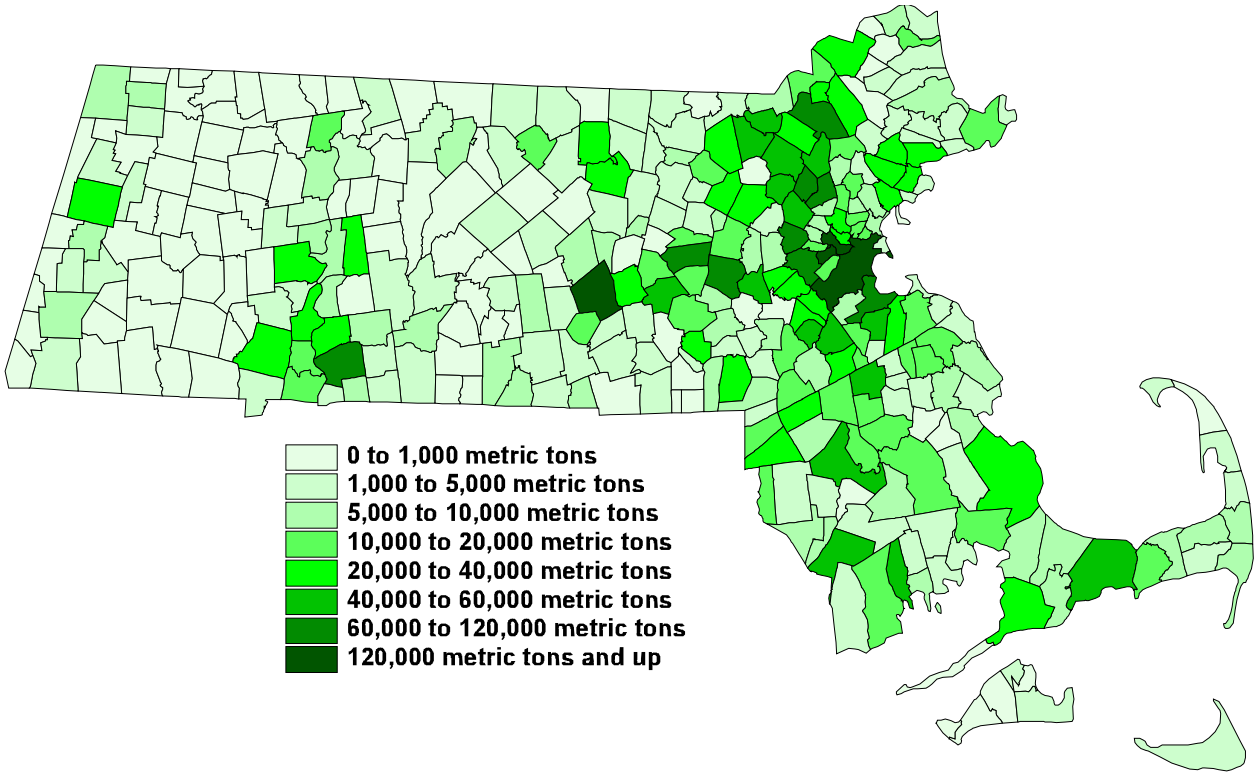
Total Carbon Dioxide Emissions by Place of Residence



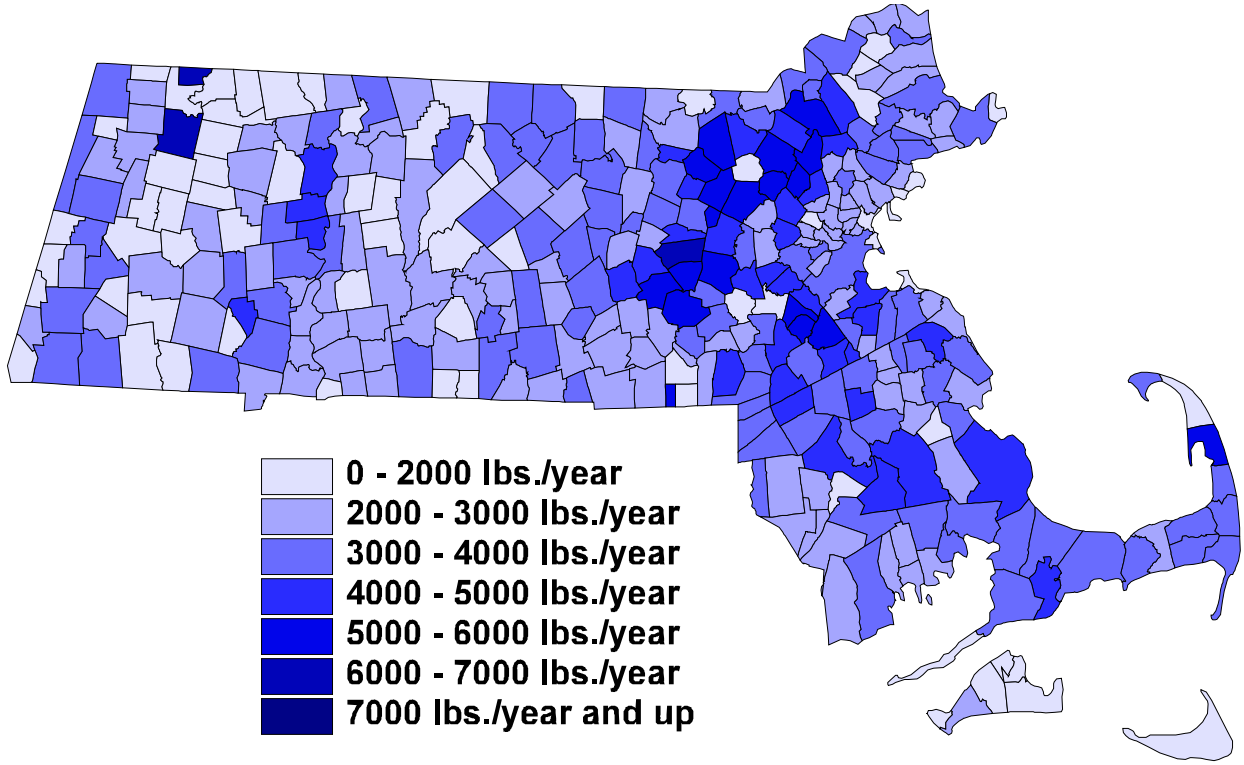
Per-Worker Carbon Dioxide Emissions by Place of Residence



Total Carbon Dioxide Emissions by Place of Work



Per-Worker Carbon Dioxide Emissions by Place of Work



The New England Climate Coalition

The New England Climate Coalition (NECC) is a coalition of state and local environmental, public health, municipal and religious organizations concerned about the effects of global warming. NECC supports reductions in emissions of global warming gases sufficient to protect the region's environment and economy from the dangers posed by global warming.

For more information about NECC visit our web site at www.newenglandclimate.org, or contact the following NECC founding organizations:

Connecticut

- Clean Water Fund, 645 Farmington Avenue, 3rd Floor, Hartford, CT 06105, 860-232-6232, www.cleanwateraction.org/ct
- ConnPIRG Education Fund, 198 Park Road, 2nd Floor, West Hartford, CT 06119, 860-233-7554, www.connpirg.org

Maine

- Natural Resources Council of Maine, 3 Wade Street, Augusta, ME 04330, 207-622-3101, www.maineenvironment.org
- Environment Maine Research & Policy Center, 39 Exchange St., #301, Portland, ME 04101, 207-253-1965, www.environmentmaine.org

Massachusetts

- Clean Water Fund, 262 Washington St., Room 301, Boston, MA 02108, 617-338-8131, www.cleanwateraction.org/ma
- MASSPIRG Education Fund, 44 Winter Street, 4th Floor, Boston, MA 02108, 617-292-4800, www.masspirg.org

New Hampshire

- Clean Water Fund, 163 Court St., Portsmouth, NH 03801, 603-430-9565, www.cleanwateraction.org/nh
- NHPIRG Education Fund, 30 S. Main St., Suite 101, Concord, NH 03301, 603-229-3222, www.nhpirg.org

Rhode Island

- Clean Water Fund, 741 Westminster St., Providence, RI 02903, 401-331-6972, www.cleanwateraction.org/ri
- RIPIRG Education Fund, 11 South Angell Street, #337, Providence, RI 02906, 401-421-6578, www.ripirg.org

Vermont

- Vermont Public Interest Research & Education Fund, 141 Main St., Suite 6, Montpelier, VT 05602, 802-223-5221, www.vpirg.org