Driving Global Warming

Commuting in Vermont and its Contribution to Global Warming

VERMONT PUBLIC INTEREST RESEARCH AND EDUCATION FUND

Summer 2005

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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 Vermont and the trips Vermonters 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 — and to meet the state's climate protection goals — Vermont 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 state 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.

Figure ES-1. Annual Per-Commuter Carbon Dioxide Emissions from Residents of the Greater Burlington Metropolitan Area

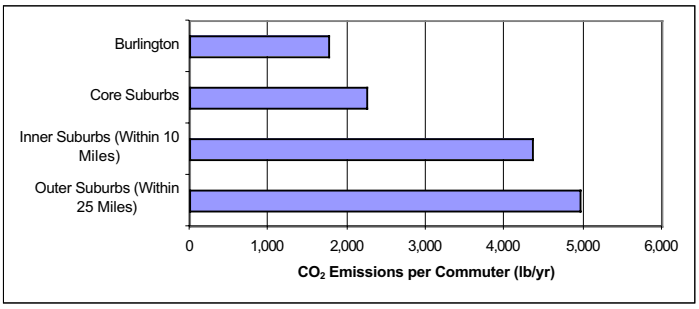
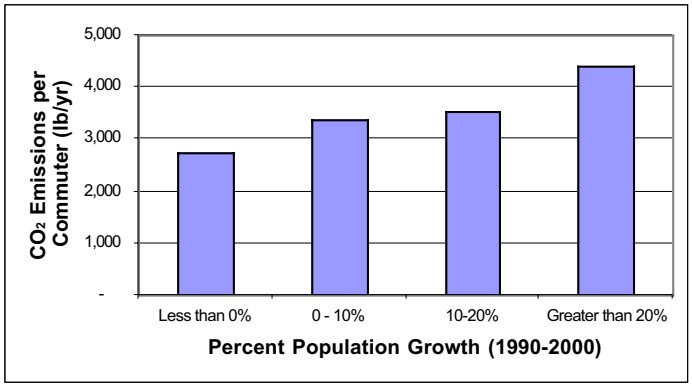


Figure ES-2. Vermont's Fastest-Growing Communities Produce More Global Warming Emissions



The average commuter living in the outer suburbs of Burlington produces two to three times more carbon dioxide from his or her journey to work than the average commuter living within a few miles of Burlington.

- Residents of Burlington and core suburbs around Burlington (such as South Burlington, Essex and Colchester) produce significantly less global warming emissions than residents of towns within 10 miles of the city (such as Milton, Richmond or Charlotte) or towns within 25 miles of the city (such as Ferrisburg, Waterbury or Georgia).

The explosion of "exurban" residential development in Vermont and the growing number of long-distance commutes pose major challenges to the state's efforts to reduce global warming emissions.

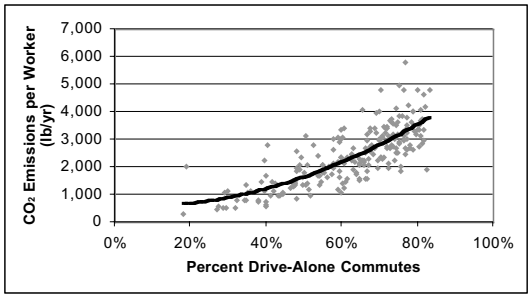
- Sprawling exurban development leads to dramatically longer commuting trips for many Vermonters. This is a worrisome trend given that the 8 percent of Vermont commuters who travel at least 20 miles to work produce a disproportionately large share — around 27 percent — of the state's commuting-related carbon dioxide emissions.

- Many of Vermont's fastest-growing communities are located on the extreme fringes of the state's metropolitan areas and in formerly rural areas where per-worker emissions are very high.

Shifting commuting away from drive-alone trips, expanding transit availability, and fostering non-vehicular commutes and home-based work can significantly reduce carbon dioxide emission from transportation.

- Throughout Vermont, 75 percent of all commuters drive alone to work. However, towns with a high reliance on alternatives to drive-alone commuting — regardless of their location within the state — tend to have lower per-worker emissions.

Figure ES-3. Drive-Alone Commutes vs. Per-Commuter Carbon Dioxide Emissions by Place of Work (Towns Attracting At Least 50 Commuters)



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

- Adopt vehicle global warming emissions standards to make all cars produce less carbon dioxide per mile.
- Adopt a sliding scale system of incentives (or "feebates") to encourage the purchase of more efficient vehicles.
- Put the brakes on exurban growth in rural areas by discouraging highway expansion projects like the Circumferential Highway that promote exurban development.
- Encourage more compact, mixed-use planning in new and existing suburbs.
- Encourage carpooling, vanpooling and other programs that reduce the number of drive-alone commutes.
- Expand local and especially inter-county bus transit services, revive local commuter rail service between Rutland and Burlington, and further integrate the state into the regional transit network by expanding rail service in Vermont.
- Develop programs to encourage residents to live near their workplaces and to encourage employers to implement telecommuting.
- Hold large workplaces accountable for the carbon dioxide emissions they generate by requiring employers to implement commute-trip reduction programs.

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 Governors and Eastern Canadian Premiers' 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. As a region, New England and Eastern Canada are committed to reducing global warming emissions to 2000 levels by 2010, to 10 percent below 2000 levels by 2020, and ultimately by the 75 to 85 percent scientists believe will be necessary to stabilize concentrations of global warming gases in the atmosphere.

One of the most promising series of developments has been with regard to transportation. Vermont and four of the five other New England states have adopted California's emission standards for automobiles and light trucks, which include requirements to produce advanced-technology vehicles that are likely to have a reduced impact on the climate. Similarly, several New England states are seriously considering adopting California's forthcoming standards for global warming emissions from automobiles.

Vermont, while traditionally a leader in the promotion of cleaner vehicles, has recently lagged. The state has not vigorously implemented California's advanced-technology vehicle standards and has been silent on whether it will adopt the global warming emission standards — falling behind states such as New York, Connecticut and Massachusetts that are championing the program. If Vermont is serious about reducing global warming pollution from cars and light trucks then we can and must pursue full implementation of California's clean cars rule, including tailpipe standards for carbon dioxide.

The impact of these initiatives is substantial: by 2020, states adopting the full California 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 by 23 percent in Vermont — 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 enables us to come up with a detailed portrait of one important source of vehicle travel: the journey to and from work.

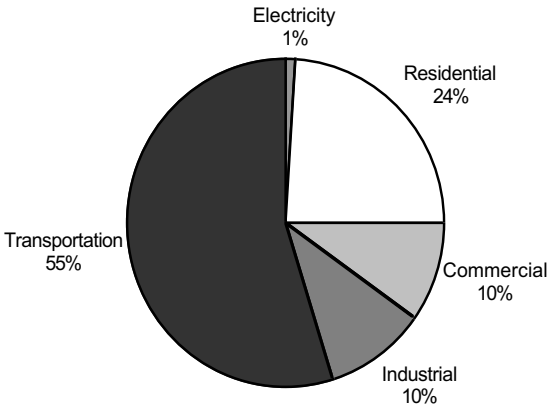
The analysis that follows suggests that wise land-use and transportation policies can reduce carbon dioxide emissions from the daily commute and can have ripple effects on other sources of vehicle travel. Gov. Douglas and other leaders must muster the political will to implement those policies and fulfill Vermont's responsibility to reduce the threat global climate change poses to the state. The time to do so is now.

The journeys that Vermont 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 by both lowering other transportation-related emissions and promoting a higher quality of life.

The Role of Transportation in Global Warming

Transportation is the number one contributor to global warming emissions in Vermont. In 2001, transportation-sector emissions represented more than half (55 percent) of Vermont's emissions of carbon dioxide — the leading global warming gas.[1] (See Figure 1.) Transportation-sector emissions of carbon dioxide increased in the state by 23 percent between 1990 and 2001.[2] No other state in New England derives as large of a share of its global warming emissions from the transportation sector and only New Hampshire experienced a larger increase in transportation-sector emissions during this period. As a result, Vermont is among the least-effective states in the region in controlling emissions of global warming from its transportation sector.

Figure 1. Vermont's Carbon Dioxide Emissions from Fossil Fuel Consumption, 2001[3]



Given recent trends in vehicle fuel economy (a major determinant of carbon dioxide emissions) and vehicle travel, carbon dioxide emissions from transportation in Vermont can be expected to increase significantly over the next several decades. The total number of vehicle miles traveled in Vermont is projected to increase by 21 percent from 2005 to 2020 and a correspondingly large increase in carbon dioxide emissions from the transportation sector can be expected.[4]

Reining in carbon dioxide emissions from the transportation sector is a key part of the state's effort to achieve the global warming emission reductions adopted by the New England states in 2001. These goals call for overall reductions in global warming 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 concentrations 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 other non-work related transportation emissions and produce other benefits for the state.

Why Commuting Matters

Vermont'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, 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 — while initially intended to speed travel and make Vermont more attractive to new residents, visitors and businesses — has also allowed workers to live farther and farther from their places of employment, creating sprawling

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 — concentrations of these heat-trapping gases in the atmosphere have increased dramatically, and the earth's surface temperatures have begun to rise in direct response.

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 decreased snowfall and shifts in forest ecosystems that threaten Vermont's skiing, maple sugaring and tourism industries while also endangering the state's ecology 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:

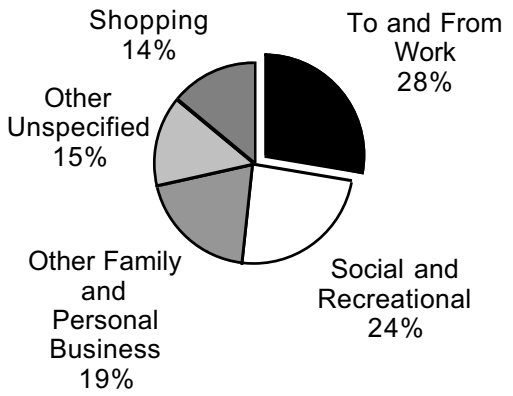
1) drive fewer miles
2) improve vehicle fuel efficiency
3) switch to low-carbon fuels

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.

new development patterns in formerly rural areas of the state.

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 single leading source of vehicle travel.[5] (See Figure 2.)

Figure 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.[6] Residents of traditional smaller towns with well-defined town centers might drive a short distance to get downtown, but then complete several errands while there. Conversely, residents of sprawling, 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 Vermont, and that policies that reduce carbon dioxide emissions from commuting will almost certainly result in additional emission reduction benefits from other types 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 Vermont. Light-duty vehicles such as cars, pickup trucks, minivans and sport utility vehicles (SUVs) are responsible for about 30 percent of all air emissions of nitrogen oxides (NOx) in Vermont and about one-quarter of all emissions of volatile organic compounds (VOCs) — the two chemical components of ozone smog.[7] Vehicles also emit other health-threatening pollutants — such as particulate matter, carcinogens and toxic chemicals — in their exhaust.

- **Congestion** — Single-passenger automobile commutes are key contributors to congestion, particularly at peak travel periods. Between 1993 and 1998 vehicle miles of travel (VMT) on freeways and principal arterial streets increased by 7 percent in Chittenden County. However, during this same period, moderate congestion increased 74 percent and heavy to extreme congestion increased by 27 percent.[8] Policies and practices that encourage single-passenger automobile commutes add to this congestion.

- **Highway expenditures** — Chronic congestion often brings calls for new or expanded road 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 2003 the state spent more than $310 million on highway construction, operation and maintenance. Local governments spent over $110 million more.[9]

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

Global Warming Emissions from Commuting in Vermont

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 Vermont 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 rail or bus lines.

2) To preserve individual privacy, the Census Bureau does not disclose information for trips between two towns that are taken by a very small number of people. These low-frequency trips, which are unlikely to make a significant contribution to global warming emissions, 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 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 park-and-ride lot and then take a bus may list their mode of travel as "bus." The automobile portion of the 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

Statewide

Commuters residing in Vermont (and included in the Census survey) were responsible for about 449,000 metric tons of carbon dioxide emissions in 2000. (See map on page A of the color insert in the center of this report.)

The list of the top 15 cities and towns whose residents generate the greatest amount of carbon dioxide emissions from commuting is dominated by cities and towns located in the greater Burlington metropolitan area (Burlington, Essex, Colchester) and by regional centers in other parts of the state (Bennington, Hartford, Brattleboro). (See Table 1.)

Table 1. Top 15 Cities and Towns, Total Carbon Dioxide Emissions by Place of Residence

City or Town	Total CO_2 Emissions (metric tons)
Burlington	16,421
Essex	10,783
Colchester	9,998
Milton	9,898
Bennington	7,780
South Burlington	7,488
Hartford	7,102
Brattleboro	7,007
Waterbury	6,498
Springfield	6,321
Swanton	6,142
St. Albans city	5,835
Montpelier	5,644
Georgia	5,587
Barre	5,497

The average Vermont commuter is responsible for about 3,430 pounds of carbon dioxide per 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 insert.)

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 63 communities with total emissions of greater than 2,500 metric tons per year, the top 10 towns for per-worker emissions are predominantly located in a wide ring around Burlington. (See Table 2.)

Table 2. Top 10 Towns for Carbon Dioxide Emissions Per Commuter by Place of Residence (Towns with Greater than 2,500 Metric Tons Annual Emissions)

City or Town	CO_2 Emissions per Commuter (lb/yr)	Total CO_2 Emissions (metric tons)
Starksboro	7,057	2,977
Highgate	6,176	4,352
Grand Isle	6,018	2,637
Huntington	5,932	2,747
Enosburg	5,925	3,323
Fairfax	5,655	4,614
Waterbury	5,490	6,498
Cambridge	5,458	4,332
Georgia	5,367	5,587
Ferrisburg	5,188	3,243

By contrast, towns with the lowest levels of per-worker emissions (among those with 2,500 metric tons of annual emissions or greater) are a mixed collection of Vermont's largest cities (Burlington), towns in close proximity to large cities (South Burlington and Essex), and smaller towns with vibrant town centers (Middlebury). (See Table 3.)

Table 3. Bottom 10 Towns for Carbon Dioxide Emissions Per Commuter by Place of Residence (Towns with Greater than 2,500 Metric Tons Annual Emissions)

City or Town	CO_2 Emissions per Commuter (lb/yr)	Total CO_2 Emissions (metric tons)
Rutland	1,559	5,398
Burlington	1,768	16,421
Middlebury	2,017	3,219
South Burlington	2,023	7,488
Essex	2,349	10,783
Colchester	2,369	9,998
Bennington	2,394	7,780
Williston	2,458	4,307
St. Johnsbury	2,642	3,806
Shelburne	2,651	3,953

A Closer Look: The Burlington Metropolitan Area

Residents living in towns within 25 miles of Burlington's city limits were responsible for more than a third (38 percent) of all commuting-related carbon dioxide emissions in the state in 2000. As noted above, residents living near Burlington's urban core produce very low levels of carbon dioxide emissions from their daily commutes. A detailed look at the Burlington metro region suggests that emissions increase dramatically as one travels from the core toward outer suburbia.

To illustrate this, we compared total and per-worker emissions from Burlington proper and three concentric rings around the city, which we term the Core Suburbs (communities within three miles of Burlington city limits); the Inner Suburbs (within 10 miles); and the Outer Suburbs (within 25 miles). (See Figure 3, next page.)

The 53,500 commuters living in the inner and outer suburbs were responsible for about one-fourth of Vermont's commuting-related carbon dioxide emissions and about two-thirds of emissions from residents

Figure 3. Rings Around Burlington[10]

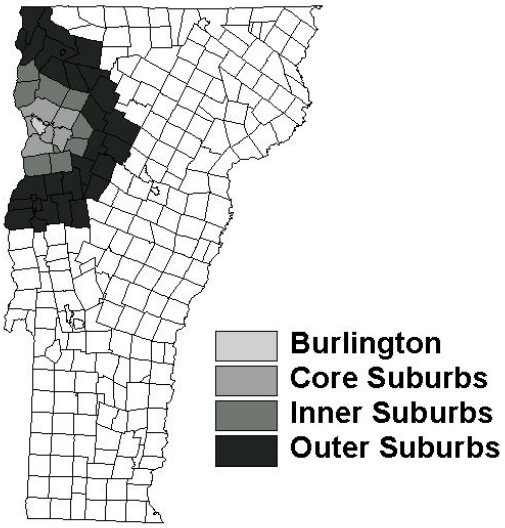


Figure 4. Total Carbon Dioxide Emissions By Place of Residence Within the Burlington Metro Area

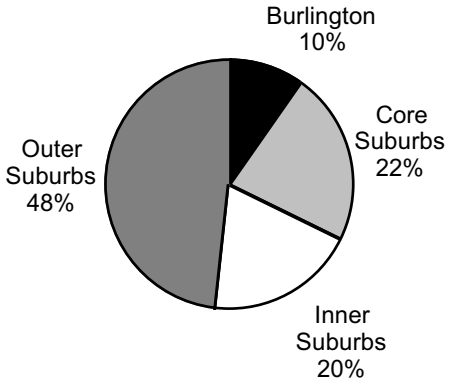
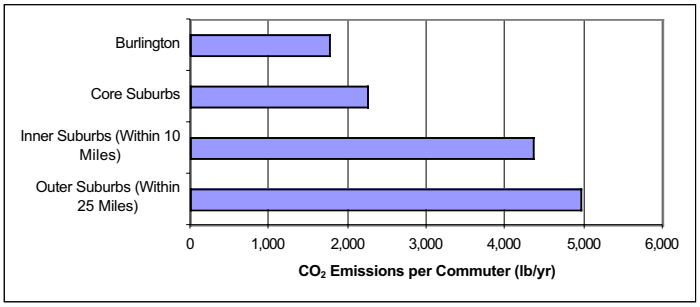


Figure 5. Per-Commuter Carbon Dioxide Emissions by Place of Residence



of the Burlington metro area. These suburban commuters produce two-and-a-half times more carbon dioxide annually from their journeys to work than residents of Burlington and residents of the core suburbs surrounding the city. (See Figures 4 and 5.)

Because suburban commuters generate more carbon dioxide than those living closer to Burlington, public policies that encourage further sprawling "exurban" development in these distant suburbs would undercut the state's efforts to reduce global warming emissions. The most damaging such idea is the proposed Circumferential Highway around Burlington, which would reduce travel times to the outer suburbs, thus making them more attractive for development. (See Text Box, next page.)

In addition to Vermont-based commuters, a number of people travel every day from surrounding states to workplaces in Vermont. These trips generate about 25,400 metric tons of carbon dioxide each year — or about 6 percent of the total commuting emissions created by Vermont residents.

The majority of global warming emissions from out-of-state residents traveling into Vermont comes from residents of New Hampshire (53 percent), but New York (35 percent) and Massachusetts (12 percent) are also big contributors. Most of these commuters live in towns close to Vermont's borders.

On average, out-of-state Vermont-bound commuters produce more global warming emissions than people living and working within the state — 5,634 pounds of carbon dioxide per year compared to the in-state average of 3,430 pounds per year.

Commuting Emissions by Place of Work

Statewide

Another way to look at the impact of commuting on global warming in Vermont is to review emissions by place of work. Carbon dioxide emissions from commuters traveling to work in Vermont totaled approximately 435,400 metric tons in 2000.

The Case Against the Circ

Vermont's Agency of Transportation (AOT) currently plans to construct a 16-mile ring road around Burlington that would cut through Colchester, Essex, Williston and Shelburne. So far only a four-mile stretch of the road is open in Essex and plans to complete the next two segments, called segments A and B, that link the Essex section to I-89 via a bridge over the Winooski River were stalled last summer when Judge William Sessions ruled that environmental impact statements had not been properly prepared.

From a global warming standpoint, completion of segments A and B of the Circ highway would dramatically increase development pressures on the outer suburbs of Burlington, including Richmond, Jericho and Underhill. These towns already produce some of the highest per-capita global warming emissions in the state, as most of their population commutes to Burlington or Montpelier. As development intensifies in these towns, the volume of commuters will skyrocket.

In addition, completion of the full Circ would provide Vermont's first exurb-to-exurb highway connection. As experience from other states clearly testifies, once multiple inner and outer ring suburbs are connected to one another by multi-lane limited access highways, global warming emissions, especially from the outer ring suburban towns, increase dramatically.

To avoid this outcome, Vermont AOT should prioritize road improvements that would:

- Perform as well as, or better than, the proposed Circ Highway in the area that would be served by segments A and B;
- Be less likely to result in sprawl development, with a special eye to not increasing global warming emissions from outer suburbs like Richmond and Jericho;
- Provide improved access to critical economic activity centers, including IBM; and
- Cost less to construct than the new limited access Circ Highway.

The two Circ Highway alternatives proposed by the Vermont Smart Growth Collaborative meet these criteria. (See text box on page 21).

Workplaces located in or near Burlington (Burlington, Essex, South Burlington, Williston) attracted the largest number of commuters and generated the largest amount of carbon dioxide emissions. However, scattered throughout the rest of the state (Rutland, Montpelier, Bennington) and along I-91 and the New Hampshire border (Brattleboro, Hartford, Springfield) are a number of cities and towns that also attract a significant number of commuters and produce substantial carbon dioxide emissions. (See map on page C of the insert and Table 4.)

Per-worker carbon dioxide emissions by place of work vary widely throughout the state. (See map on on page D of the insert.) Among the 33 Vermont cities and towns that generate at least 2,500 metric tons of inbound carbon dioxide from commuters, the highest per-commuter emissions come from workers traveling to towns within 25 miles of Burlington (Waterbury, Williston) and to mid-sized towns and regional centers throughout the state. (See Table 5, next page.)

Table 4. Top 15 Cities and Towns, Total Carbon Dioxide Emissions by Place of Work

City or Town	Total CO_2 Emissions (metric tons)
Burlington	46,423
Essex	30,439
South Burlington	29,369
Williston	23,498
Brattleboro	18,985
Rutland	17,977
Montpelier	16,291
Colchester	13,754
Middlebury	12,417
Bennington	12,088
Hartford	11,570
St. Albans city	9,255
Manchester	8,808
Springfield	6,617
St. Johnsbury	6,234

Table 5. Top Five Towns for Per-Worker Carbon Dioxide Emissions by Place of Work (Towns with Greater than 2,500 Metric Tons Annual Emissions)

City or Town	Per-Commuter CO_2 Emissions (lb/yr)	Total CO_2 Emissions (metric tons)
Hartford	4,803	11,570
Williston	4,789	23,498
Waterbury	4,784	6,049
Manchester	4,595	8,808
Montpelier	4,235	16,291

The list of destination cities and towns with the lowest per-capita emissions is a mixture of small and mid-sized communities that also happen to be some of the most densely populated communities in the state — in terms of population per square mile, Winooski ranks 1st, Barre ranks 5th, Newport ranks 8th and Bennington ranks 11th. (See Table 6.)

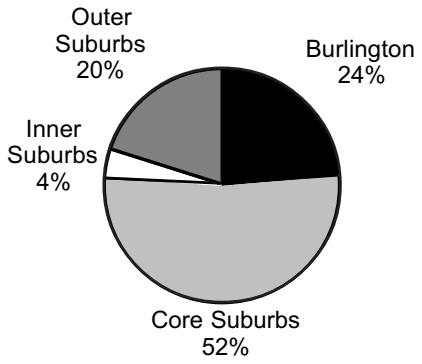
Table 6. Bottom Five Towns for Carbon Dioxide Emissions Per Worker by Place of Work (Towns with Greater than 2,500 Metric Tons Annual Emissions)

City or Town	Per-Commuter CO_2 Emissions (lb/yr)	Total CO_2 Emissions (metric tons)
Barre	2,608	6,011
Winooski	2,652	2,912
Bennington	2,654	12,088
Newport	2,730	4,182
Rutland	2,933	17,977

Working in the Burlington Metropolitan Area

Commutes to business locations in the greater Burlington metropolitan area (including towns within 25 miles of Burlington's city limits) generate nearly half (46 percent) of the state's commuting-related carbon dioxide emissions. Commutes to Burlington itself account for only 11 percent of statewide emissions — indeed, more commuters travel daily to Burlington's core suburbs than to the city itself. (See Figure 6.)

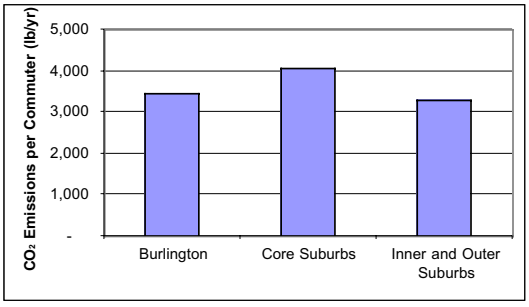
Figure 6. Total Carbon Dioxide Emissions by Place of Work, Burlington Metro Area



The traditional hub-and-spokes model of suburban development predicts that the suburbs primarily act as bedroom communities for urban centers and that one of the main transportation challenges is getting people in and out of the metropolitan core. More recently, the growth of job opportunities in the suburbs has led to an increase in suburb-to-suburb commutes.

The average level of per-commuter carbon dioxide emissions is highest for commuters traveling to the core suburbs (average of 4,084 pounds per year), followed by commuters traveling to Burlington (average of 3,436 pounds per year), and commuters traveling to the inner and outer suburbs (average of 3,280 pounds per year). (See Figure 7.)

Figure 7. Per-Commuter Carbon Dioxide Emissions by Place of Work



A significant number of Vermont residents also routinely commute to out-of-state workplaces. These commuters are responsible for annually producing about 39,000 metric tons of carbon dioxide — or about 8 percent of commuting-related emissions created by people working in Vermont.

The majority of global warming emissions from Vermont residents commuting out of state are generated on trips to workplaces in New Hampshire (72 percent), Massachusetts (15 percent) and New York (11 percent). New Hampshire towns near the Vermont border are the leading attractions for Vermont residents, but the small number of long-distance commutes to Boston and New York City also generate significant amounts of carbon dioxide emissions because the trip lengths are so long. (See Table 7.)

Table 7. Top Five Out-of-State Cities for Carbon Dioxide Emissions from Commuters from Vermont

City or Town	Total CO_2 Emissions (metric tons)
Lebanon, NH	12,899
Hanover, NH	6,180
Boston, MA	2,331
Littleton, NH	1,926
Manhattan, NY	1,598

Of particular note is the fact that commutes from Vermont residents to Lebanon, New Hampshire generate a substantial amount of global warming emissions. Indeed, if Lebanon were a city in Vermont, it would rank 9th on the list of cities and towns for carbon dioxide emissions by inbound commuters.

On average, Vermont commuters traveling out of state produce more than twice as much global warming emissions as people living and working within Vermont — 6,432 pounds of carbon dioxide per year compared to the in-state average of 3,430 pounds per year.

Factors Influencing Emissions

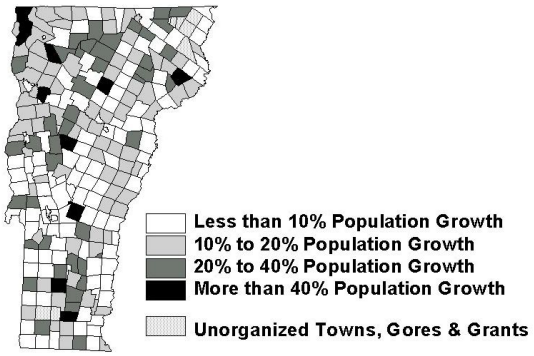
Across Vermont's nine cities and 237 towns, variations in global warming emissions from commuting can be explained by several factors, specifically: the emerging pattern of "exurban" development, the degree to which commuters live near their work, and the availability of transit service and other transportation alternatives.

Land Use and Exurban Development

All across New England and the country, 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 Vermont, growth of formerly rural, residential "exurbs" has threatened to further exacerbate global warming emissions from commuting.

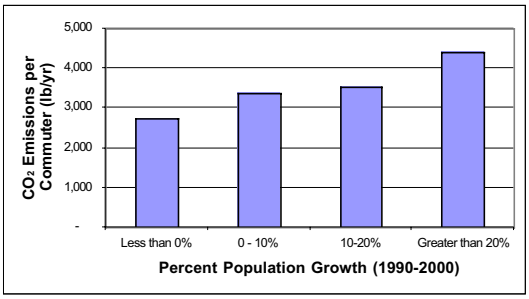
In the past several decades, Vermont has seen strong population growth in rural regions of the state. Between 1990 and 2000 many of fastest growing communities were located in north-central and south-central Vermont. (See Figure 8.)

Figure 8. Population Growth 1990 to 2000[11]



The state's fastest-growing towns also tend to have higher per-commuter carbon dioxide emissions. Residents of towns with greater than 10 percent population growth between 1990 and 2000 emitted more carbon dioxide than the statewide average (3,430 pounds per year) and significantly more than residents of Vermont's slowest growing towns. (See Figure 9.)

Figure 9. Average Per-Commuter Carbon Dioxide Emissions (by Place of Residence) in Cities and Town with Various Rates of Population Growth



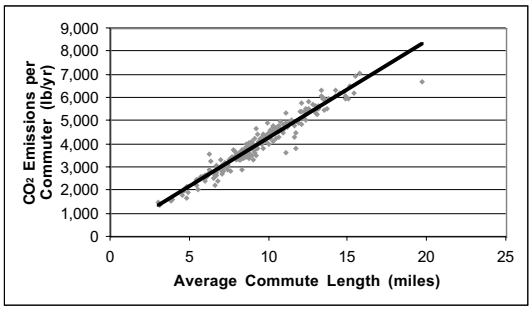
Exurban development poses several problems from a global warming perspective. Most notably, exurban communities are distant from centers of employment and transit infrastructure, meaning longer commutes that are less likely to occur via transit.

Continued exurban development in rural regions poses a significant challenge to Vermont's ability to control carbon dioxide emissions from commuting in the future. Therefore, encouraging more compact development in already developed areas, combining residential and commercial development, and expanding access to transit alternatives — while working to reduce exurban development itself — are important steps the state could take to deal with this trend.

Proximity to Work

Average commute trip length appears to have the strongest relationship of any factor with carbon dioxide emissions by place of residence. (See Figure 10, next page.) This conclusion may appear obvious at first blush, but it shows that the distance that Vermonters travel to and from work — rather than how they get there — is the most important factor in commuting-related global warming emissions (given the prevalence of automobile commuting and the lack of transportation alternatives for many Vermont residents).

Figure 10. Average Commute Length vs. Per-Commuter Carbon Dioxide Emissions (by Place of Residence)



Thus, one of the most powerful steps Vermont 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 commercial development.

One important step Vermont could take is to channel new commercial growth into the state's existing downtowns, thus revitalizing Vermont's traditional town centers. (For more on downtown redevelopment, see text box, below.)

Revitalizing Vermont's Downtowns

Encouraging commercial development in Vermont's existing downtowns and village centers can reduce global warming emissions by reducing the need for long commutes to centers of employment. Downtown redevelopment can also support the emergence of vibrant local economies.

Unfortunately, across Vermont, more and more communities are seeing an increase in development at the fringes of their towns, rather than on the main streets and in town centers. Notable examples include Bennington, Brattleboro, St Albans, and St. Johnsbury. Act 250 and local town and regional planning commissions are sometimes effective at combating this sprawling effect, but more can and should be done to both educate local planning commissions and decision-makers about the effects of sprawl and to support investments in our downtowns and village centers.

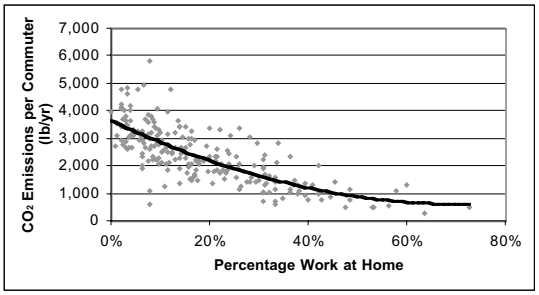
In 2003, the Vermont Smart Growth Collaborative found that there is significant room for improvement in the state's use of taxpayer dollars to support smart growth. The report found that the Vermont Economic Development Authority (VEDA) and Vermont Economic Progress Council (VEPC) were spending more than 60 percent of their total funds supporting sprawl development. This is despite the fact that VEPC has guidelines that relate to smart growth and sprawl. Second, the report found that spending for new highways dramatically outpaces spending on road repair, investments in mass transit and transportation enhancements such as bike paths and sidewalks.[12]

In one example of how VEDA and VEPC money is spent to encourage sprawl, the VSGC found that an electronics company received $679,515 to build a new facility three miles outside of Bennington in a rurally zoned neighborhood surrounded by wetlands and prime agricultural land — a project that cannot be defined as "smart growth." The money spent on the Bennington project was twice that spent to assist a cosmetics company that received $336,479 to renovate a site in downtown Bristol that same year.[13]

To correct this problem, the state needs to adopt a comprehensive downtown development bill that provides an appropriate mix of "carrots and sticks." Expedited permitting, as well as the easier access to and higher levels of funding by VEDA, VEPC and other agencies would provide an expanded incentive for businesses to locate in downtowns. However, these encouragements are useless without appropriate controls on development outside of designated downtowns and without strict controls on how "downtowns" are designated. Some progress has been made by the current administration and Legislature, but future proposals must be explicit that sprawl developments are not to be encouraged by inclusion as designated downtowns.

The propensity of residents of some Vermont towns to work at home is another factor in global warming emissions from commuting — indeed, working at home produces zero commuting-related emissions. Communities in Vermont with the highest percentage of work-at-home commuters are located in mountainous and heavily agricultural parts of the state and places with little non-agricultural employment. These communities tend to have very low per-commuter carbon dioxide emissions. Indeed, there exists a very strong relationship between percentage of "commuters" who work from home and a town's average per-commuter carbon dioxide emissions. (See Figure 11.)

Figure 11. Percentage Work At Home vs. Per-Commuter Carbon Dioxide Emissions (Towns Attracting At Least 50 Commuters)



Although towns with the greatest percentage of people who work at home are typically in rural Vermont, there is no reason why a higher percentage of people living in more densely developed parts of the state could not also work from home. Encouraging employers to consider telecommuting arrangements for their employees could reduce both carbon dioxide emissions and traffic congestion.

The robust relationship between commute length and per-commuter carbon dioxide emissions is one that the state cannot ignore. Reducing global warming emissions from transportation must include efforts to prevent sprawling land development and long-distance commutes. Given that there is a strong relationship between working at home and global warming emissions, the state should also develop programs to protect Vermont's many small family farms (where people are able to live and work at the same place) and encourage more people to telecommute or work from home.

Living Far From Work: Long-Distance Commutes

The average trip to work in Vermont is approximately 8 miles, yet more than 22,000 Vermonters routinely commute at least 20 miles to work. The 8 percent of commuters who make these long-distance trips produce about 27 percent of the state's commuting-related emissions — or more than three-and-a-half times more carbon dioxide per worker than the average Vermonter.

In Vermont, and all across the country, commutes have steadily become longer in the past several decades. 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 vehicles.[14]

The town of Starksboro is one example of a bedroom community whose residents commute long distances to work. The vast majority of carbon dioxide emissions — 92 percent — from residents of this town are from trips to cities and regional employment centers located at least 15 miles away. Most of these commuters are traveling to work in the Burlington urban core or to Middlebury to the southwest. (See Table 8.)

Table 8. Top Five Destinations for Commuters From Starksboro, By Percentage of Total Carbon Dioxide Emissions

Destination	Distance (miles)	Pct. of Emissions
Burlington	22	26%
South Burlington	19	16%
Williston	17	15%
Essex	21	13%
Middlebury	15	7%

As a source of total emissions, Starksboro ranks only 46th among Vermont towns. Yet Starksboro and other towns with a high percentage of long-distance commuters are indicators of a broader movement toward exurban development in Vermont. Starksboro's population grew by 26 percent between 1990 and 2000. This type of rapid population growth in an area with

such high per-commuter emissions has significant potential impacts on carbon dioxide emissions in the future.

Getting it Right: College Towns

Residents of Vermont's college towns have some of lowest per-commuter carbon dioxide emissions in the state. For example, the average commuter living in Middlebury, home to Middlebury College, produces 2,017 pounds of carbon dioxide per year — 41 percent below the state average. Similarly, the presence of the University of Vermont may be an important factor contributing to low per-commuter emissions in Burlington.

A major reason for low per-commuter emissions among Middlebury residents is the fact that the typical commuter travels less than 6 miles to get to work. Because of this short commute length, many residents are able to bike or walk to work. Indeed, Middlebury has one of the highest percentages of non-vehicular commutes in the state — 27 percent of commuters walk or ride their bikes.

In May 2004, the Trustees of Middlebury College passed a resolution supporting carbon reduction as a priority of the Middlebury College community. They endorsed the goal of reducing greenhouse gas emissions by 8 percent below 1990 levels by 2012 (given present levels of energy use, this equates to a 35 percent reduction below Fiscal Year 2000-2001 levels by 2012) and recognized that it will require a commitment of resources to achieve necessary technological and behavioral shifts.[15]

To achieve this goal, Middlebury must reverse trends that have caused faculty and staff commuting emissions to rise by 30 percent since 1990 while allowing student commuting emissions to rise by 13 percent.[16] To achieve this reversal, the college has developed a series of proposals. Such proposals include limiting on-campus parking, providing incentives for carpooling, expanding shuttle bus service, improving the college's bicycle, pedestrian and multi-modal infrastructure, and increasing the availability of affordable local housing.

The low levels of commuting-related emissions generated by college towns have little to do with them hosting colleges, per se. Rather, they are the result of compact development patterns, the presence of vibrant downtown commercial areas, and the location of housing within walking distance of campuses. As a result, college towns can provide valuable lessons about the importance of short commute lengths and a low reliance upon drive-alone commuting. By encouraging people to live near their work and by promoting and developing transportation alternatives, other Vermont towns can break from exurban patterns of development occurring elsewhere in the state and across New England.

Use of Transit and 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 car and vanpools, walking and biking, and telecommuting) can significantly reduce global warming emissions.

In Vermont, 75 percent of all commuters drive alone when traveling to work. Across the 217 cities and towns that attract at least 50 inbound commuters, there is a strong correlation between single-passenger commuting and per-worker carbon dioxide emissions. (See Figure 12.)

Figure 12. Percentage Drive-Alone Commuters vs. Per-Commuter Carbon Dioxide Emissions by Town of Work (Minimum of 50 Commuters)

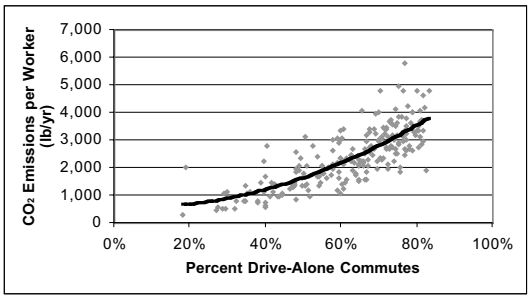


Figure 12 clearly illustrates that drive-alone commuting correlates with higher per-commuter carbon dioxide emissions. Reducing the percentage of drive-alone commutes by even a small amount can have a significant impact on overall emissions. Al-

Transit Opportunities: The Champlain Flyer

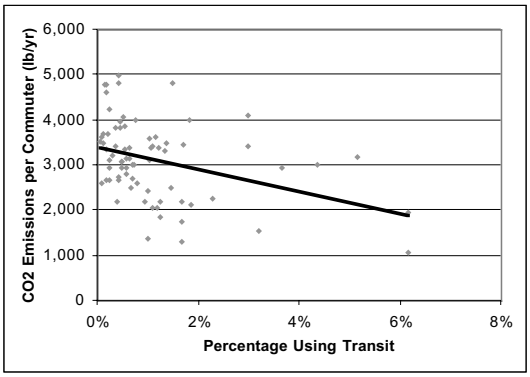
From 2000 to 2003, the Champlain Flyer commuter rail line ran from Charlotte to Burlington. Originally designed to alleviate congestion during construction on Route 7, the Flyer never achieved initial projections for ridership — in part, perhaps, because the road construction was delayed and the service was discontinued before the road construction began. In spite of the construction delay, the Flyer did carry about 6,900 passengers per month on average.[17]

Now that the Route 7 project has begun, Vermont should take a second look at the Champlain Flyer and other opportunities to reinvigorate rail transit. Should the state restore commuter rail service, a long-term commitment to the service, effective marketing, good connections to the region's bus system — as well as support for policies that can maximize the impact of the service, such as transit-oriented development — are key. With assurance that rail service will continue to exist in the future, Vermonters could feel confident in making changes to their transportation habits that include the use of rail.

though Figure 12 properly shows that many towns in Vermont have fewer than 50 percent of inbound commuters driving alone to work, it is important to note that many of these towns are quite small and have little non-agricultural employment. (See "Proximity to Work," page 16.)

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 or ferry) increases. (See Figure 13.)

Figure 13. Percentage of Commutes via Transit vs. Per-Commuter Carbon Dioxide Emissions by Place of Work

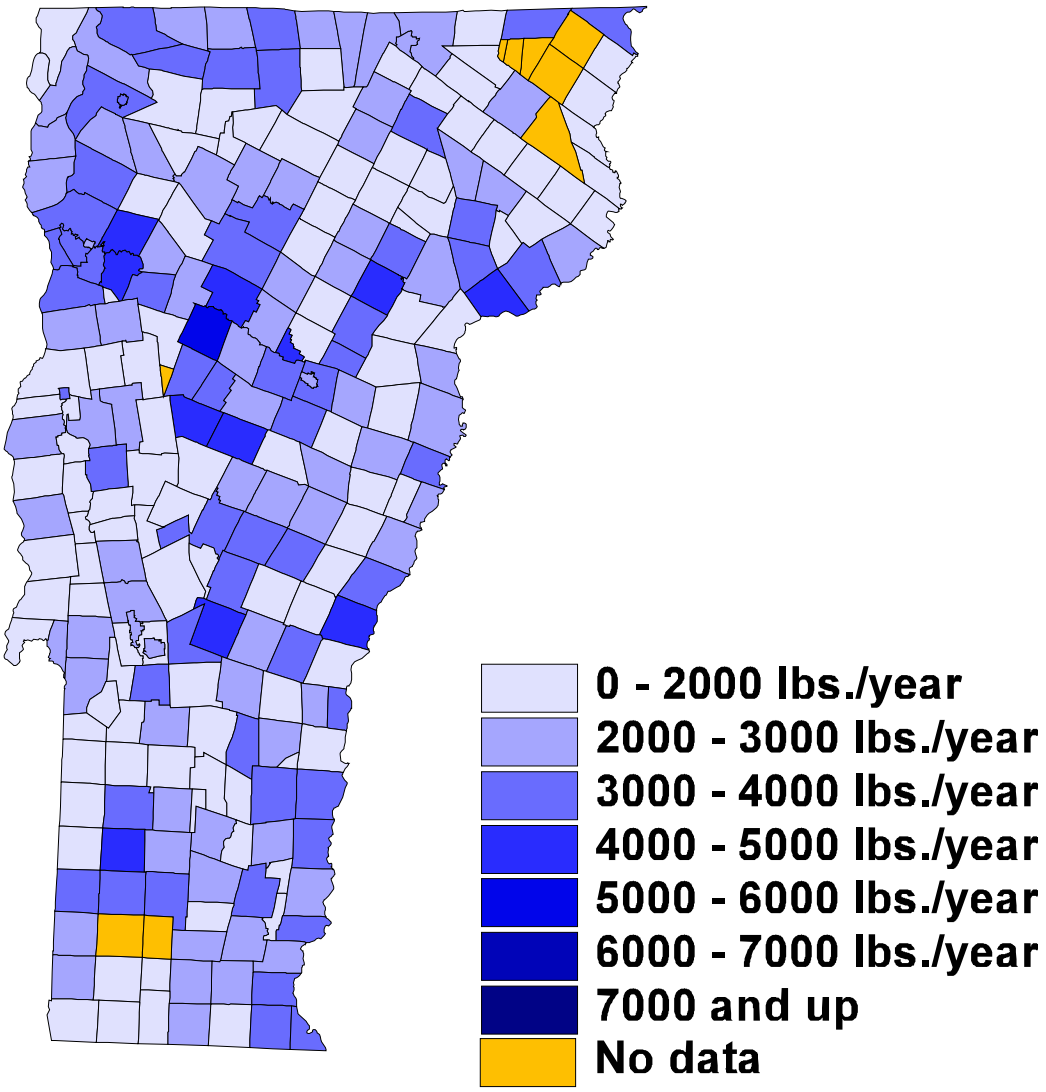


Since Vermont is the most rural state in the nation — as defined by the 2000 U.S. Census — it is not surprising that there is little transit service in the state. However, even in Burlington — the only U.S. Census-designated urbanized area in Vermont — less than 2 percent of workers commute using transit. Were Vermont to increase levels of transit ridership, especially in the core of Chittenden County and large towns in other parts of the state, the impact on carbon dioxide emissions would be significant.

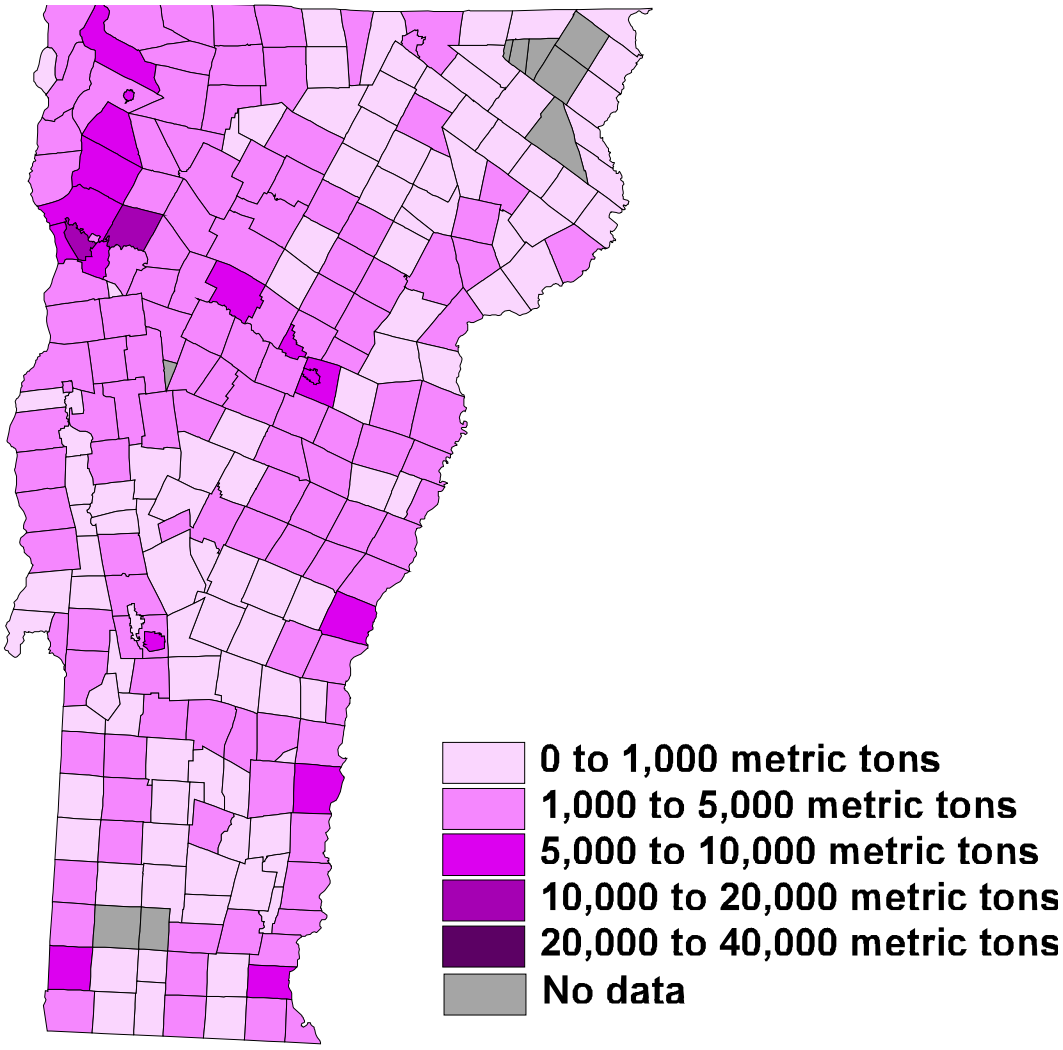
Figure 13 has only 75 data points — representing the 75 cities and towns in Vermont that have any significant use of transit — illustrating the lack of transit options available to Vermonters. However, the relationship between transit use and carbon dioxide emissions suggests that provision of additional transit services could be a successful strategy to reduce carbon dioxide emissions — even in a predominantly rural state such as Vermont.

Another alternative is walking or riding a bike to work. Towns with a high percentage of pedestrian and bicycle commuting generate lower levels of carbon dioxide emissions per worker. (See Figure 14, next page.)

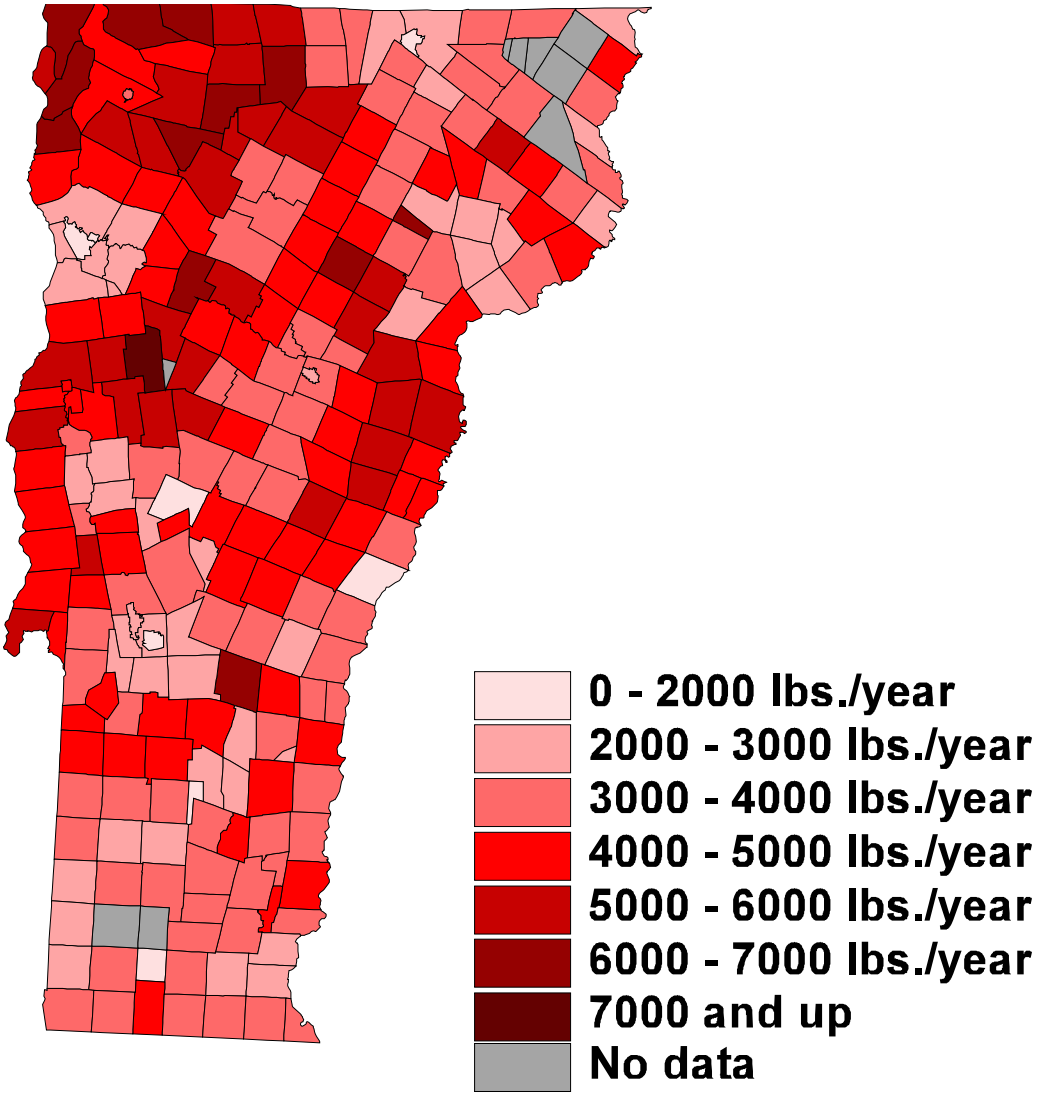
Per-Worker Carbon Dioxide Emissions by Place of Work



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

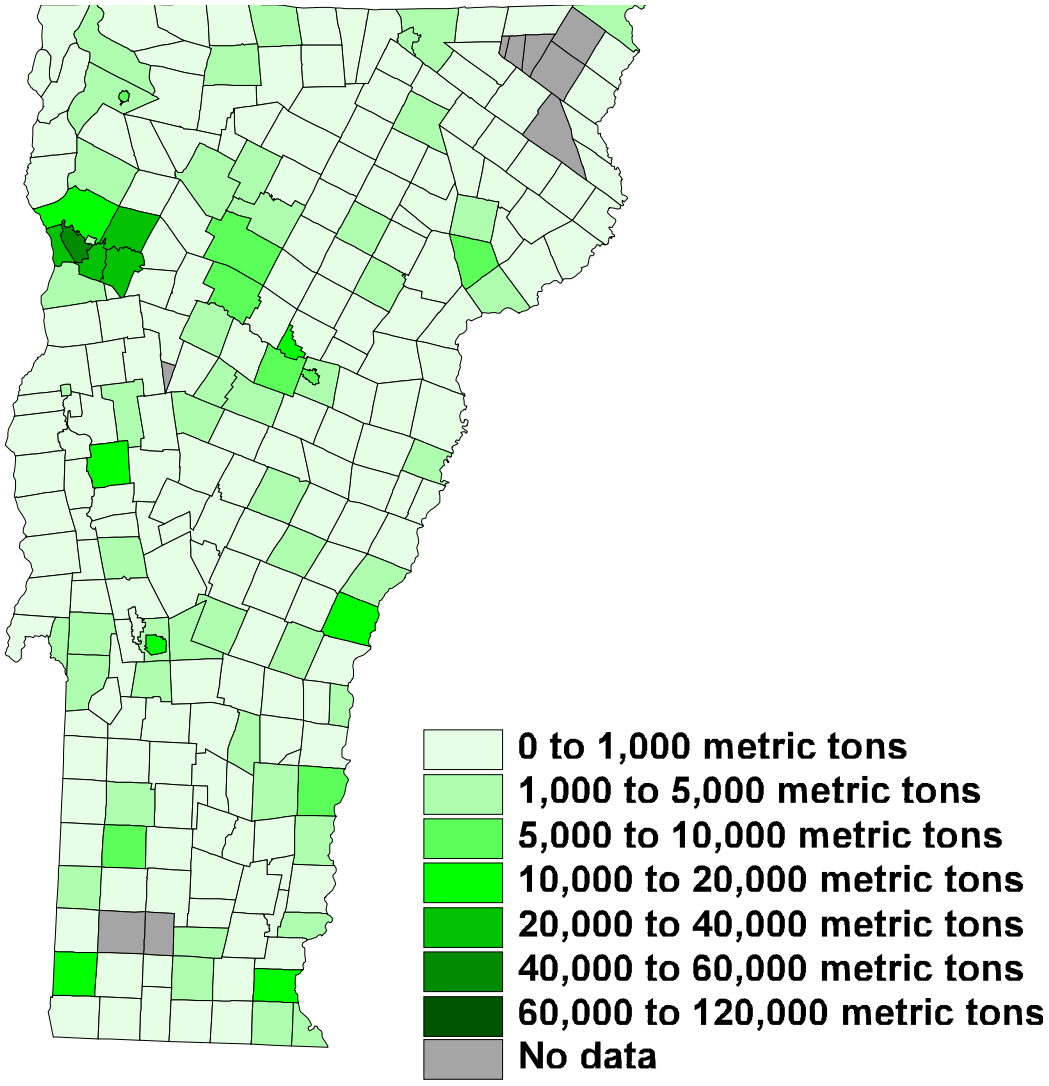
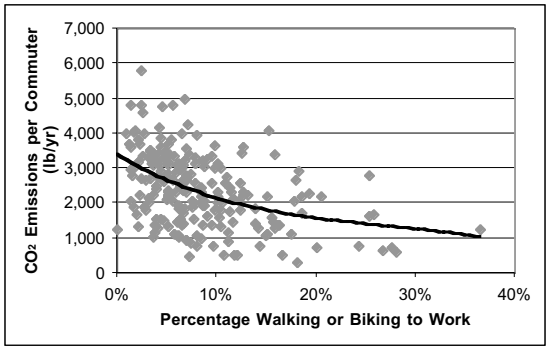


Figure 14. Percentage Walking and Biking Commutes vs. Per-Commuter Carbon Dioxide Emissions (Workplaces Attracting At Least 50 Commuters)



Efforts to encourage more non-vehicular commutes — such as walking or biking to work — have the potential to significantly reduce carbon dioxide emissions from commuting. Expanding bike paths, creating dedicated bike lanes, and employing a variety of pedestrian-friendly traffic calming techniques should therefore be an important part of the state's transportation plans.

These relationships suggest that efforts to encourage alternatives to drive-alone commuting, such as transit and non-vehicular commutes, can yield significant reductions in carbon dioxide emissions from commuting. Promoting and broadening the availability of transportation alternatives must therefore be a key component of any plan to reduce global warming emissions in Vermont.

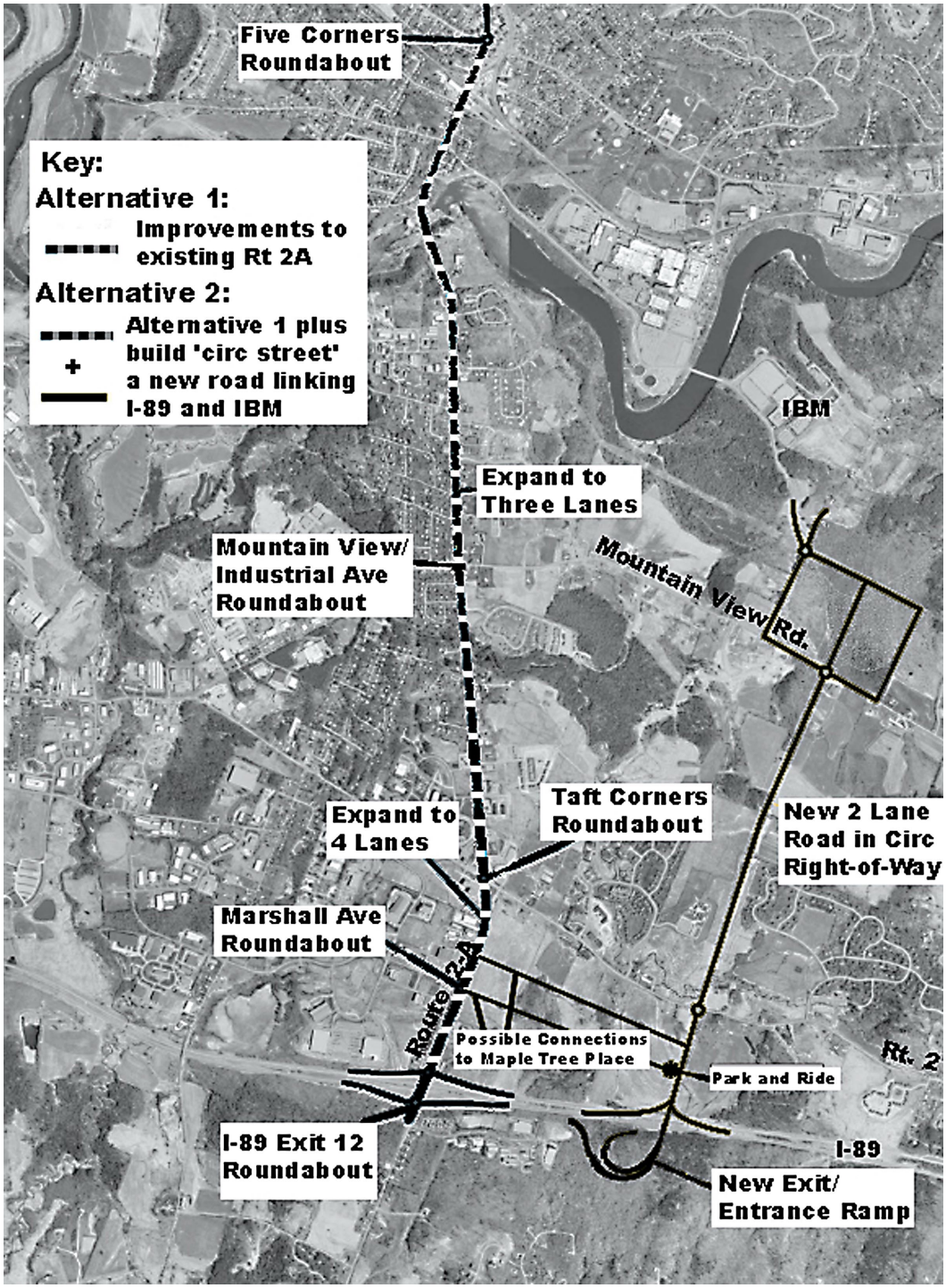
Promoting Smart Growth: Alternatives to the Circ Highway

Experts and the public agree that something needs to be done about traffic in Williston and Essex Junction. Traffic jams and frequent delays at key intersections like Five Corners and Taft Corners are not only a nuisance for drivers, they are a real detriment to area businesses, and a public health risk to commuters on foot and bicycle. But building the proposed Circumferential Highway will not solve traffic problems in Chittenden County, and may well create additional problems. According to Vermont's Agency of Transportation, building the Williston segments of the Circ Highway would make commutes an average of only 7 seconds faster, would increase traffic at key intersections, cost taxpayers more than $55 million and funnel jobs away from Burlington, South Burlington and other communities while accelerating sprawl.[18]

The Vermont Smart Growth Collaborative — a group of business, housing, transportation, planning, and environmental organizations — has proposed two alternatives to the Circ that would save taxpayers $10-25 million; cut wait times by half or more at key intersections; protect family farms, wildlife habitat and open space; and increase investment in Williston and Essex Junction.

The collaborative's first alternative incrementally widens sections of Rt. 2A and replaces several congested intersections with modern roundabouts that are safer and more efficient. The second alternative includes the same modifications to Rt. 2A but also includes the construction of a two-lane "Circ Street" in the Circ's right of way that would connect to I-89, IBM and a network of interconnected streets just north of Mountain View Rd. (See Figure 15, next page.) The addition of this street increases connectivity to IBM and the CCSWD landfill. Neither proposal, however, crosses the Winooski River to connect with the Circ. This is significant because modeling using AOT's software and projections found that without suburb-to-suburb connections, sprawl induced by development in the path of the Circ is dramatically decreased, as is the global warming pollution associated with it.

Figure 15. An Alternative to the Circ



Policy Recommendations

In its efforts to reduce commuting-related carbon dioxide emissions Vermont must focus on getting cleaner and more efficient cars onto the roads and promoting land-use patterns that reduce the need for long, single-passenger automobile commutes. Expansion of transit service, vanpooling and ridesharing are also important parts of a comprehensive transportation strategy for the state — despite Vermont's rural character and working landscape.

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

Clean Vehicles

The majority of commutes in Vermont are likely to take place via automobile for the foreseeable future. Therefore, the state should take a series of immediate and long-term actions to reduce global warming emissions from cars, SUVs, and light trucks.

First, Vermont should adopt vehicle global warming emissions standards pioneered by California. The standards establish a fleet average limit for carbon dioxide emissions, requiring automakers to reduce emissions from new cars by approximately 34 percent and from new light trucks by about 25 percent by 2016.[19]

Second, Vermont should provide incentives for the purchase of efficient cars, while discouraging purchases of large, gas-guzzling cars, light trucks and SUVs. One option Vermont can use to implement such an incentive program is to institute a sliding-scale motor vehicle purchase tax. Vermont currently assesses a 6 percent tax in place of a sales tax. That tax could be changed to a sliding-scale tax of between 0 percent and 12 percent based on a car's efficiency. Purchases of the most polluting vehicles (such as a Hummer H2) would be taxed at 12 percent, while purchases of the most efficient cars (such as a Toyota Prius or Honda Civic hybrid) would not be taxed at all. Purchases of average vehicles (like Subaru Legacy sedans) would be charged the same 6 percent rate they currently are charged.

Put the Brakes on Exurban Development

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

Proposed highway projects like the Circumferential Highway around Burlington and the Bennington bypass would accelerate the trend toward exurban development. The Circ, for example, would dramatically expedite suburb-to-suburb commuting between suburbs like Richmond, Jericho and Shelburne. This change will bring dramatic development pressure on these suburbs and push residential sprawl even further into rural areas.

More than 30 years ago, Vermont attracted national attention by passing Act 250 — a law designed to protect the environment and provide a forum for neighbors, municipalities and other interest groups to voice their concerns with proposed development and subdivisions. However, this act has not been enough to prevent sprawling development and rapid exurban growth from spreading through many parts of Vermont.

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. In addition, state investments in reinvigorating Vermont's traditional downtowns and town centers — coupled with stringent limits to ensure that such investments are not inappropriately used to encourage new sprawling development — could make a major difference.

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 infrastruc-

ture improvements that will facilitate further sprawl, but rather should be targeted towards areas in which growth is desirable. Instead of investing more tax dollars in the Circ highway, the state should invest in incremental road improvements along Route 2A, Route 15 and other existing roads. In addition, the state should adopt a "fix-it-first" approach to transportation spending in which state funds may not be used to develop new roads in a town or county until at least 60 percent of the approved road repair projects are funded first. This strategy is even more effective if new mass transit and enhancement projects are funded first out of the remaining funds and new road construction is used as a "last resort" of transportation planning.

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

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

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. 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. Even densely developed suburbs should not be sited at great distance from major employment and economic centers, and should provide a significant level of goods and services locally for the benefit of residents. Existing suburbs should be encouraged to promote "infill" development.

State investments also should be directed to encouraging the redevelopment of existing properties in urban areas that would be sites for affordable housing or new commercial development. A comprehensive downtown development plan that includes expedited permitting as well as easier access to and higher levels of funding by VEDA, VEPC and other agencies would encourage businesses to locate in downtowns. However, the state must also take care to ensure that such funds are directed to true downtowns, not to sprawling developments on the urban fringe.

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.

Hold Large 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 Vermont. 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 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.

Invest in Transit

The scarcity of transit alternatives in Vermont leads to an increased reliance on drive-alone commutes and increased global warming emissions. Vermont should invest in its transportation infrastructure in ways that will lead to reductions in global warming emissions.

Specifically, the state should expand regional rail connections and bus services — and spend less money on projects likely to lead to increased drive-alone automobile traffic, such as highway expansion.

The state should consider restoration of the Champlain Flyer commuter rail service, as well as expansion of commuter rail in other corridors. Regional rail service along the western edge of the state — from Bennington through Rutland and on to Burlington — should also seriously be considered.

A variety of bus services — including fixed-route, demand-response and commuter bus services — also have the potential to provide transportation alternatives to Vermonters. For example, the "Link Express," which runs through the Burlington/Essex Junction to Montpelier corridor has experienced ridership beyond forecasted levels — more reasonable fares and more frequent service could make the service and others like it even more successful.[20] The state should also consider similar commuter bus services along the VT-15 and US-7 corridors.

Vermont currently has an incentive program for state workers participating in vanpools. The state should expand the availability of this program while developing further ride sharing, ride matching and other coordinated carpooling services.

Transit becomes a more effective option if it is integrated into compact development patterns that include a mix of uses. "Transit-oriented development" can provide a sustained ridership base for transit services, while also maximizing transit's role in reducing the need for long automobile trips.

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. Vermont 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. However, 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 Vermont 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 Vermont 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 other transit modes in which Vermont 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.

This paper looks only at emissions from commuters from or traveling to work in Vermont's 246 incorporated cities and towns. Vermont's nine gores, grants, and "unorganized towns" were not included in this analysis, they include: Buels Gore, Glastenbury, Somerset, Averill, Ferdinand, Lewis, Warren Gore, Warners Grant, and Averys Gore. These nine gores, grants and unorganized towns have negligible carbon dioxide emissions from commuting.

The definitions of the "Core Suburbs," "10 Mile Ring" and "25 Mile Ring" around Burlington were based on GIS mapping using ArcView 3.2. Towns included in the Core Suburbs are those identified by ArcView as within 3 miles of Burlington city limits, towns in the two suburban rings were identified by ArcView as within 10 and 25 miles of Burlington 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.

- Incorporating other data sources — such as transportation models — to provide more detailed assessments of carbon dioxide emissions and to estimate the impact of various policy changes on the state's global warming emissions.

Appendix B: Emissions and Commuting Data by Town of Residence

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Addison town	74%	5,944	14	1,818	82
Albany town	72%	4,691	65	672	171
Alburg town	74%	6,277	6	2,294	65
Andover town	67%	2,864	201	266	220
Arlington town	73%	2,977	198	1,495	98
Athens town	70%	3,810	127	211	229
Bakersfield town	76%	6,941	2	1,735	87
Baltimore town	84%	2,598	220	159	233
Barnard town	77%	4,411	84	844	152
Barnet town	75%	4,405	85	1,476	101
Barre city	74%	2,886	200	5,497	15
Barre town	81%	3,068	188	5,299	17
Barton town	68%	3,747	133	1,937	78
Belvidere town	68%	5,384	34	269	218
Bennington town	72%	2,394	230	7,780	5
Benson town	75%	4,602	70	927	147
Berkshire town	66%	5,256	40	1,443	105
Berlin town	80%	3,416	167	2,034	74
Bethel town	72%	4,223	103	1,620	92
Bloomfield town	47%	3,784	130	284	216
Bolton town	79%	6,080	11	1,459	104
Bradford town	71%	4,707	64	2,480	52
Braintree town	72%	3,277	182	795	155
Brandon town	81%	4,092	109	3,171	39
Brattleboro town	69%	2,763	208	7,007	8
Bridgewater town	79%	3,886	120	779	156
Bridport town	68%	4,520	78	1,231	118
Brighton town	69%	3,613	144	701	165
Bristol town	74%	5,108	43	4,237	27
Brookfield town	74%	3,884	121	1,015	139
Brookline town	79%	4,017	113	352	208
Brownington town	73%	2,806	207	463	200
Brunswick town	40%	2,629	218	42	241
Burke town	76%	3,604	145	1,234	117
Burlington city	62%	1,768	241	16,421	1
Cabot town	70%	5,614	24	1,404	108
Calais town	72%	4,574	72	1,557	95
Cambridge town	73%	5,458	31	4,332	23
Canaan town	69%	2,536	225	564	191
Castleton town	79%	3,702	138	3,146	41
Cavendish town	69%	3,766	132	1,001	141
Charleston town	64%	3,458	163	585	187
Charlotte town	73%	4,095	107	3,165	40
Chelsea town	76%	4,593	71	1,152	127

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Chester town	81%	4,759	60	3,078	42
Chittenden town	80%	3,453	164	899	148
Clarendon town	83%	2,564	223	1,680	90
Colchester town	82%	2,369	231	9,998	3
Concord town	86%	3,953	118	891	149
Corinth town	81%	5,481	28	1,428	106
Cornwall town	74%	2,597	221	673	170
Coventry town	81%	3,250	183	662	174
Craftsbury town	62%	4,092	108	982	143
Danby town	74%	4,927	50	1,265	114
Danville town	79%	3,855	123	1,724	88
Derby town	80%	2,609	219	2,366	61
Dorset town	80%	3,055	189	1,153	126
Dover town	79%	3,603	146	1,158	123
Dummerston town	81%	2,751	210	1,242	116
Duxbury town	75%	4,767	58	1,495	99
East Haven town	73%	4,274	94	214	228
East Montpelier town	79%	3,337	175	2,048	73
Eden town	83%	5,687	22	1,153	125
Elmore town	80%	4,373	87	692	167
Enosburg town	70%	5,925	17	3,323	35
Essex town	83%	2,349	232	10,783	2
Fair Haven town	80%	4,129	104	2,252	67
Fairfax town	78%	5,655	23	4,614	20
Fairfield town	74%	5,314	39	2,082	72
Fairlee town	71%	4,492	79	1,082	133
Fayston town	74%	5,339	38	1,475	102
Ferrisburg town	73%	5,188	42	3,243	36
Fletcher town	71%	6,274	7	1,794	83
Franklin town	64%	6,090	10	1,758	85
Georgia town	78%	5,367	37	5,587	14
Glover town	61%	3,385	170	666	173
Goshen town	56%	2,851	203	91	238
Grafton town	67%	3,530	154	401	207
Granby town	44%	3,497	161	29	244
Grand Isle town	79%	6,018	13	2,637	49
Granville town	54%	3,292	181	223	225
Greensboro town	59%	3,509	157	418	206
Groton town	77%	5,802	20	876	150
Guildhall town	79%	2,659	214	114	235
Guilford town	76%	3,551	150	1,634	91
Halifax town	66%	3,786	129	549	193
Hancock town	49%	1,627	242	89	239
Hardwick town	69%	4,848	54	3,012	45

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Hartford town	80%	3,179	184	7,102	7
Hartland town	75%	3,823	126	2,746	48
Highgate town	74%	6,176	8	4,352	22
Hinesburg town	80%	4,270	97	4,318	24
Holland town	71%	3,081	187	291	214
Hubbardton town	74%	4,764	59	591	186
Huntington town	78%	5,932	16	2,747	47
Hyde Park town	82%	3,797	128	2,423	57
Ira town	73%	2,500	226	225	224
Irasburg town	71%	3,123	185	731	164
Isle La Motte town	63%	5,923	18	477	199
Jamaica town	77%	3,834	124	758	159
Jay town	72%	3,323	177	218	227
Jericho town	86%	4,087	110	4,930	18
Johnson town	64%	3,506	159	2,437	54
Killington town	82%	3,031	191	745	160
Kirby town	68%	2,415	229	247	222
Landgrove town	70%	1,462	245	13	246
Leicester town	81%	4,748	61	930	146
Lemington town	88%	4,265	98	95	236
Lincoln town	75%	5,827	19	1,560	94
Londonderry town	73%	3,541	152	1,316	111
Lowell town	70%	5,457	32	670	172
Ludlow town	77%	2,857	202	1,349	109
Lunenburg town	85%	4,252	99	1,028	136
Lyndon town	79%	2,998	196	3,209	38
Maidstone town	100%	3,549	151	23	245
Manchester town	79%	2,579	222	2,322	63
Marlboro town	66%	2,807	206	630	179
Marshfield town	75%	5,044	45	1,580	93
Mendon town	81%	2,656	215	604	183
Middlebury town	58%	2,017	238	3,219	37
Middlesex town	74%	4,047	111	1,744	86
Middletown Springs-town	73%	4,274	95	699	166
Milton town	80%	4,236	102	9,898	4
Monkton town	76%	5,934	15	2,476	53
Montgomery town	69%	6,166	9	1,071	134
Montpelier city	66%	3,025	192	5,644	13
Moretown town	75%	4,769	57	1,864	79
Morgan town	71%	3,407	168	480	197
Morristown town	77%	3,358	172	3,713	32
Mount Holly town	78%	4,489	80	1,161	122
Mount Tabor town	74%	4,937	48	180	232
New Haven town	74%	4,325	91	1,681	89
Newark town	77%	5,415	33	441	203
Newbury town	72%	5,214	41	1,979	76

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Newfane town	68%	3,535	153	1,297	112
Newport city	73%	1,590	243	1,192	120
Newport town	73%	2,222	233	680	169
North Hero town	72%	6,514	4	1,093	132
Northfield town	69%	3,505	160	4,318	25
Norton town	70%	3,509	158	32	243
Norwich town	68%	1,903	240	1,267	113
Orange town	80%	4,306	93	838	153
Orwell town	70%	4,920	52	1,187	121
Panton town	75%	4,649	66	683	168
Pawlet town	74%	4,319	92	1,127	129
Peacham town	66%	2,899	199	336	209
Peru town	68%	3,112	186	266	219
Pittsfield town	71%	2,559	224	221	226
Pittsford town	84%	3,325	176	2,373	60
Plainfield town	66%	3,296	179	1,026	137
Plymouth town	73%	6,683	3	635	178
Pomfret town	74%	3,515	155	732	163
Poultney town	73%	3,859	122	2,508	50
Pownal town	82%	3,977	117	3,019	44
Proctor town	85%	2,423	228	969	144
Putney town	70%	3,298	178	1,844	80
Randolph town	68%	3,981	116	3,872	30
Reading town	77%	4,240	101	594	185
Readsboro town	67%	4,009	114	629	180
Richford town	69%	5,481	29	2,240	68
Richmond town	85%	4,392	86	4,372	21
Ripton town	79%	3,657	140	434	204
Rochester town	77%	4,565	74	1,127	130
Rockingham town	72%	3,823	125	4,049	28
Roxbury town	80%	4,874	53	507	195
Royalton town	66%	4,114	105	2,132	69
Rupert town	79%	3,726	136	449	202
Rutland city	72%	1,559	244	5,398	16
Rutland town	84%	2,167	235	2,013	75
Ryegate town	74%	4,569	73	991	142
Salisbury town	74%	2,759	209	655	175
Sandgate town	64%	3,493	162	198	230
Searsburg town	73%	1,938	239	35	242
Shaftsbury town	82%	2,999	195	2,488	51
Sharon town	79%	4,732	62	1,465	103
Sheffield town	77%	4,937	49	595	184
Shelburne town	79%	2,651	216	3,953	29
Sheldon town	73%	4,998	46	2,119	70
Shoreham town	67%	4,484	81	1,258	115
Shrewsbury town	76%	2,996	197	652	176

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
South Burlington city	80%	2,023	237	7,488	6
South Hero town	73%	4,534	76	1,824	81
Springfield town	77%	3,375	171	6,321	10
St. Albans city	74%	3,556	148	5,835	12
St. Albans town	76%	4,248	100	4,721	19
St. George town	80%	2,849	204	453	201
St. Johnsbury town	74%	2,642	217	3,806	31
Stamford town	85%	3,664	139	558	192
Stannard town	84%	6,319	5	198	231
Starksboro town	80%	7,057	1	2,977	46
Stockbridge town	78%	4,561	75	581	189
Stowe town	72%	3,630	142	3,605	33
Strafford town	77%	4,636	67	1,026	138
Stratton town	91%	3,731	135	93	237
Sudbury town	79%	5,725	21	570	190
Sunderland town	81%	3,615	143	616	182
Sutton town	78%	4,450	82	870	151
Swanton town	67%	4,445	83	6,142	11
Thetford town	74%	3,990	115	2,429	55
Tinmouth town	65%	3,554	149	330	210
Topsham town	74%	5,591	25	1,154	124
Townshend town	68%	3,443	165	743	161
Troy town	66%	3,440	166	1,115	131
Tunbridge town	77%	5,077	44	1,343	110
Underhill town	80%	4,847	55	3,415	34
Vergennes city	72%	4,111	106	2,345	62
Vernon town	84%	3,295	180	1,529	97
Vershire town	68%	5,467	30	581	188
Victory town	79%	4,636	68	59	240
Waitsfield town	72%	3,712	137	1,549	96
Walden town	72%	3,747	134	525	194
Wallingford town	78%	4,606	69	2,301	64
Waltham town	69%	4,529	77	478	198
Wardsboro town	75%	3,647	141	628	181
Warren town	78%	5,513	26	2,108	71
Washington town	76%	4,355	89	1,014	140
Waterbury town	77%	5,490	27	6,498	9
Waterford town	77%	2,727	212	643	177
Waterville town	75%	5,380	35	765	158
Weathersfield town	80%	4,027	112	2,270	66
Wells town	76%	4,369	88	769	157
West Fairlee town	70%	4,947	47	742	162
West Haven town	78%	5,370	36	278	217
West Rutland town	82%	2,161	236	1,133	128

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
West Windsor town	76%	3,601	147	818	154
Westfield town	60%	3,351	173	302	212
Westford town	79%	4,721	63	2,389	58
Westminster town	85%	4,336	90	3,033	43
Westmore town	66%	3,049	190	143	234
Weston town	51%	2,201	234	229	223
Weybridge town	72%	3,002	194	494	196
Wheelock town	64%	2,824	205	314	211
Whiting town	75%	3,943	119	285	215
Whitingham town	72%	3,783	131	1,032	135
Williamstown town	79%	3,388	169	2,425	56
Williston town	85%	2,458	227	4,307	26
Wilmington town	75%	3,019	193	1,481	100
Windham town	80%	4,927	51	296	213
Windsor town	76%	3,513	156	2,379	59
Winhall town	71%	2,747	211	430	205
Winooski city	74%	1,363	246	1,945	77
Wolcott town	66%	4,271	96	1,425	107
Woodbury town	72%	6,033	12	1,193	119
Woodford town	72%	3,347	174	251	221
Woodstock town	67%	2,663	213	1,768	84
Worcester town	70%	4,774	56	946	145

Appendix C: Emissions and Commuting Data by Town of Work

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Addison town	60%	2,330	111	251	129
Albany town	57%	2,002	141	126	160
Alburg town	60%	1,382	180	197	142
Andover town	47%	1,309	187	57	190
Arlington town	71%	3,108	57	1,348	56
Athens town	13%	132	243	2	241
Bakersfield town	30%	1,129	199	48	198
Baltimore town	40%	236	240	1	244
Barnard town	54%	1,359	181	108	169
Barnet town	48%	1,917	145	295	117
Barre city	79%	2,608	94	6,011	17
Barre town	76%	3,120	56	3,364	30
Barton town	71%	3,079	60	2,251	35
Belvidere town	29%	609	226	10	227
Bennington town	77%	2,654	88	12,088	10
Benson town	59%	1,141	197	69	182
Berkshire town	40%	2,207	122	259	126
Berlin town	81%	3,686	22	5,923	19
Bethel town	72%	3,200	50	957	70
Bloomfield town	44%	968	209	20	213
Bolton town	19%	2,003	140	86	177
Bradford town	72%	3,133	55	1,807	44
Braintree town	70%	2,335	110	254	127
Brandon town	75%	2,898	73	2,005	41
Brattleboro town	77%	3,801	19	18,985	5
Bridgewater town	67%	2,302	115	223	137
Bridport town	43%	1,394	177	194	143
Brighton town	65%	2,058	134	336	112
Bristol town	68%	2,564	98	1,210	59
Brookfield town	52%	950	211	63	187
Brookline town	43%	478	234	8	230
Brownington town	54%	1,682	159	68	183
Brunswick town	20%	278	239	3	239
Burke town	74%	2,750	81	509	94
Burlington city	71%	3,436	32	46,423	1
Cabot town	70%	4,798	4	1,173	61
Calais town	36%	1,094	202	82	178
Cambridge town	70%	2,997	67	1,533	48
Canaan town	60%	3,076	61	1,132	62
Castleton town	70%	2,221	120	1,244	58
Cavendish town	75%	2,837	75	772	78
Charleston town	38%	731	220	48	197

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Charlotte town	50%	2,314	113	677	84
Chelsea town	77%	2,418	105	433	100
Chester town	72%	3,409	34	1,650	46
Chittenden town	48%	1,389	178	78	180
Clarendon town	80%	3,190	51	1,954	43
Colchester town	79%	3,991	14	13,754	8
Concord town	74%	3,183	52	224	136
Corinth town	70%	2,336	109	252	128
Cornwall town	48%	1,326	186	111	167
Coventry town	48%	1,460	173	102	171
Craftsbury town	47%	1,239	192	180	149
Danby town	64%	1,716	158	175	151
Danville town	71%	2,305	114	590	88
Derby town	78%	2,647	91	2,055	40
Dorset town	72%	3,419	33	1,034	67
Dover town	77%	2,947	68	1,421	54
Dummerston town	67%	2,044	137	288	121
Duxbury town	77%	5,804	1	1,485	52
East Haven town	33%	672	223	9	228
East Montpelier town	50%	1,358	182	243	132
Eden town	58%	1,945	143	115	164
Elmore town	34%	762	219	24	210
Enosburg town	76%	3,236	47	1,515	50
Essex town	81%	4,049	12	30,439	2
Fair Haven town	78%	2,781	79	1,363	55
Fairfax town	58%	2,586	96	465	97
Fairfield town	40%	1,643	161	174	152
Fairlee town	66%	2,071	133	362	108
Fayston town	69%	3,373	38	573	90
Ferrisburg town	50%	1,587	165	381	104
Fletcher town	35%	1,307	188	59	188
Franklin town	48%	2,568	97	320	113
Georgia town	49%	2,054	135	522	93
Glover town	44%	1,056	205	112	166
Goshen town	67%	1,012	208	7	232
Grafton town	72%	2,640	93	280	123
Granby town	0%	0	246	0	246
Grand Isle town	65%	2,214	121	291	120
Granville town	29%	1,058	204	31	205
Greensboro town	50%	1,754	156	189	145
Groton town	67%	1,550	167	63	186
Guildhall town	62%	1,133	198	20	212
Guilford town	68%	3,396	35	1,118	63

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Halifax town	27%	471	235	12	224
Hancock town	51%	1,330	184	87	176
Hardwick town	68%	2,432	103	1,015	68
Hartford town	80%	4,803	3	11,570	11
Hartland town	55%	1,801	153	393	103
Highgate town	67%	3,296	44	442	98
Hinesburg town	68%	2,723	84	698	81
Holland town	43%	1,327	185	48	199
Hubbardton town	29%	494	233	8	229
Huntington town	27%	533	229	30	207
Hyde Park town	71%	2,351	108	694	82
Ira town	38%	776	218	18	217
Irasburg town	59%	2,179	127	316	114
Isle La Motte town	60%	1,074	203	24	209
Jamaica town	59%	2,907	72	312	116
Jay town	65%	2,225	119	222	138
Jericho town	61%	2,355	107	598	87
Johnson town	65%	2,270	116	1,107	65
Killington town	75%	4,099	10	3,492	27
Kirby town	13%	180	242	2	240
Landgrove town	56%	1,170	194	13	222
Leicester town	51%	1,160	196	55	191
Lemington town	100%	1,631	162	3	236
Lincoln town	41%	966	210	52	193
Londonderry town	68%	2,783	78	875	73
Lowell town	60%	1,627	163	66	184
Ludlow town	74%	3,484	30	2,529	33
Lunenburg town	81%	2,838	74	347	110
Lyndon town	79%	3,263	46	4,707	22
Maidstone town	100%	1,514	170	3	238
Manchester town	82%	4,595	7	8,808	13
Marlboro town	51%	2,045	136	313	115
Marshfield town	51%	3,100	59	493	95
Mendon town	79%	3,619	24	1,428	53
Middlebury town	73%	3,614	25	12,417	9
Middlesex town	53%	2,803	76	343	111
Middletown Springs-town	48%	843	215	52	194
Milton town	76%	3,820	18	3,809	25
Monkton town	32%	777	217	55	192
Montgomery town	59%	3,059	62	221	139
Montpelier city	78%	4,235	8	16,291	7
Moretown town	58%	2,128	128	244	131
Morgan town	29%	507	230	19	215
Morristown town	81%	3,317	43	4,955	20
Mount Holly town	51%	1,387	179	96	173

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Mount Tabor town	56%	1,332	183	15	221
New Haven town	61%	2,197	123	422	101
Newark town	38%	624	224	11	225
Newbury town	69%	2,683	86	707	80
Newfane town	54%	2,407	106	490	96
Newport city	80%	2,730	83	4,182	23
Newport town	75%	2,492	99	682	83
North Hero town	74%	2,246	117	179	150
Northfield town	66%	2,652	90	2,499	34
Norton town	70%	3,509	28	32	204
Norwich town	69%	3,235	48	1,532	49
Orange town	63%	2,673	87	169	153
Orwell town	48%	1,297	191	141	157
Panton town	73%	1,970	142	115	165
Pawlet town	64%	1,787	155	271	124
Peacham town	43%	945	212	49	196
Peru town	72%	2,738	82	227	135
Pittsfield town	57%	1,725	157	101	172
Pittsford town	75%	2,647	92	971	69
Plainfield town	61%	3,396	36	932	72
Plymouth town	73%	2,775	80	119	162
Pomfret town	49%	1,869	148	168	154
Poultney town	64%	2,186	126	1,041	66
Pownal town	59%	1,856	149	270	125
Proctor town	76%	2,005	139	285	122
Putney town	77%	3,216	49	1,709	45
Randolph town	70%	2,944	70	3,367	29
Reading town	44%	920	213	37	202
Readsboro town	61%	1,236	193	64	185
Richford town	69%	3,943	16	1,559	47
Richmond town	74%	3,020	63	802	75
Ripton town	42%	1,123	200	35	203
Rochester town	73%	3,657	23	673	85
Rockingham town	77%	3,276	45	3,458	28
Roxbury town	66%	4,060	11	194	144
Royalton town	67%	3,148	54	1,489	51
Rupert town	45%	1,018	207	51	195
Rutland city	82%	2,933	71	17,977	6
Rutland town	83%	1,889	146	1,302	57
Ryegate town	66%	2,187	125	238	133
Salisbury town	65%	1,555	166	181	148
Sandgate town	67%	1,306	189	18	216
Searsburg town	27%	423	236	3	237
Shaftsbury town	72%	2,090	130	551	92
Sharon town	63%	1,881	147	199	141
Sheffield town	42%	1,428	176	39	201

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
Shelburne town	77%	3,389	37	3,820	24
Sheldon town	60%	3,007	65	738	79
Shoreham town	55%	2,077	132	295	118
Shrewsbury town	56%	1,799	154	166	155
South Burlington city	79%	3,994	13	29,369	3
South Hero town	63%	2,197	124	364	107
Springfield town	81%	3,102	58	6,617	14
St. Albans city	80%	3,500	29	9,255	12
St. Albans town	77%	3,477	31	4,864	21
St. George town	0%	0	245	0	245
St. Johnsbury town	80%	3,349	40	6,234	15
Stamford town	65%	1,490	171	58	189
Stannard town	40%	387	237	2	242
Starksboro town	61%	1,460	174	111	168
Stockbridge town	74%	3,571	27	185	146
Stowe town	73%	3,695	21	5,967	18
Strafford town	56%	1,591	164	141	158
Stratton town	70%	3,982	15	796	76
Sudbury town	48%	1,298	190	17	218
Sunderland town	81%	3,700	20	587	89
Sutton town	60%	2,324	112	184	147
Swanton town	67%	2,947	69	2,229	36
Thetford town	63%	2,418	104	664	86
Tinmouth town	40%	623	225	21	211
Topsham town	62%	1,542	168	91	174
Townshend town	75%	3,151	53	951	71
Troy town	66%	2,243	118	396	102
Tunbridge town	65%	2,109	129	205	140
Underhill town	40%	1,097	201	137	159
Vergennes city	72%	3,363	39	2,901	32
Vernon town	82%	3,333	42	1,111	64
Vershire town	40%	728	221	25	208
Victory town	40%	718	222	3	235
Waitsfield town	75%	3,593	26	2,196	37
Walden town	58%	3,001	66	250	130
Wallingford town	63%	2,461	102	434	99
Waltham town	9%	72	244	1	243
Wardsboro town	67%	1,822	152	115	163
Warren town	75%	4,965	2	2,185	38
Washington town	29%	502	231	19	214
Waterbury town	76%	4,784	6	6,049	16
Waterford town	82%	4,162	9	2,170	39
Waterville town	32%	497	232	17	219
Weathersfield town	70%	1,921	144	347	109
Wells town	66%	1,542	169	88	175
West Fairlee town	18%	285	238	7	231
West Haven town	40%	580	228	7	233

City or Town	Pct. Drive Alone Commutes	CO_2 Emissions per Commuter (lb/yr)	Per-Commuter Rank	Total CO_2 Emissions (metric tons)	Total Emissions Rank
West Rutland town	76%	1,839	150	366	106
West Windsor town	68%	2,700	85	557	91
Westfield town	35%	789	216	41	200
Westford town	39%	1,434	175	108	170
Westminster town	75%	2,481	101	773	77
Westmore town	35%	1,045	206	31	206
Weston town	54%	1,674	160	159	156
Weybridge town	55%	1,468	172	81	179
Wheelock town	9%	204	241	4	234
Whiting town	40%	582	227	13	223
Whitingham town	61%	2,088	131	378	105
Williamstown town	60%	3,340	41	871	74
Williston town	83%	4,789	5	23,498	4
Wilmington town	78%	2,593	95	1,180	60
Windham town	28%	1,161	195	15	220
Windsor town	77%	3,013	64	1,990	42
Winhall town	66%	2,491	100	292	119
Winooski city	73%	2,652	89	2,912	31
Wolcott town	48%	1,835	151	228	134
Woodbury town	41%	2,795	77	75	181
Woodford town	40%	906	214	10	226
Woodstock town	75%	3,851	17	3,751	26
Worcester town	55%	2,040	138	123	161

Notes

1. 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.

2. Ibid.

3. Ibid.

4. Projected vehicle-miles traveled estimated using an average annual growth rate from 1990 to 2003 (adjusting for change in VMT collection procedures) of 1.3 percent. Historic vehicle-miles traveled data from Vermont Agency of Transportation, *Annual Vehicle Miles of Travel,* downloaded from www.aot.state.vt.us/techservices/Documents/HighResearch/Publications/pub.htm, 28 April 2005.

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

6. 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.

7. Based on 1999 data extracted from U.S. Environmental Protection Agency, *AirData* Web site at www.epa.gov/air/data/index.html, 5 May 2005.

8. Chittenden County Metropolitan Planning Organization, *Regional Indicators: Measuring Our Progress Toward Chittenden County's 20-Year Transportation Goals*, 12 September 2000.

9. Federal Highway Administration, *Highway Statistics,* "State Funding for Highways-Summary-2003," November 2004.

10. In this and other maps of Vermont included in this report, Lake Champlain does not appear. The political boundaries of several towns bordering Lake Champlain extend into the lake and the area covered by the lake appears on this map.

11. Vermont Indicators Online, *Population Data*, downloaded from maps.vcgi.org/indicators, 26 April 2005.

12. Vermont Smart Growth Collaborative, *Smart Growth Progress Report,* October 2003, 24. Available for download at www.vpirg.org.

13. Ibid, 16.

14. 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.

15. Trustees of Middlebury College, *Middlebury College's Commitment to Carbon Reduction*, 8 May 2004.

16. John Isham et al, *Carbon Neutrality at Middlebury College: A Compilation of Potential Objectives and Strategies to Minimize Campus Climate Impact*, 20 June 2003.

17. Neil Schickner, Vermont Joint Fiscal Office, *Audit of the Champlain Flyer Commuter Rail Service*, 4 February 2003.

18. Vermont Agency of Transportation, Federal Highway Administration, *Chittenden County Circumferential Highway Reevaluation of the 1986 FEIS, Segments A - F* , Revised August 15, 2003. Specific per-second wait times were calculated using AOT software by Lucy Gibson at Smart Mobility using the projected traffic numbers in this document.

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

20. Vermont Agency of Transportation, *Vermont Public Transportation Overview,* 31 December 2003.

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 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.nrcm.org
- Environment Maine Research & Policy Center, 39 Exchange Street #301, Portland, ME 04101, 207-253-1965, www.environmentmaine.org

Massachusetts

- Clean Water Fund, 262 Washington St. #301, Boston, MA 02108, 617-338-8131, www.cleanwateraction.org/ma
- MASSPIRG Education Fund, 44 Winter Street, 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, 80 North Main Street, 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 Street Suite 6, Montpelier, VT 05602, 802-223-5221, www.vpirg.org