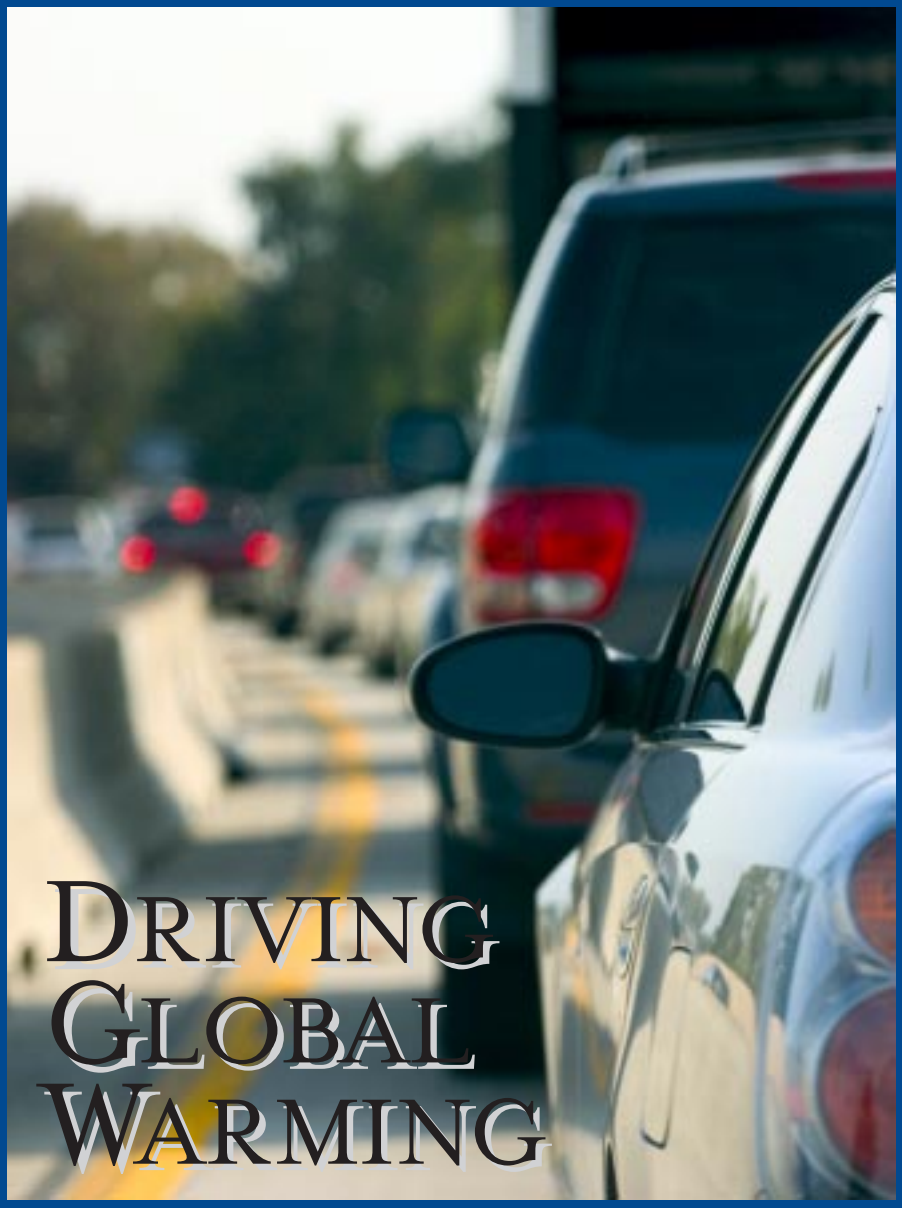

Driving Global Warming

Commuting in Rhode Island and its Contribution to Global Warming

RIPIRG 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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Executive Summary

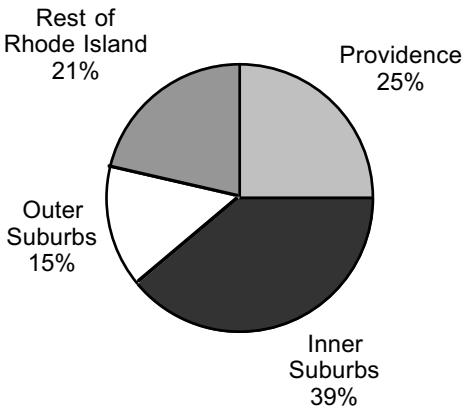
Transportation is the leading source of global warming pollution in Rhode Island, accounting for more than a third of the state's global warming emissions. The trips state residents make to and from work are a major contributor to the problem. Just over a quarter of all vehicle miles nationally are driven on trips to and from work. To reduce global warming emissions from cars and trucks, Rhode Island 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. An analysis based on data collected by the U.S. Census Bureau identifies which towns in the Ocean State produce the greatest amount of carbon dioxide (the leading cause of global warming) from commuting and suggests ways that the state can effectively reduce emissions.

Commuters traveling to Providence and its immediate suburbs for work generate nearly two-thirds of all carbon dioxide emissions among commuters working in Rhode Island.

- Commuters traveling to the inner suburbs of Providence (those located within five miles of the city) are responsible for more than a third of Rhode Island's commuting-related carbon dioxide emissions, while commuters traveling to Providence itself generate about one-quarter of the state's commuting emissions. (See Fig. ES-1.)

Fig. ES-1. Carbon Dioxide Emissions from Commuting By Place of Work



The average commuter living in small but fast-growing towns in western Rhode Island produces two to three times more carbon dioxide from his or her commute than the average commuter living in more densely developed communities.

- Commuters living in densely developed areas (such as Providence, Newport and Pawtucket) produce some of the lowest per-worker emissions in the state. In contrast, less densely developed communities, especially western towns such as West Greenwich and Foster, are responsible for significantly larger amounts of per-commuter emissions. (See Fig. ES-2.) These are some of the fastest growing communities in the state and this trend has significant potential impacts on carbon dioxide emissions in the future.

Commuting trips across state lines are a significant contributor to global warming. Commuters who travel between Rhode Island and neighboring states generate two and a half times more emissions, on average, than commuters who live and work in Rhode Island.

- Rhode Island residents commuting out of state produce 22 percent of the emissions generated by people living in Rhode Island. Similarly, out-of-state residents traveling to Rhode Island are responsible for 9 percent of the carbon dioxide emissions generated by people working in Rhode Island. These interstate trips generate significantly more global warming pollution per commuter than trips made within Rhode Island. (See Fig. ES-3.)

Fig. ES-2. Per-Worker Emissions by Residence in the Three Most Densely Populated and Least Densely Populated Towns (pounds per year)

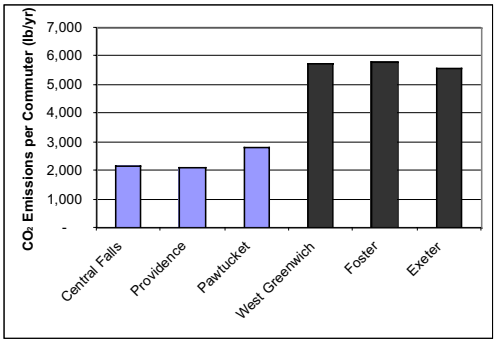
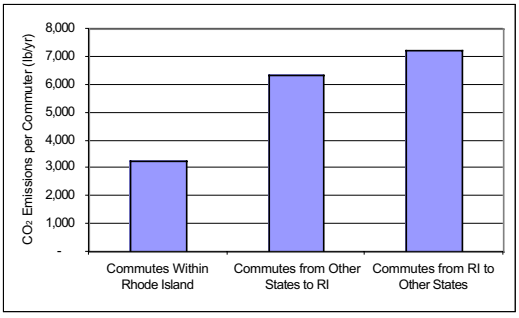


Fig. ES-3. Per-Commuter Carbon Dioxide Emissions for Different Commuting Patterns (pounds per year)



Carbon dioxide emissions from transportation can be cut by reducing per-mile emissions from cars and light trucks, encouraging people to live closer to their place of work, shifting more commuting away from drive-alone trips, and fostering pedestrian commuting and home-based work.

- Fully implementing recently adopted standards for carbon dioxide emissions from cars and light trucks would reduce commuting-related global warming pollution from all drivers in the state. The standards would reduce global warming emissions from cars and light trucks by about 12 percent below projected levels by 2020.

- Regardless of their location within the state, towns where commuters make fewer drive-alone trips and are more likely to use transportation alternatives – such as transit, walking or riding a bike to work – have lower per-worker emissions of carbon dioxide from commuting. Encouraging greater use of carpooling, transit and other alternatives would reduce the global warming impact of commuting in Rhode Island.

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

- Ensure full implementation of vehicle global warming emissions standards and other measures to encourage the purchase of vehicles that produce less carbon dioxide per mile.

- Expand commuter rail service down the west side of Narragansett Bay to allow suburban commuters to more easily utilize commuter rail to the Boston metropolitan area. Construction of the proposed commuter rail stations in Warwick, near the T.F. Green Airport, and at Wickford Junction would be good first steps towards expanding the regional rail network.

- Improve transit connections to allow suburban commuters to more easily utilize commuter rail for commutes to and from both the Providence metropolitan area and Massachusetts towns that are connected to the Boston metropolitan commuter rail network.

- Hold suburban workplaces accountable for the carbon dioxide emissions they generate by requiring employers to implement commute-trip reduction programs.

- Encourage carpooling, vanpooling and other programs that reduce the number of drive-alone commutes, while discouraging projects that increase highway capacity to allow more single-passenger commuting.

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

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

Introduction

The New England states have taken a position of leadership 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 (RGGI) 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 Rhode Island, 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 a significant reduction in emissions from cars and light-duty trucks. This cut will roughly stabilize transportation emissions at today's levels, averting a projected 20% increase.

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. 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 develop a detailed portrait of one important source of vehicle travel: the journey to and from work.

The analysis that follows suggests that wise transportation and land-use policies can reduce carbon dioxide emissions from commutes and can have ripple effects on other sources of vehicle travel. Creating the political will to implement those 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.

The journeys Rhode Island residents and residents of nearby states make to and from work 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 Ocean State.

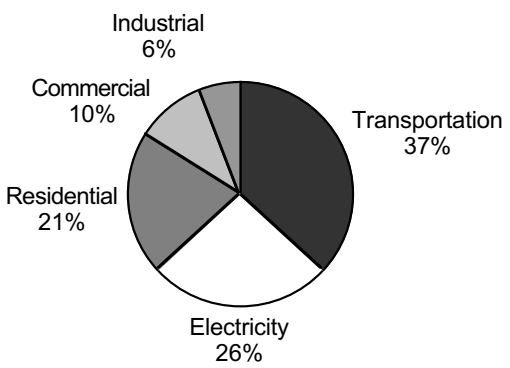
The Role of Transportation in Global Warming

Transportation is the number one contributor to global warming emissions in Rhode Island. In 2001, transportation-sector emissions represented 37 percent of Rhode Island's emissions of carbon dioxide – the leading global warming gas.[1] (See Fig. 1.) Transportation-sector emissions of carbon dioxide increased in the state by 13 percent between 1990 and 2001, while the amount of vehicle miles traveled increased by 14 percent between 1990 and 2003.[2]

Rhode Island's 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 economy of 96 nations.[3] That same year, Rhode Island's transportation system produced more carbon dioxide per resident than is produced per-capita by the entire economy of Mexico.[4]

Given recent trends in vehicle fuel economy (a major determinant of carbon dioxide emissions) and vehicle travel in Rhode Island, carbon dioxide emissions from cars and light trucks within the state can be expected to increase over the next two decades by 14 percent.[5]

Fig. 1. Rhode Island Carbon Dioxide Emissions from Fossil Fuel Consumption, 2001[6]



As outlined in the Rhode Island Greenhouse Gas Action Plan, 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.[7] These goals call for overall reductions in greenhouse gas emissions to 1990 levels by 2010 and to 10 percent below 1990 levels by 2020.

Strategies to reduce global warming emissions from commuting can play a key role in lowering overall transportation sector emissions. They 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

Rhode Island's transportation system is designed with many goals in mind, but 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, when 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 (such as the I-295 beltway around Providence), allowed workers who had long lived in urban areas to build homes in distant suburbs. At the same time, those highways allowed 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. And while commuting makes up a smaller proportion of vehicle travel than it has in the past (28 percent in 2001 versus one-third in 1969), it is still the leading source of vehicle travel.[8] (See Fig. 2.)

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.

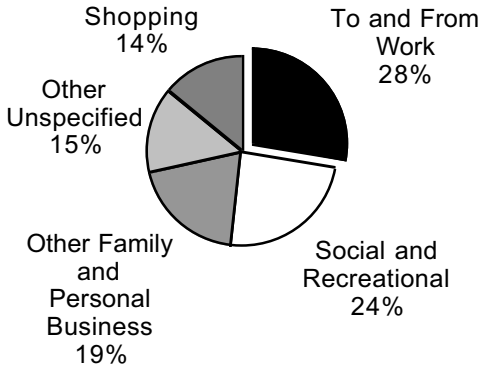
Scientists believe that continued releases of global warming gases – the most significant of which is carbon dioxide – will lead to increasing global average temperatures in the decades to come. Among the potential impacts of global warming are rising sea levels, more severe storms, changes in precipitation,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

Carbon dioxide is released into the atmosphere mainly through the burning of fossil fuels, such as the gasoline consumed in cars and light trucks. Unlike other 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, 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.

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



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 opportunities.[9] 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 reconcile his or her schedule with public transit timetables.

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 Rhode Island, and that policies that reduce carbon dioxide emissions from commuting may result in additional emission reduction benefits from other forms of 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 Rhode Island. Cars and light trucks are responsible for about one-fifth of emissions of nitrogen oxides (NOx), and one-quarter of emissions of volatile organic compounds (VOCs) – the two chemical components of ozone smog. Vehicles also emit other health-threatening pollutants – such as particulate matter and toxic chemicals – in their exhaust.[10]

- **Congestion** – Single-passenger automobile commutes are key contributors to congestion, particularly at peak travel periods. In the Providence metropolitan area in 2003, the average rush-hour driver spent 33 hours per year in traffic – up from 19 hours just five years earlier and 5 hours in 1982. Providence-area congestion resulted in the consumption of 11 million excess gallons of gasoline and cost the region about $363 million in lost time and wasted fuel.[11] 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, nearly $400 million was spent by all levels of government on construction, operation and maintenance of Rhode Island's highways.[12]

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

Global Warming Emissions from Commuting in Rhode Island

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 Rhode Island and neighboring states. This analysis uses the Census Bureau's counts of the number of commuters traveling to and from Rhode Island towns by various modes of transportation to produce rough estimates of total and per-commuter emissions from commuting.

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 allows only one choice of 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 rail station and then take 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 is not 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

Statewide

Commuters residing in Rhode Island generated almost 747,000 metric tons of carbon dioxide emissions in 2000.[13] About one-half of these emissions came from residents of 10 cities and towns.

Providence and nearby communities dominate the list for total carbon dioxide emissions. North and South Kingstown, both located in Washington County, are the exceptions to this pattern, producing significant amounts of carbon dioxide from commuting. (See Table 1 and the map on page A of the color insert at the center of this report.)

Table 1. Commuting-Related Carbon Dioxide Emissions by Place of Residence, Top 10 Cities and Towns
(Metric Tons)

City or Town	Total CO_2 Emissions (metric tons)
Providence	63,408
Warwick	62,765
Cranston	44,708
Pawtucket	40,360
Portsmouth	40,210
Coventry	33,652
Woonsocket	29,513
North Kingstown	28,398
Cumberland	26,643
South Kingstown	26,409

On average, commuters from Rhode Island produce 3,280 pounds of carbon dioxide emissions each year. However, 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-commuter emission levels are among residents of Block Island. This reflects the fact that, although per-commuter emissions for people who work and live on Block Island are quite low (less than 400 pounds per commuter per year), people commuting to the mainland produce large amounts of carbon dioxide and raise the island's average per-commuter emissions.

The three fast-growing Washington County towns of Hopkinton, Charlestown and Richmond have some of the highest per-commuter emissions in the state. Growth in these more traditionally rural communities follows a national trend toward the expansion of "exurbs" – formerly rural communities that are increasingly the site of sprawling, auto-dependent suburban development, a topic to which we will return later.

Among the 27 communities with total emissions of greater than 10,000 metric tons per year, the top 10 towns for per-worker emissions are primarily located along the state's western edge and southern shore. (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 Providence metropolitan area. (See Table 3.) The most notable exception to this pattern is Newport. Low per-commuter emissions in Newport are a reflection of the fact that Newport has the second-highest percentage of residents who also work in their hometown (63 percent), and that 13 percent of commuters walk to their place of employment.

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

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

City or Town	CO_2 Emissions per Worker (lb/yr)	Total CO_2 Emissions (metric tons)
Charlestown	5,996	10,247
Hopkinton	5,886	10,554
Glocester	5,440	12,622
Burrillville	5,307	18,611
Narragansett	5,062	19,165
North Kingstown	4,738	28,398
Tiverton	4,575	14,671
South Kingstown	4,490	26,409
Coventry	4,381	33,652
Westerly	4,172	20,290

Table 3. Lowest 10 Towns for Per-Worker Carbon Dioxide Emissions
(Towns with Total Annual Emissions Greater than 10,000 Metric Tons)

City or Town	CO_2 Emissions per Worker (lb/yr)	Total CO_2 Emissions (metric tons)
Newport	1,959	23,743
Providence	2,132	63,408
North Providence	2,341	15,978
East Providence	2,631	26,145
Cranston	2,794	44,708
Pawtucket	2,815	40,360
Johnston	2,830	16,404
Bristol	2,914	13,813
Barrington	3,045	10,057
Lincoln	3,092	13,944

Workers Commuting into Rhode Island from Other States

In addition to commuters based in Rhode Island, a large number of commuters travel every day from other states to workplaces within Rhode Island. These trips are a significant source of emissions, responsible for approximately 76,300 metric tons of carbon dioxide emissions each year – or about 9 percent of the total emissions generated by people who work in Rhode Island.

Commuters from Massachusetts (89 percent of out-of-state emissions) and Connecticut (8 percent of out-of-state emissions) are responsible for the majority of carbon dioxide emissions generated by out-of-state commuters working in Rhode Island. In terms of total emissions by town of residence, the greatest amount of carbon dioxide comes from commuters who live in southern Massachusetts – particularly those towns in close proximity to Rhode Island's borders and to major highways, such as I-95 and I-195. (See Table 4.)

Unsurprisingly, commuters traveling from other states to Rhode Island for work produce substantially more emissions than commuters traveling within the state – an average of 6,347 pounds of carbon dioxide per worker per year (compared to the in-state average of 3,280 pounds).

Rhode Island towns with the highest percentage of inbound carbon dioxide emissions from out-of-state workers are located along the state's borders and are close to major highways. Almost a quarter of carbon dioxide emissions generated by commutes to workplaces in Tiverton, are from people who live in Massachusetts. Providence and East Providence each generate approximately 20 percent of total inbound emissions from out-of-state commuters.

Table 4. Commutes from Out-of-State into Rhode Island, Top 10 Towns by Total Carbon Dioxide Produced

City or Town	Total CO_2 Emissions (metric tons)
Fall River, MA	10,979
Attleboro, MA	4,817
Swansea, MA	3,844
Seekonk, MA	3,714
New Bedford, MA	3,466
Rehoboth, MA	3,057
North Attleborough, MA	3,023
Somerset, MA	2,776
Dartmouth, MA	2,631

Commuting Emissions by Place of Work

Statewide

Carbon dioxide emissions from workers traveling to Rhode Island businesses totaled approximately 640,000 metric tons in 2000. Commuters heading to Providence were responsible for 25 percent of the global warming emissions generated by people traveling to work in Rhode Island.

The list of top 10 cities and towns for commuting emissions by place of work is dominated by Providence and other towns in the Providence metropolitan area. Also on the list are Newport and towns along the Route 4 corridor (South Kingstown and North Kingstown). (See Table 5 and map on page C of the color insert.)

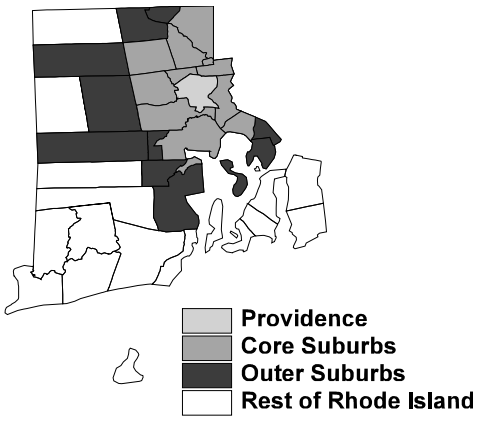
Table 5. Top 10 Towns for Total Carbon Dioxide Emissions by Place of Work in Rhode Island

City or Town	Total CO_2 Emissions (metric tons)
Providence	156,974
Warwick	70,694
Cranston	44,884
Newport	37,730
Pawtucket	32,399
East Providence	29,384
South Kingstown	26,346
North Kingstown	23,533
Woonsocket	21,908
Lincoln	20,661

The traditional hub-and-spokes model of suburban development suggests that suburbs primarily act as bedroom communities for a center city and that one of the main transportation challenges is getting people in and out of the metropolitan core. However, since the advent of the automobile there has been an increased shift towards suburb-to-suburb commutes – for example, commutes to work along Interstate 295.

Commutes in the Providence metropolitan area reflect both patterns. To illustrate this, we compared total emissions and commuting patterns from Providence proper and two concentric "rings" around the city, which we term the Core Suburbs (within five miles of Providence), the Outer Suburbs (within 10 miles of Providence).[14] (See Fig. 3.)

Fig. 3. Towns Included in Various "Rings" Around Providence



People commuting to work in Providence generate more carbon dioxide emissions than workers in any other city or town in the state – commuters to the city account for 25 percent of carbon dioxide generated by people traveling to work in Rhode Island. However, more people commute to the Providence suburbs than to the center city, and they generate more carbon dioxide emissions. (See Table 6.)

Among towns with inbound commuting emissions of 10,000 metric tons or more, communities with the highest per-worker emissions are in close proximity to major highways – North and South Kingstown are on the Route 4 corridor, Smithfield is off of Interstate 295, Lincoln is close to Highway 146, and East Greenwich is located on Route 1, near where Interstate 95 and Route 4 join. (See Table 7.)

The list of towns with the lowest per-capita inbound emissions (among towns with total inbound emissions of 10,000 metric tons or more) includes Newport and several towns just outside Newport and Providence. However, it does not include Providence itself, which attracts a significant number of long-distance commuters who produce larger amounts of global warming emissions. (See Table 8.)

Table 6. Carbon Dioxide Emissions by Place of Work

Place of Work	Total CO_2 Emissions (metric tons)
Providence	156,974
Core Providence Suburbs	252,020
Outer Providence Suburbs	98,815
The Rest of RI	132,395

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

City or Town	CO_2 Emissions per Commuter (lb/yr)
North Kingstown	4,251
South Kingstown	3,798
Smithfield	3,614
Lincoln	3,466
Warwick	3,288

Table 8. Bottom Five Towns for Carbon Dioxide Emissions Per Worker, by Place of Work
(Total Emissions Over 10,000 Metric Tons)

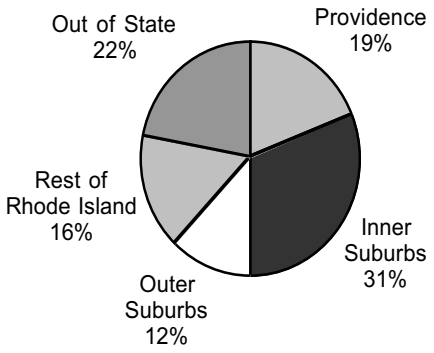
City or Town	CO_2 Emissions per Commuter (lb/yr)
Newport	2,392
Middletown	2,503
Pawtucket	2,685
Cumberland	2,729
West Warwick	2,764

Commuting Out of State from Rhode Island

Just as some commuters travel from outside the state to work in Rhode Island, so too do some Rhode Island residents travel to workplaces in neighboring states. These trips are a significant source of emissions, responsible for almost 183,000 metric tons of carbon dioxide emissions each year – or 22 percent of the total emissions created by Rhode Island residents. (See Fig. 4.)

Rhode Island residents traveling to other states generate more than twice as much carbon dioxide per worker as out-of-state commuters traveling to workplaces in Rhode Island.

Fig. 4. Total Carbon Dioxide Emissions Generated by Rhode Island Residents, By Place of Work



Boston is the leading attraction for Rhode Island residents. However, towns between Rhode Island and Boston (Attleboro, North Attleboro, Franklin and Canton), east of Rhode Island along Interstate 195 (Fall River and New Bedford), and southwest of Rhode Island along Interstate 95 (Groton and Ledyard) are also leading draws. (See Table 9.)

In terms of total emissions, commuters traveling from Providence to out-of-state workplaces produce more carbon dioxide than commuters who travel out-of-state and live in any other town in Rhode Island. (See Table 10.) However, a number of other towns derive a larger percentage of their total outbound emissions from residents commuting out-of-state. The high percentage of global warming emissions generated by commutes to other states strongly suggests that efforts to reduce carbon dioxide emissions from Rhode Island residents must include a focus on greater regional cooperation.

Table 9. Top 10 Out-of-State Towns for Carbon Dioxide Emissions from Residents of Rhode Island

City or Town	Total CO_2 Emissions (metric tons)
Boston, MA	24,883
Attleboro, MA	11,343
Fall River, MA	10,863
Groton, CT	9,990
Ledyard, CT	8,054
New Bedford, MA	7,010
Franklin, MA	6,280
North Attleborough, MA	6,073
Canton, MA	5,431
Seekonk, MA	5,262

Table 10. Carbon Dioxide Emissions Generated from Rhode Island Residents Who Work Out-of-State, Top 5 Cities and Towns

City or Town	CO_2 Emissions from Commutes to Other States (metric tons)	Percent of Total Emissions for Town's Residents
Providence	22,290	35%
Pawtucket	18,610	46%
Woonsocket	16,173	55%
Warwick	12,038	19%
Cranston	10,527	40%

Out-of-state commuters produce substantially more emissions than commuters within the state – an average of 7,214 pounds of carbon dioxide per worker per year (compared to the in-state average of 2,787 pounds).

Across the state's 39 cities and towns, global warming emissions from commuting can be explained by several factors, specifically: the availability of transportation alternatives, the distance commuters live from work, and interstate commuting patterns.

Availability of Transportation Alternatives

The frequency with which commuters drive alone to work, and the degree to which commuters use transit, are major factors driving up global warming emissions around the state.

Across the Rhode Island's 39 cities and towns, there is a correlation between single-passenger commuting and per-worker carbon dioxide emissions. As Fig. 5 shows, global warming emissions per worker increase as the percentage of commutes made in single-passenger vehicles increases.

Fig. 5. Percentage of Drive-Alone Trips versus Carbon Dioxide Emissions per Worker by Place of Work

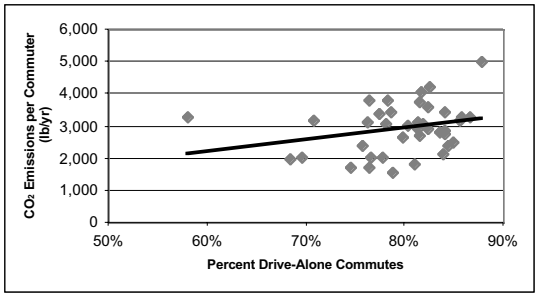
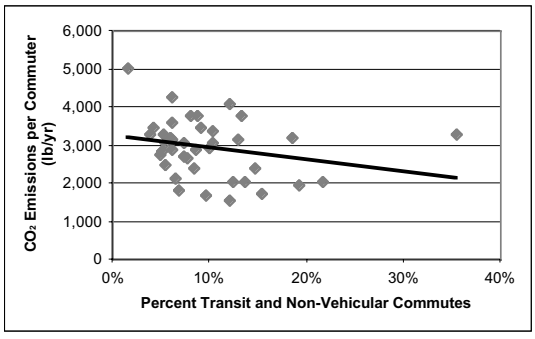


Fig. 6. Percentage of Transit and Non-vehicular Commuters versus Average Carbon Dioxide Emissions per Worker by Place of Work



Looking more specifically at transportation choices, per-worker emissions of carbon dioxide decline as the percentage of workers taking any form of transit (bus, commuter rail, or other) and making non-vehicular commutes (those that that take place on foot or via bicycle, or those in which people telecommute or work from home) increases. (See Fig. 6.)

The general trend is clear: towns with more transit and non-vehicular commuting generate lower levels of carbon dioxide emissions per worker.

These relationships show that efforts to encourage transit use, improve public transit infrastructure and options, and promote telecommuting, pedestrian commutes, and other transportation alternatives can yield significant reductions in carbon dioxide emissions from commuting. Thus, developing more and stronger transit networks and encouraging non-vehicular commutes must be a key component of any plan to reduce global warming emissions in Rhode Island.

Transportation Choices in the Providence Metropolitan Area

Commuters traveling to Providence and its surrounding suburbs are responsible for 79 percent of all transportation-related carbon dioxide emissions generated by people working in Rhode Island. Because the Providence metropolitan area produces the majority of Rhode Island's global warming emissions from commuting, finding ways to reduce this region's per-commuter emissions is especially important.

Commuting to Work in Providence Proper

The majority (69 percent) of Providence workers commute into the city from other parts of Rhode Island or from other states. These commuters generate 93 percent of Providence's inbound carbon dioxide emissions.

A primary reason why these commuters produce more than their share of global warming emissions is linked to choices they make when deciding how to travel to

work. Generally, the farther away commuters live from Providence, the more likely they are to utilize high-emission forms of transportation. (See Fig. 7.)

For example, 86 percent of Providence workers who commute into the city drive alone. In contrast, only 54 percent of people who live and work within the city drive alone. Compared to people who commute into the city, people living in Providence are less likely to drive alone to work, they are more likely to use public transportation, and they are significantly more likely to walk or ride a bike to work.

Commuting to Work in the Providence Suburbs

People traveling to workplaces in the core suburbs around Providence generate more emissions than workers traveling to the city itself. The majority of these emissions are generated by commuters who live in either in Providence's core suburbs or in its outer suburbs. These suburb-to-suburb commutes generate slightly less carbon dioxide per commuter than the average trip to work in Providence (2,473 pounds per commuter as compared to 3,136 pounds per commuter). However, the sheer number of suburban residents traveling to suburban workplaces makes this commuting pattern quite significant.

In general, commuters traveling to workplaces in the core suburbs – whether they come from the suburbs, other parts of Rhode Island, or other states – use high-emission forms of transportation.

More than 90 percent of commutes to the core suburbs are made in cars, minivans, SUVs or light trucks – and the majority of these trips are made by people driving alone. Only 1 percent of people who work in the core suburbs take some form of transit to work. (See Fig. 8.)

Of particular interest is the fact that people who live in Providence and work in the core suburbs are more likely to take transit to work than people who live and work in the core suburbs. The total number of transit trips made by residents traveling within the core suburbs is slightly greater than the total number of transit trips made by residents of Providence. Yet, as a percentage of total transit trips, commuters from Providence are more likely to use suburban transit networks than are their suburban counterparts.

An examination of commuting patterns in the Providence metropolitan area highlights important areas for improvement – most notably reducing the per-commuter emissions from suburban residents by developing a better regional transit network and encouraging carpooling. This same analysis also identifies areas where other communities should discourage low-density, sprawling development; encourage mixed-use communities where people live near centers of employment; and build an infrastructure designed to promote walking, biking and other types of non vehicular commuting.

The challenge of providing transportation alternatives – both to commuters traveling between Providence's suburban rings and from the suburban rings into Providence – is formidable, but there are opportunities to do so.

Fig. 7. Transportation Choices Made By Providence-Bound Commuters by Place of Residence, 2000

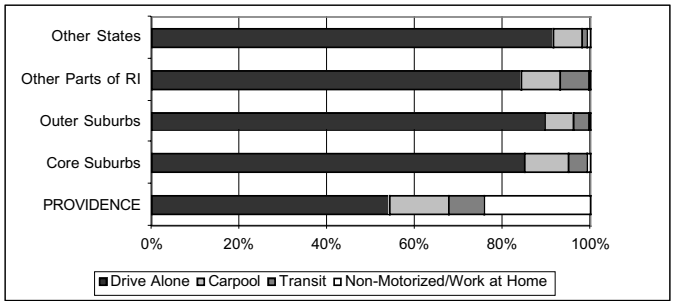
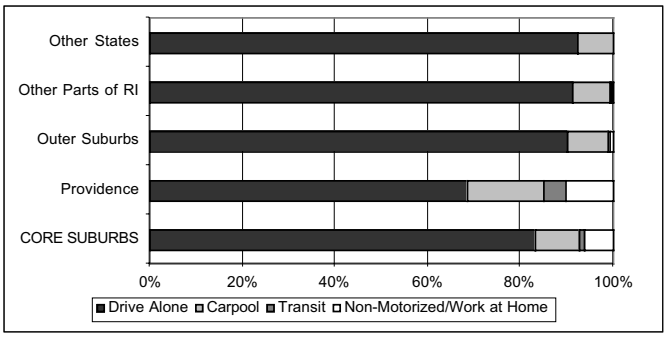


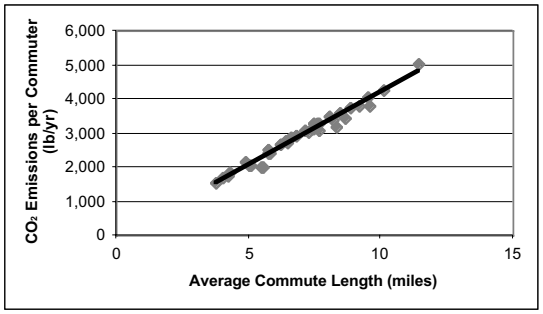
Fig. 8. Transportation Choices Made By Core Suburb-Bound Commuters, by Place of Residence, 2000



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. Average commute length has a very strong relationship with carbon dioxide emissions by place of work and by place of residence. (See Fig. 9.)

Fig. 9. Average Commute Length versus Carbon Dioxide Emissions per Worker by Place of Work

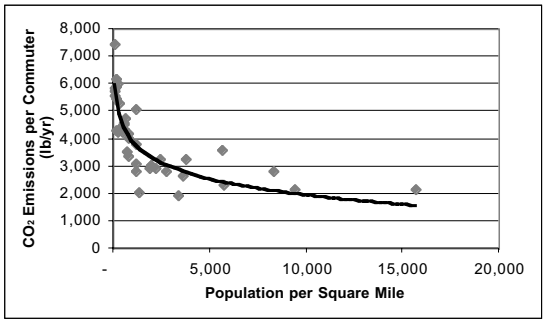


The importance of living near work is exemplified by workers and residents of Jamestown, an island community in Narragansett Bay. The average person working in Jamestown (the sole town on Conanicut Island) commutes less than 4 miles each day and produces approximately 1,564 pounds of carbon dioxide emissions per year. Such low per-worker emissions are directly related to the fact that 43 percent of people who work on Conanicut Island also live on the island. In contrast, 74 percent of Jamestown residents drive off the island to work. These commuters travel nearly three times as far to get to work and produce an average of 4,973 pounds of carbon dioxide emission each year. The Jamestown example also illustrates the importance of having a healthy balance between the number of residents and the number of jobs in any given town.

One of the most powerful steps Rhode Island could take to reduce global warming emissions from commuting would be to encourage people 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 commercial development.

Short commuter trips are also often associated with densely developed areas. Thus, it is not surprising that per-commuter carbon dioxide emissions are closely correlated with the population density of towns in which commuters live. (See Fig. 10.)

Fig. 10. Population Density versus Carbon Dioxide Emissions per Worker by Place of Residence



In other words, low-density, sprawling residential development encourages greater carbon dioxide emissions from commuters, while higher density development encourages low levels of global warming emissions. The reasons for this are open to debate, but there are several possible factors including the likelihood that, in more densely developed communities, jobs will be in closer proximity to place of residence and there will be a greater availability of transportation alternatives.

Exurban Growth

Some of the highest per-commuter emissions in Rhode Island come from residents of formerly rural "exurbs" located in Washington County and along the southern part of Interstate 95. For example, commuters from Exeter, West Greenwich and Richmond each generate an average of 5,500 pounds of carbon dioxide per year.

The I-95 corridor in the southern part of the state is one of the least densely populated areas of the state – in a ranking of least densely populated towns in Rhode Island, Exeter ranks second, West Greenwich ranks third and Richmond ranks sixth. However, these communities have experienced tremendous growth over the past decade. Between 1990 and 2000 Rhode Island's total population grew by 4.5 percent. How-

ever, Exeter's population increased by 11 percent, Richmond's population grew by 35 percent, and West Greenwich's population grew by 46 percent.

From a global warming perspective, exurban development poses several problems. Most importantly, many exurban developments are distant from centers of employment and transit infrastructure, meaning longer commutes that are less likely to occur via transit. The trend towards longer commutes is not just a Rhode Island phenomenon: nationally, the trend towards 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 vehicles.[15]

Two examples of these communities are the towns of Richmond and West Greenwich, both in Washington County. Both communities rank very high for per-worker carbon dioxide emissions – with Richmond ranking second among the state's 39 cities and towns and West Greenwich ranking sixth.

In both of these communities, larger shares of commuting-related global warming emissions come from trips to regional centers – such as the Providence metropolitan area, and to a lesser extent, North and South Kingstown. (See Table 11 and Table 12.)

Table 11. Top Five Destinations for Total Carbon Dioxide Emission from Richmond Commuters

Richmond	Total CO_2 Emissions	Percent of Total
Providence	1,458	15%
Warwick	1,394	14%
South Kingstown	721	7%
Cranston	688	7%
Westerly	636	7%

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

West Greenwich	Total CO_2 Emissions	Percent of Total
Providence	1,327	20%
Warwick	1,257	19%
Cranston	629	10%
North Kingstown	318	5%
Pawtucket	311	5%

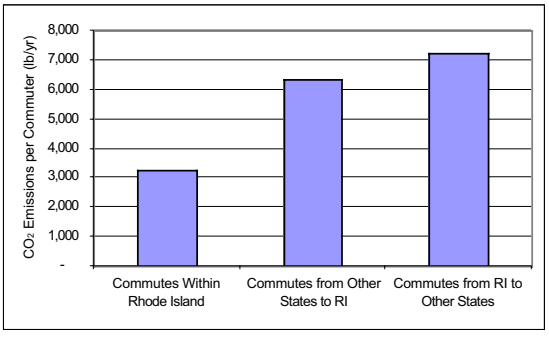
What is interesting about Richmond and West Greenwich is that, even though more than half of commuters from these towns travel either into Providence or one of the surrounding suburbs, the majority (89 percent) of commuters from these towns drive alone when traveling to work. This suggests that there is some potential to develop transit from exurban communities into workplaces in the Providence metropolitan area.

However, even with increased transit, because exurban residents have very long commutes, continued exurban development poses a significant challenge to Rhode Island's ability to control carbon dioxide emissions from commuting. Therefore, promoting compact development patterns, allowing a mix of land uses enabling people to live near their workplace, and reducing exurban development itself are potentially important steps the state could take to deal with this trend.

Interstate Commutes

Considerable global warming emissions are generated by people commuting between Rhode Island and neighboring states. The average in-state commuter produces significantly less carbon dioxide (2,786 pounds per commuter) than the average out-of state resident commuting into Rhode Island (6,347 pounds per commuter) or the average Rhode Island resident commuting out of state (7,214 pounds per commuter). (See Fig. 11.)

Fig. 11. Carbon Dioxide Emissions from Commutes to and from Other States



Rhode Island Residents Commuting Out of State

The majority of global warming pollution generated by commuters traveling from Rhode Island to work in other states comes from residents of "border towns" – those near Rhode Island's borders with Massachusetts and Connecticut.

For all intents and purposes, many of these border towns are as much a part of Massachusetts' and Connecticut's transportation networks as that of Rhode Island. This is particularly true of Tiverton and Little Compton, which are integrated with the larger Fall River and New Bedford metropolitan areas.

Commuting patterns from residents of Rhode Island's "border towns" can be separated into two distinct patterns; long-distance commutes (to cities such as Boston), and shorter cross-border commutes (to cities and towns such as Attleboro or Fall River).

Long-Distance Commutes

Rhode Island residents traveling long distances to work – typically to Boston or its surrounding suburbs – are responsible for producing a significant amount of global warming pollution.

The 4,700 commuters traveling from Rhode Island to Boston generate more carbon dioxide than commuters to any other out-of-state location (24,883 metric tons). If Boston were a town in Rhode Island, it would rank in the state's top 10 cities and towns for inbound commuting emissions.

Although nearly 42 percent of commuters traveling from Rhode Island to Boston use transit, commuter rail service to the Boston metropolitan area currently originates only in Providence. Commuters who live farther from the Providence rail station are less likely to use transit when traveling to work in the Boson metropolitan area. This significantly increases the amount of per-commuter carbon dioxide generated.

For example, the trip from Cranston to Boston is only a few miles longer than the trip from Providence to Boston, yet Cranston residents traveling to Boston generate nearly 50 percent more emissions per commuter (11,161 pounds per commuter) than their Providence neighbors (7,625 pounds). The difference in emissions is linked to the fact that 60 percent of Providence residents but only 40 percent of Cranston residents use some form of public transportation when commuting to Boston. Unlike Providence, Cranston does not have a direct connection to commuter rail and there are limited parking spaces and transit connections that would allow Cranston residents to use the Providence rail station for their commutes to Boston.

Extension of the Boston-bound MBTA (Massachusetts Bay Transportation Authority) commuter rail line to other areas of Rhode Island would divert many of the automobile trips to Boston, decrease the strain on regional highways, and significantly reduce global warming emissions generated by Rhode Island residents.

Cross-Border Commutes

The average out-of-state commute made by Rhode Island residents is much shorter than the trip to Boston. Indeed, five of the top 10 out-of-state towns for carbon dioxide emissions from Rhode Island residents have an average commute length of 12 miles or less. (See Table 13.)

Table 13. Top 10 Out-of-State Towns for Carbon Dioxide Emissions from Residents of Rhode Island, with Commutes of 12 Miles or Less Highlighted

City or Town	Total CO_2 Emissions (metric tons)	Average Commute Length (miles)
Boston, MA	24,883	41
Attleboro, MA	**11,343**	**9**
Fall River, MA	**10,863**	**11**
Groton, CT	9,990	21
Ledyard, CT	8,054	21
New Bedford, MA	7,010	22
Franklin, MA	**6,280**	**12**
North Attleborough, MA	**6,073**	**11**
Canton, MA	5,431	27
Seekonk, MA	**5,262**	**8**

Attleboro, Fall River and Franklin, Massachusetts and Groton, Connecticut are located within a few miles of Rhode Island's borders. Commutes to these towns are significant because of the sheer number of commuters and the high percentage of commuters who drive alone.

For example, more trips are made from Rhode Island to Attleboro than to any other out-of-state location. The average Rhode Island commuter to Attleboro produced 3,896 pounds of carbon dioxide emissions each year. This is primarily due to the fact that 86 percent of trips to Attleboro are made in single passenger vehicles, and only 0.38 percent of trips are made using transit.

Just as commuter rail service between Providence and Boston is negotiated between Rhode Island and Massachusetts through the Pilgrim Partnership – whereupon Rhode Island transfers federal capital funds that they receive from the Federal Transit Administration (FTA) to Massachusetts to be used by the MBTA in return for train service – there needs to be greater interstate cooperation in addressing shorter commutes from border towns. For example, the Rhode Island Public Transit Authority (RIPTA) should work with the Greater Attleboro-Taunton Regional Transit Authority (GATRA) to provide bus service to the greater Attleboro area. RIPTA should also move forward on the proposal to provide bus service from Pawtucket to the South Attleboro station. Similarly, RIPTA should explore the possibility of working with the Southeastern Regional Transit Authority (SRTA) to provide bus service from Rhode Island to the Dartmouth, Fall River and New Bedford areas.

Policy Recommendations

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

Clean Vehicles

Implementing tailpipe emission standards for global warming pollution from cars and light trucks is among the most effective steps the state can take immediately to reduce the impact of commuting and all vehicle travel on global warming. California's global warming emission standards – which are in the process of being adopted by Rhode Island and six other northeastern states – would reduce global warming pollution from Rhode Island's cars and light trucks by about 12 percent below projected levels by 2020, even if the state takes no other actions to reduce commuting-related emissions.[16] Combining implementation of the standards with other policy options to encourage carpooling, shorter commutes and greater use of public transportation will yield even greater results. Thus, the state should ensure it fully implements the California global warming standards as a strong first step toward reducing its emissions of global warming pollution from transportation.

Invest in Low Emission Transit Alternatives

Rhode Island should invest in its transportation infrastructure in ways that will lead to reductions in global warming emissions. Specifically, the state needs to invest more in transit – both through expanding regional rail and developing regional bus services – and less money on projects likely to lead to increased drive-alone automobile traffic – such as the proposed widening of Routes 95 and 295 and a proposed upgrade to the Route 6/10 interchange.

Develop Rhode Island's Regional Rail

Expanding regional commuter rail service in Rhode Island has the potential to significantly reduce carbon dioxide emissions from commuting. Expanding rail service down the west side of the Narragansett Bay would allow suburban commuters to more easily utilize existing commuter rail to the Boston metropolitan area.

Construction of the proposed commuter rail stations in Warwick, near the T.F. Green Airport, and at Wickford Junction would be good first steps towards a truly integrated regional rail network in Rhode Island. Further expansion of commuter rail along the existing Amtrak corridor between South Kingstown and Providence should also be considered. In addition to reducing carbon dioxide emissions from Rhode Island residents working out of state, expansion of the regional rail network has the potential to significantly reduce emissions from Rhode Island residents commuting within the state – especially commutes made to the Providence metropolitan region.

However, the success of an expanded regional rail network as a global warming-fighting tool depends on the maintenance of high standards of service quality and affordable fares. Reductions in service quality or significant increases in fares that discourage transit use could set the region back in its quest to reduce transportation-sector global warming emissions and must be avoided.

Promote Transit Connectivity

Better connections between different forms of transportation would make it easier to commute to and from suburban areas.

In addition to the improvements to rail infrastructure discussed above, Rhode Island needs to develop a more integrated transportation network capable of efficient and seamless movement from one type of transit to another. The Kingston Railroad Station in South Kingstown is an excellent example of this type of integrated system. This station is a stop along Amtrak's Northeast Corridor, is used as a base for local and express bus trips, and is connected to local bike paths.

Further, an important part of improving transit connectivity requires developing a bus network that is more integrated with the transit infrastructure and transit providers in other states.

The large number of commuters traveling between Rhode Island and neighboring states reinforces the fact that global warming emissions are a regional problem – one that Rhode Island cannot solve simply by acting on its own. The state must therefore work both to expand the regional transportation network, and to develop local transportation systems that can interface with the regional network.

Hold Suburban Workplaces Accountable for the Emissions They Generate

Suburban workplaces are responsible for a significant portion of the carbon dioxide emissions generated by people working in Rhode Island. Employers who choose to build in these areas must be required to mitigate the impact they have on the state's transportation network and the global climate.

One way to do this is to mandate 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. Among other efforts, employers could offer transit subsides, provide carpooling, participate in guaranteed ride home programs, or offer financial incentives for living near work.

Put the Brakes on Exurban Development

The growth of "exurbs" – formerly rural areas that are now being converted into long-distance bedroom communities for multiple regional centers – is one of the most ominous trends for Rhode Island's efforts to reduce global warming emissions from transportation. These areas are unlikely to ever have the population density or truly mixed-use development that that can make alternatives to driving possible. They are likely to remain permanently automobile-dependent.

Slowing exurban growth requires both carrots and sticks. Providing incentives for people to live closer to their place of work and guaranteeing that there are affordable housing options near major centers of employment would be part of the solution. For example, several states, including Massachusetts, have created programs to help people qualify for larger mortgages if they choose to live near transit lines.

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 rather should be targeted towards areas in which growth is desirable. The state should investigate how to adopt tools developed in other states – such as municipal service boundaries and priority funding areas – to fit with New England's strongly held tradition of home rule. Finally, because Rhode Island's exurban areas are among the state's last open and natural spaces, the state should take steps to preserve many of those areas from development.

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

As the data presented above shows and the experiences of communities around the state demonstrates, living near work can be a powerful force to reduce carbon dioxide emissions.

Pedestrian commutes often are disregarded in transportation planning, but from a global warming perspective they are very important. However, pedestrian commutes are possible only when workplaces and residences are in close proximity and where pedestrian infrastructure (such as sidewalks and safe crossing points) exists. New England's traditional town centers provide a model of 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 developments 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 use "infill" development. And state investments should be directed to encouraging the redevelopment of existing properties in urban areas that would be sites for affordable housing or new commercial development.

The state, towns and employers should explore novel ways to encourage commuters to live near their work or near transit. Commuters who live near their place of work not only reduce global warming emissions, but also reduce the strain on the state's transportation infrastructure. They should be rewarded for their choices.

Telecommuting also holds promise to reduce the number and length of commuting trips made. Employers should be encouraged to develop telecommuting alternatives for their employees.

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. Rhode Island 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 Rhode Island 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 Rhode Island transit agencies reporting energy use data to the database 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 Rhode Island 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 Providence was based on GIS mapping using ArcView 3.x. Towns included in each ring are those identified by ArcView as within 5 or 10 miles of Providence 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	CO_2 Emissions per Worker (lb/yr)	Per-Worker Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Barrington town	85%	3,045	28	10,057	27
Bristol town	79%	2,914	29	13,813	22
Burrillville town	86%	5,307	9	18,611	16
Central Falls city	62%	2,151	36	6,546	34
Charlestown town	85%	5,996	3	10,247	26
Coventry town	88%	4,381	15	33,652	6
Cranston city	85%	2,794	33	44,708	3
Cumberland town	87%	3,800	21	26,643	9
East Greenwich town	86%	4,021	20	10,271	25
East Providence city	82%	2,631	34	26,145	11
Exeter town	86%	5,587	7	7,529	32
Foster town	89%	5,826	5	5,257	36
Glocester town	84%	5,440	8	12,622	23
Hopkinton town	87%	5,886	4	10,554	24
Jamestown town	83%	4,522	13	5,200	37
Johnston town	87%	2,830	31	16,404	17
Lincoln town	88%	3,092	27	13,944	21
Little Compton town	83%	4,319	16	3,013	38
Middletown town	85%	2,023	38	7,543	31
Narragansett town	85%	5,062	10	19,165	15
New Shoreham town	77%	7,441	1	1,759	39
Newport city	69%	1,959	39	23,743	12
North Kingstown town	85%	4,738	11	28,398	8
North Providence town	86%	2,341	35	15,978	18
North Smithfield town	88%	4,224	18	9,321	30
Pawtucket city	76%	2,815	32	40,360	4
Portsmouth town	86%	3,553	23	40,210	5
Providence city	60%	2,132	37	63,408	1
Richmond town	89%	6,206	2	9,732	28
Scituate town	89%	4,249	17	9,675	29
Smithfield town	86%	3,367	24	14,424	20
South Kingstown town	76%	4,490	14	26,409	10
Tiverton town	86%	4,575	12	14,671	19
Warren town	83%	2,908	30	6,973	33
Warwick city	87%	3,272	25	62,765	2
West Greenwich town	89%	5,738	6	6,520	35
West Warwick town	84%	3,257	26	20,949	13
Westerly town	83%	4,172	19	20,290	14
Woonsocket city	79%	3,597	22	29,513	7

Appendix C: Emissions and Commuting Data by Town of Work

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Worker (lb/yr)	Per-Worker Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Barrington town	76%	1,730	37	2,591	32
Bristol town	77%	2,026	33	6,966	21
Burrillville town	79%	3,448	9	5,282	24
Central Falls city	75%	1,698	38	3,183	30
Charlestown town	82%	4,069	3	3,024	31
Coventry town	80%	3,046	20	9,526	18
Cranston city	82%	2,903	22	44,884	3
Cumberland town	82%	2,729	26	10,681	17
East Greenwich town	87%	3,287	12	10,928	16
East Providence city	84%	2,892	23	29,384	6
Exeter town	71%	3,193	14	1,437	35
Foster town	70%	2,025	34	423	38
Glocester town	76%	3,798	5	3,280	29
Hopkinton town	77%	3,392	10	2,313	33
Jamestown town	79%	1,564	39	1,073	36
Johnston town	83%	2,826	24	14,581	12
Lincoln town	84%	3,466	8	20,661	10
Little Compton town	68%	1,974	35	794	37
Middletown town	85%	2,503	28	14,064	13
Narragansett town	81%	2,931	21	5,250	25
New Shoreham town	58%	3,283	13	231	39
Newport city	76%	2,392	30	37,730	4
North Kingstown town	83%	4,251	2	23,533	8
North Providence town	84%	2,139	31	7,570	20
North Smithfield town	81%	3,147	16	5,285	23
Pawtucket city	80%	2,685	27	32,399	5
Portsmouth town	78%	2,037	32	9,212	19
Providence city	76%	3,136	17	156,974	1
Richmond town	82%	3,761	6	3,564	27
Scituate town	78%	3,083	18	2,235	34
Smithfield town	82%	3,614	7	15,393	11
South Kingstown town	78%	3,798	4	26,346	7
Tiverton town	84%	2,402	29	4,275	26
Warren town	81%	1,826	36	3,528	28
Warwick city	86%	3,288	11	70,694	2
West Greenwich town	88%	5,033	1	5,548	22
West Warwick town	84%	2,764	25	11,626	15
Westerly town	86%	3,193	15	11,827	14

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. "Transportation-sector emissions" 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; "vehicle miles traveled" based on Federal Highway Administration, *Highway Statistics* series of reports.

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 Greg Marland, Tom Boden, Bob Andres, Oak Ridge National Laboratory, *"Ranking of the World's Countries by 2000 Total CO_2 Emissions from Fossil-Fuel Burning, Cement Production and Gas Flaring,"* downloaded from cdiac.esd.ornl.gov/trends/emis/top2000.tot, 23 February 2005.

4. Ibid.

5. Rhode Island Public Interest Research Group Education Fund, *Cars and Global Warming: Policy Options for Rhode Island to Reduce Global Warming Pollution from Cars and Light Trucks,* Winter 2005.

6. See note 1.

7. Rhode Island Greenhouse Gas Stakeholder Process, *Rhode Island Greenhouse Gas Action Plan*, 15 July 2002; Conference of New England Governors and Eastern Canadian Premiers, *Climate Change Action Plan 2001*, August 2001.

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

9. 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.

10. RIPIRG Education Fund, *Ready to Roll: The Benefits of Today's Advanced-Technology Vehicles for Rhode Island,* June 2003.

11. Data from Texas Transportation Institute, *The 2005 Urban Mobility Study*, downloaded from mobility.tamu.edu/ums/congestion_data/tables/providence.pdf, 30 November 2005.

12. Federal Highway Administration, *2000 State Highway Briefing Sheet for Rhode Island*, downloaded from www.fhwa.dot.gov/ohim/hbs/ma.htm, 18 March 2005.

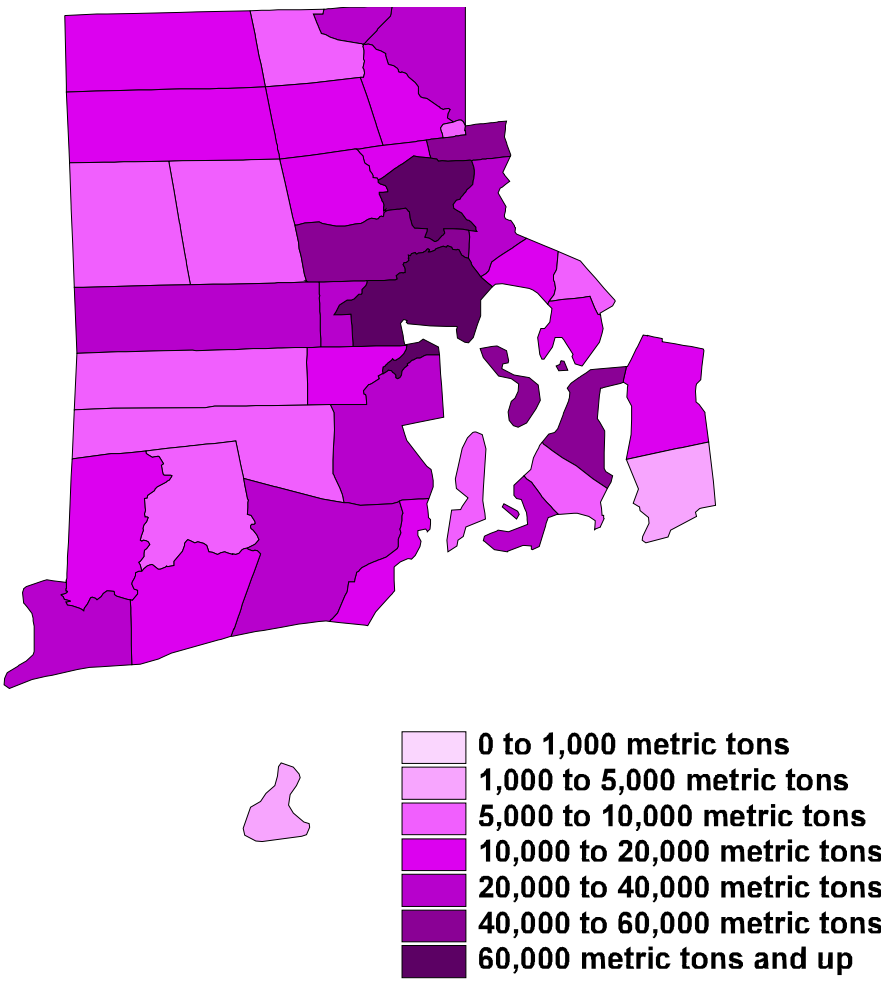
13. This figure includes emissions from residents of Rhode Island commuting to workplaces in other states. See "Methodology" for more details.

14. Towns in the "5 mile ring" include Barrington, Central Falls, Cranston, Cumberland, East Providence, Johnston, Lincoln, North Providence, Pawtucket, Smithfield and Warwick. Towns in the "10 mile ring" include Bristol, Coventry, East Greenwich, Glocester, North Kingstown, North Smithfield, Scituate, Warren, West Warwick and Woonsocket.

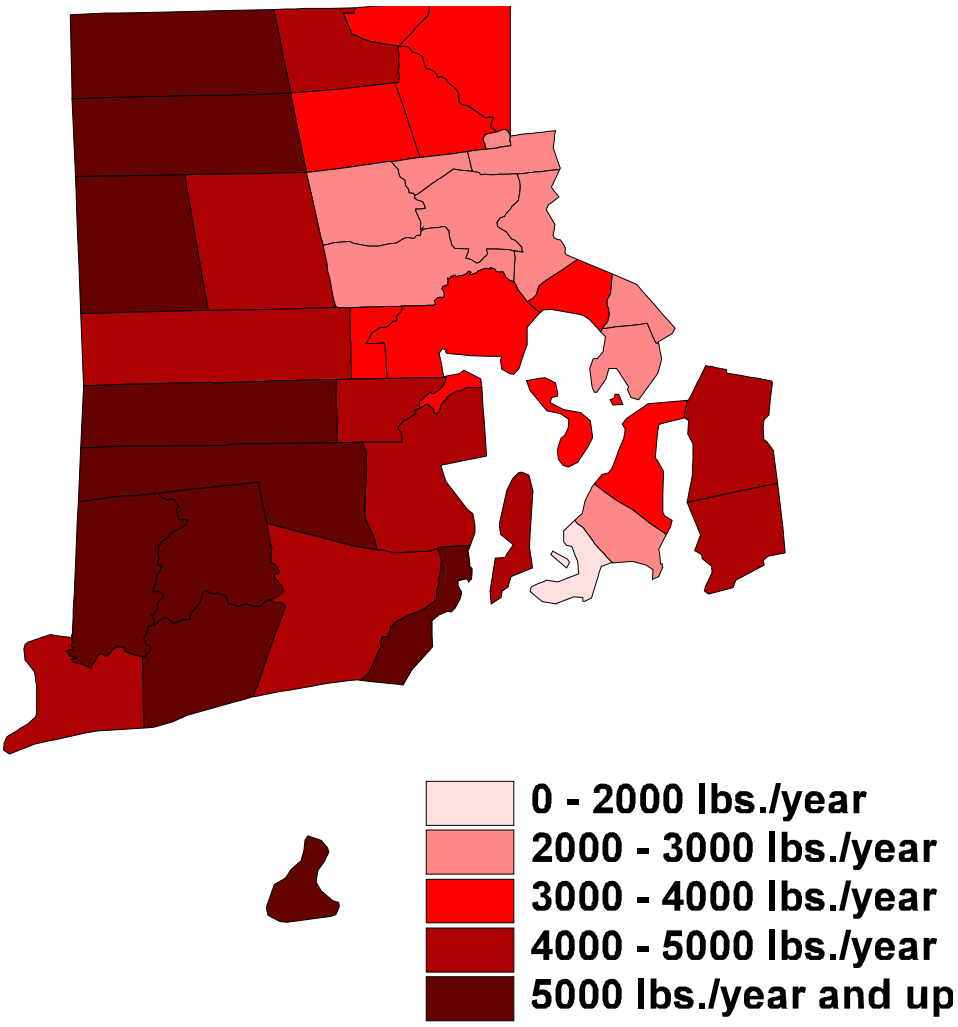
15. U.S. Department of Transportation, *BTS Reports that 3.3 Million Americans Are "Stretch Commuters" Traveling at least 50 Miles One-Way to Work,* press release, 12 May 2004.

16. See note 5.

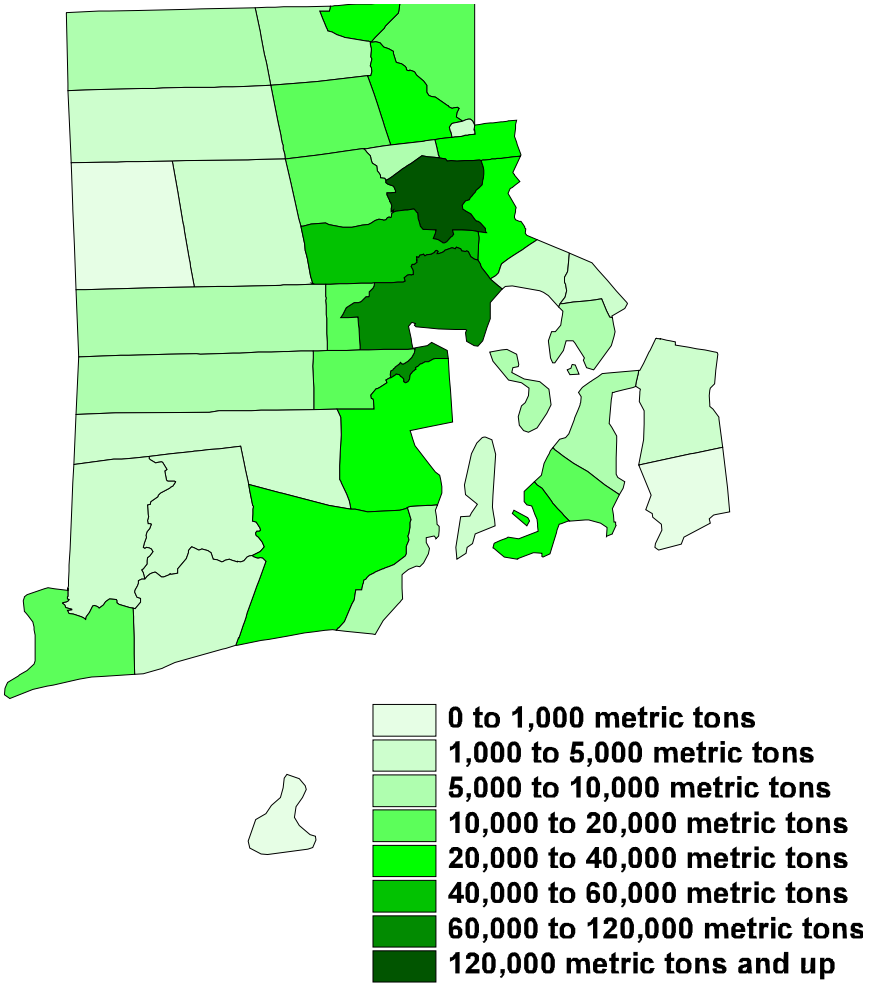
Total Carbon Dioxide Emissions by Place of Residence



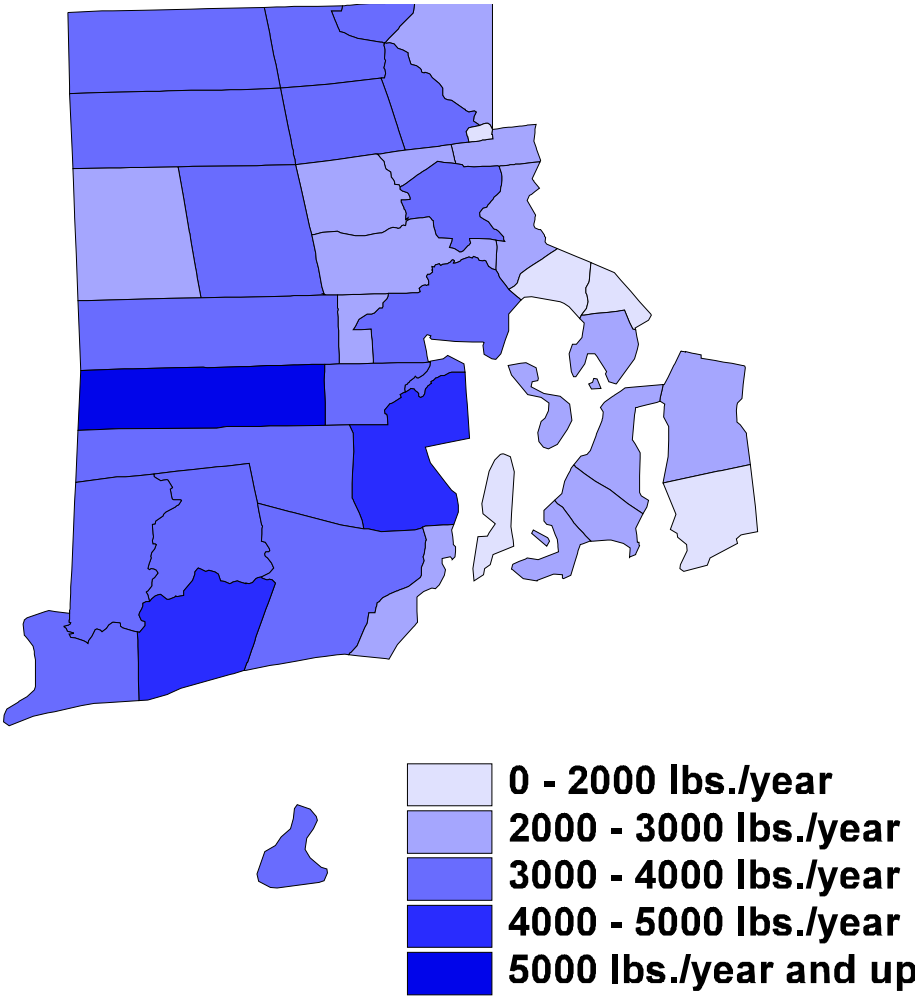
Per-Worker Carbon Dioxide Emissions by Place of Residence



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